Intentionality vs Chaos

Brain Connectivity through Emotions and Cooperation Levels beyond Sensory Modalities.

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***Abstract*—Empirical evidence shows the efficiency of coordinated interaction in mother-infant dyads through unintentional movements: social entrainment, early imitation. The growing body of the literature evidently shows an impact of arousal on group performance and spreading emotion from one individual to another organism, called emotional contagion. The emotion sharing somehow stimulates shared intentionality in individuals of "primary group". Although there is increasing evidence of consistency between some "motion" and "emotion" concepts, research demonstrating the synergy of the integrative process of all these five concepts is limited. This study presents a dynamic integrated model of motion-emotions synergy that combines and manages all the above-mentioned appearances–the Model of Coherent Intelligence. This model is supported by arguments that are strictly based on experimental evidence in the literature and 24 online experiments in 2020. Primary groups show empirical evidence of a more significant accuracy in problem-solving in the coherent intelligence state. In specific, we conducted 13 online experiments in dyads (116 subjects) with *P*-value < 0.001, and 7 experiments in primary group adults (41 subjects) with the *P*-value < 0.002. Experiments with not well-known adults from the secondary group show the effect only within task UL3 (41 subjects in experiment No.12 with translation of unfamiliar language). Non-semantic tasks–SL3 (synthetic language) and US3 (two-color symbols)–did not stimulate the effect in 3 experiments with 207 secondary group subjects (unfamiliar students). The outcome demonstrates inter-brain connectivity through ongoing emotions and motion dynamics, creating cooperation levels beyond sensory modalities.**

Keywords-social cognition; coherent intelligence; embodied cognition; emotion contagion; imitation; interactional synchrony; social entrainment.

I. INTRODUCTION

Empirical evidence shows the efficiency of coordinated interaction in mother-infant dyads through unintentional movements: social entrainment [1][2], early imitation [3][4], and interactional synchrony [5][6]. The growing body of the literature evidently shows an impact of arousal on group performance [7]-[9] and spreading emotion from one individual to another organism [10]-[12], called emotional contagion. That is, emotion sharing somehow stimulates sharing intentionality in individuals of "primary group"[13]. Although there is increasing evidence of consistency between some "motion" and "emotion" concepts, research demonstrating the synergy of the integrative process of all these five concepts is limited.

Recent research presented a more significant accuracy level when participants independently completed similar tasks parallel with confederates who were primed with the correct answer [14]. This research design stimulated their emotional arousal and interactional synchrony in face-to-face performances. The current paper presents the outcome of 24 online experiments in 2020, which were designed following the Model of Coherent Intelligence (MCI).

Section II presents the hypothesis of how ongoing social dynamics can create a coherent mental process in groups. This Model of Coherent Intelligence (MCI) argues that social interaction shapes organisms' intentionality. Section III contains research data of 24 online experiments, their research problem, paradigm, and procedure. Section IV discusses limitations and difficulties of this research. Section V elaborates all findings, describing their meanings.

II. THE MODEL OF COHERENT INTELLIGENCE

According to Danilov and Mihailova [15], the MCI assumes that ongoing social dynamics create a coherent mental process in dyads (primary group) where movement coordination is cyclically enhanced under ever-growing arousal. A supranormal environment, 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. How the infant captures and reproduces the kinematic of movements. The MCI proposes that common emotional arousal together with the identical rhythm create coherent mental processes in dyads–Coherent Intelligence–as it is shown in Figure 1.

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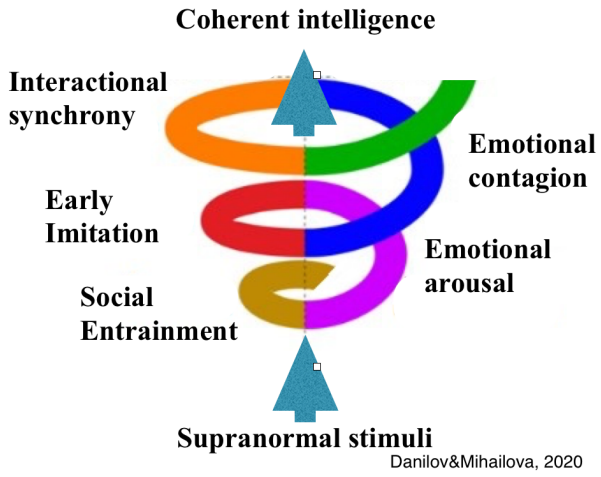

Figure 1. The model of coherent intelligence

At Stage 3 of the Model of Hierarchical Complexity MHC [16], organisms (such as human infants) do not maintain bilateral communication. According to Danilov and Mihailova [17], individuals are able to interact by distinguishing perceptual signals of identical modality by their significance. This is the foundation of intentionality. This ability can contribute to ostensive cues, categorizing reality. 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. In such a manner, organisms at Stage 3 of the MHC development begin to categorize the chaos of sensory stimuli. 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.

III. EXPERIMENTS

In 2020, we conducted 24 experiments with 407 subjects to test the MCI hypothesis of whether this effect also appears online.

A. The Research Problem

The research problem of these 24 online experiments was whether or not 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. Would a confident knowledge of the confederates on the tasks help target participants to solve these unintelligible problems without communication, when they simultaneously pass the same testing?

B. Experiment Paradigm and the Procedure

The within subjects paradigm was applied to verify the difference between the correct responses of the participants (unprimed subjects) to the "primed block" and "unprimed block" of tasks. Specifically, subjects (unprimed participants and primed confederates) with their computers joined the experiment through an online conference. They were also asked to prepare their mobile phones to complete the experimental tasks during the online conference by connecting to the experiment's website via their mobile phones. As soon as they all are online, experimenters divided subjects into two groups (participants and confederates) and informed them about the task.

Then, all subjects were asked to use their mobile phones to contact the experiment's website for completing the test. As soon as all subjects were connected via their mobiles to the website, testing began simultaneously. The experiment design stimulated arousal by the experiment's unusual situation and rhythmically changing red/purple colors of the mobiles' screens. Many studies on emotion arousal in learning show increased participants' cortisol levels during experiments [15]. It is highly likely that unintelligible tasks also contributed to emotional excitement in subjects as well as the participation of strangers (experimenters) in these performances. Interactional synchrony in subjects was stimulated by rhythmically changing colors of the mobiles' screen (80 bpm), that was identical for all.

During testing, the website simultaneously presented to all subjects 10 tasks. The all tasks design was the same for all subjects (participants and confederates)–all subjects saw the same picture with the similar mapping of the task and its answer options. The design of each task promoted the same geometrical navigation on the screen for all. The mapping of Unfamiliar Language (UL) task presented 10 answer options in one line on the screen of the mobile phones. The mapping of unfamiliar Synthetic Language (SL) task presented 8 answer options located on the square's perimeter on the screen. The mapping of Unintelligible Symbols (US) task presented on the screens 4 answer options located on the square's corners. That is, each task had the same for all subjects task-options mapping design, and answer options were in the same place on the mobile phone screens for all subjects (participants and confederates). In such a manner, we designed the same geometrical point of the correct answer on the screens for all participants and confederates.

The confederates were asked to follow hints on the right answers, solving tasks. They received hints on all even-numbered tasks (2-4-6-8-10)–"primed block" of tasks. The unprimed tasks for the confederates were all un-even (odd-numbered) tasks (1-3-5-7-9)–"unprimed block" of tasks. They did not receive instructions on odd-numbered tasks. In evaluating the outcome, the "unprimed block" of uneven tasks (1-3-5-7-9) became the baseline of the experiment. Unprimed participants did not receive any instruction on any task; both the unprimed block (1-3-5-7-9) and the primed block (2-4-6-8-10) were unintelligible tasks for them. That is, we tested whether or not unprimed participants (target participant) would be more accurate in solving unintelligible tasks when they were doing this simultaneously with confederates who knew the correct answer. Would unprimed subjects' (participants') results be better in the primed block than in the unprimed one? Would a confident knowledge of confederates on primed block tasks help unprimed subjects (target participants) to solve them without communication?

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The result was estimated by two values: (1) Rb – the ratio between the correct responses of the unprimed participants to the "primed block" and "unprimed block" of tasks, (2) Rch – the ratio between the correct responses of the unprimed participants to the "primed block" and possible responses by chance.

B. Experiments with Translation of Unfamiliar Language (UL)

UL1: We conducted 6 online experiments with 22 dyads (44 person); we tested subjects who are typical representatives of the primary group. The task was to choose the correct translation of an unfamiliar language from 10 variants from the list of 10 options. Before the experiment, we asked the subjects if they spoke the investigated language to make sure that this language was unfamiliar for them. Each dyad was divided into unprimed participants (a child) and primed confederates (her mother). They were asked to avoid any communication between them during testing. Dyads were required to translate unfamiliar foreign words themselves (independently) by choosing one correct translation from 10 variants in their native language in a congruent design and, with the opposite task, in an incongruent one. The confederates received correct answers on "primed block" of tasks (all even tasks 2-4-6-8-10). These online experiments in different languages found evidence of an increase of Rb=48% in a group performance between "primed block" of tasks and "unprimed block", and an increase of Rch=90% above chance in "primed block", the results are in Table 1.

UL2: The same tasks under the similar procedure were tested with 24 adults: students and groups of friends. These subjects cannot be attributed as typical representatives of the primary group; nevertheless, many of them stay in a coordinated state of social entrainment with their fellow, as we believe. We estimated them as primary group. The subjects of five experiments No. from 7 (18/04/2020) to 11 (12/05/2020) had been studying together since many years. These online experiments with different unfamiliar languages found evidence of an increase of Rb=143% in a group performance between "primed block" of tasks and "unprimed block", and an increase of Rch=216% above chance in "primed block", the results are in Table 1.

UL3: We repeated the same procedure in experiment No. 12 (12/05/2020) with subjects who were 41 second-year university students. They knew each other not more then two years and it seemed difficult to define their biological state as close to the social entrainment. We estimated them as secondary group. The results of 4 students were excluded from the outcome, since they speak the examined language. The online experiment No.12 shows evidence of an increase of Rb=133% in a group performance between "primed block" of tasks and "unprimed block", and an increase of Rch=380% above chance in "primed block", the results are in Table 1.

C. Experiments with a Rebus from Synthetic Language (SL)

SL1: We conducted 4 online experiments with 23 children and 19 mothers (specifically 19 families). The task was to choose the correct version of the rebus from 8 options placed around the square's perimeter. The rebus consisted of unknown symbols from synthetic language created especially for this experiment. These online experiments found evidence of an increase of Rb=394% in a group performance between "primed block" of tasks and "unprimed block", and an increase of Rch=42% above chance in "primed block", the results are in Table 1.

SL2: We tested the same tasks with 7 adults (M=18): students of the last year of high school. We believe they were in a coordinated state of social entrainment because of many years studying together under the same schedule. We estimated them as primary group. These online experiments found evidence of an increase of Rb=300% in a group performance between "primed block" of tasks and "unprimed block", and an increase of Rch=28% above chance in "primed block", the results are in Table 1.

SL3: We tested the same tasks with 56 adults (M=21): students of the second year of university. We estimated them as secondary group. They knew each other for not more than two years, and it does not seem easy to define their biological state as close to social entrainment. These online experiments did not find evidence of Rb's increase in a group performance between "primed block" of tasks and "unprimed block". At the same time participants' outcome in both conditions was Rch=28% above chance, the results are in Table 1.

D. Experiments with Unintelligible Symbols US

US1: We conducted 3 online experiments with 17 children (M=9) and 13 mothers (M=40); specifically, there were 13 families. Their task was to choose the two-color symbol related to one of the natural numbers from 1 to 5 among four options. In each task, four answer options (different two-color symbols) were located in the corners of the square's perimeter. These five two-color symbols related to a natural number from 1 to 5 were created specifically for this experiment. These symbols consisted of two colored circles (one in the other). The meanings of these unfamiliar symbols were unintelligible for subjects. Experimenters asked subjects to solve the tasks applying different strategies. Participants (unprimed subjects) were asked to guess the correct answer intuitively. In contrast, confederates were asked to solve the problems rationally, following hints on the correct answer. These online experiments in different languages found evidence of an increase of Rb=123% in a group performance between "primed block" of tasks and "unprimed block", and an increase of Rch=32% above chance in "primed block", the results are in Table 1.

US2: We conducted 1 online experiment with a group of 10 friend adults: 4 confederates and 6 participants (M=30). Their task was the same as of US1: to choose the two-color symbol related to one of the natural numbers from 1 to 5 among four options. Their meanings were unintelligible for subjects. Experimenters asked subjects to solve the tasks applying different strategies. Participants (unprimed subjects) were asked to guess the correct answer intuitively. In contrast, confederates were asked to solve the problems rationally, following hints on the correct answer. These online experiments in different languages found evidence of an increase of Rb=127% in a group performance between "primed block" of tasks and "unprimed block", and an increase of Rch=30% above chance in "primed block", the results are in Table 1.

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US3: We conducted 2 online experiments with 151 students from the first year of the university (M=19). We estimated them as secondary group. They knew each other for not more than a few days (if they knew each other, they did not meet because of the online university course), and it seems impossible to define their biological state as close to the social entrainment. Their task was the same as of US1: to choose the two-color symbol related to one of the natural numbers from 1 to 5 among four options. Experimenters asked subjects again to solve the tasks applying different strategies. Participants (unprimed subjects) were asked to guess the correct answer intuitively.

In contrast, confederates were asked to solve the problems rationally, following hints on the correct answer. These online experiments in different languages found evidence of an increase of Rb=3% in a group performance between "primed block" of tasks and "unprimed block". Their results Rch were below chance, see Table 1.

E. Results

The 20 experiments in subjects from the primary group includes 13 experiments in dyads (with 58 mothers and 68 children), and 7 experiments with 41 adults. The 4 experiments in subjects from the secondary group with 250 adults showed the effect only in UL3 task (a translation of an unfamiliar language). Other experiments in secondary group with the tasks SL3 and US3 did not show the effect.

The results are presented in the Table 1. There are several abbreviations to note: UL – the experiments with translation of an unfamiliar language; SL – the experiments with a rebus from unknown symbols of a synthetic language; US – the experiments with two-color round symbols; Rb, equation (1) – the ratio between the correct responses of the unprimed participants to the "primed block" and "unprimed block" of tasks; Rch, equation (2) – the ratio between the correct responses of the unprimed participants to the "primed block" and possible responses by chance; Mp – mean primed; Mb – mean baseline (unprimed); E – estimated by chance; O – observed results (both Mp and Mb); *P*-value – the significance of results, rejecting the null hypothesis; and values of the Chi-squared distribution is χ^2 .

IV. DISCUSSION

The limitations of the unfamiliar language task (UL) and synthetic language task (SL) are grounded in the life experience of subjects. Translation of an unfamiliar language (or solving a rebus) is challenging; however, subjects could casually hear some foreign words in the past and/or create associative relationships with words/symbols they already knew.

$$100\% \times (Mp - Mb)/Mb = Rb. \quad (1)$$

$$100\% \times (Mp - E)/E = Rch. \quad (2)$$

$$\Sigma (O - E)^2/E = \chi^2. \quad (3)$$

TABLE 1. RESULTS OF 24 EXPERIMENTS IN 2020

Group	The Ratio of Correct Responses					
	Ratio	***Task UL, %***	***Task SL, %***	***Task US, %***	χ^2	***P-value***
1. Dyads, 116 subjects	Rb	48	394	123	16.142	< 0.001
	Rch	90	42	32		
2. Primary group, 41 subjects	Rb	143	300	127	13.493	< 0.002
	Rch	216	28	20		
3 Secondary group, 250 subjects	Rb	–	–8	3	O.083	< 0.975
	Rch	–	31	–9		
	Rb	133	–	–	250.624	< 0.001
	Rch	380	–	–		

This implicit knowledge cannot be completely excluded from the outcome. Even though we selected unfamiliar foreign words (as it seemed to us) verifying this linguistic task with a control group, this did not exclude such cultural influence on subjects' results. Possible past experience and/or associative relationships between words/symbols could make an adjustment to the results. Nevertheless, it seems uncontroversial to say that young children acquire knowledge through a communication environment: language and other communicative signs. The current paper explores the modalities of social interaction that help organisms to assimilate knowledge. Therefore we propose to take into account this outcome because language is a typical communicative cue for children. It is possible to suppose that a communicative environment–symbols' domain–can enhance non-perceptual interaction. Principally we suggest mentioning this since the control group did not show any difference in results between even-numbered tasks and un-even (odd-numbered) tasks, testing all of them under unprimed conditions. This control group outcome may mean that the set of foreign words was unfamiliar for the particular subjects of the control group and may provide hope that this was a spread case also for other subjects. In contrast, the tasks with two-color round symbols (US) could create less association with previous knowledge in participants. From this perspective, the task US could show pure non-perceptual social interaction. These limitations can describe the difference in results between UL, SL, and US tasks in different groups. For instance, the primary group (dyads and adults) perform better linguistic task UL than the tasks with rebus from unknown symbols SL and two-colored symbols US, showing in the UL better results above chance.

It seems uncontroversial to say that the third task US with two-color round symbols excluded participants' experience (previous knowledge) from problem-solving to a greater extent. Comparing results between different tasks and groups shows the lowest increase of the Rch coefficient – the ratio between the correct responses between the "primed block" and responses by chance.

One of the research difficulties was to ensure the intentionality of the primed subjects (confederates), since the only following the instructions on the correct answers was not too exciting for them. We expected their mental collaboration instead of indifferent action in choosing of correct option. Therefore, for each experiment we created the special game for confederates depending on their personal interests. Although, in the sense of a person's unexpected choice, none can be sure on what to expect from a person, within reasonable limits, of course. Human uncertainty creates the problem for any research in psychology. Frankness, sincerity and involvement in the experiment are most influent factors of the testee's impact on the results of research. The experimenter can never exactly know the real intention and involvement of the examinee. We believe that the difference in the outcomes of the different groups also shows the participants involvement in the process.

The outcome was questioned: whether the correlation of results between teams of subjects (participants and confederates) is an evident pattern, or it happened by chance. The hypothesis evaluation using the *P*-value shows the significance of results in experiments with dyads and adults attributed to the primary group. The 20 experiments with subjects from primary group show: (i) the *P*-value < 0,001 in 13 experiments in dyads; and (ii) the *P*-value < 0,002 in 7 experiments in adults. We believe this outcome is statistically significant, rejecting the null hypothesis in subjects attributed to the primary group.

V. CONCLUSIONS

We conducted 24 online experiments with subjects of the primary group (20 experiments, 157 subjects) and subjects of the secondary group (4 experiments, 250 subjects). To our mind, the results of these online experiments support a hypothesis of inter-brain connectivity, which appears in individuals of primary groups (including dyads) at the beginning of cognition and lasts the entire social life. The unprimed subjects (participants) attributed to the primary group showed a more significant level of accuracy when they completed a thought task in the presence of confederates (primed subjects from the same group) who were simultaneously primed with the correct answer to the same task. We believe that the outcome of the primary group (dyads and adults) is statistically significant, rejecting the null hypothesis. The current research demonstrated inter-brain connectivity through ongoing emotions and motion dynamics, creating cooperation levels within individuals of the primary group beyond sensory modalities.

We did not expect the coherent intelligence effect in experiments with subjects of the secondary group; and we did not find it in the experiments with the SL3 (one experiment with 56 adults, M=21) and US3 tasks (2 experiments with 151 first-year students, M=19). Surprisingly, the outcome of the experiment No.12, 12/05/2020 with the task UL3 (an unfamiliar language) was very high; and the Chi-squared distribution and *P*-value of this experiment are very significant. This deviation from the expected result for this team was 380% higher than the probability of a random choice. We tested these subjects before the experiment on the knowledge of examined language, and the results of 4 students were excluded from the outcome, since they speak it. Other subjects did not speak this language at all. Following the secondary group definition, we rated this team as the secondary group, while they showed results as members of the primary group. The result of the experiment No.12 led us to additional study the history of these students' relationships and the formation of their team. Additional information at the stage of the results analysis showed that these second-year students had been visiting university facilities daily before the pandemic in 2020. They followed the same social rhythm during two academic years before the experiment. While studying at the university, they also completed an additional team training program to increase the level of inter-group cooperation. To our mind, the UL3 outcome means that these subjects had more close social cooperation between them than we thought at the moment of the experiment. This additional information may be useful for understanding why these subjects from the secondary group (as we thought earlier) also showed a significant accuracy in translating an unfamiliar language, as if they were members of the primary group. We believe that the results of the experiment No.12 (UL3) provides an opportunity for further research on the formation of close social bonds in groups that can also promote the more precise determination of the primary group's criteria. Further research on how the modality of communication can affect the message's understanding, even if the language of the message is unfamiliar to the recipient, can also develop knowledge about the inter-group cooperation.

The results of other teams with subjects of the secondary group in the tasks SL3 and US3 supported our expectations that there should be no coherent intelligence effect in the secondary group. The unexpected result in UL3 does not reject the significant outcomes of experiments in dyads (UL1, SL1, and US1) and adults from the primary group (UL2, SL2, and US2). We believe that the research outcome supports the hypothesis that from the beginning of cognition, the effect of coherent intelligence allows the nervous system to distinguish particular sensory stimuli from chaos, following shared intentionality with intimately related individuals. This outcome is consistent with our previous research outcome in 2019 from 7 experiments with 104 subjects, including 51 confederates and 53 participants [14]. The presented results complemented the already published research about 12 online experiments with 67 adults and children, *P*-value < 0,001 [19]. We believe that, future research should aim to understand the possible application of this effect to the advanced online curriculum for small children.

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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.

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