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Cognitive Architectures of Effective Speech-language Communication and Prospective Challenges for Neurophysiological Speech Studies

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ABSTRACT

The paper focuses on the importance of social cognitions and priors in natural human cognitive architectures. The structures and content of perceptual-cognitive-metacognitive processes are analyzed using the material of natural speech-language communication related to early human ontogenesis. Metacognitive processes are defined as a property and an integral part of the cognitive system. The prospects of neurophysiological research are formulated, which are designed to clarify the distribution, the nature of connections and neuronal dynamics in the system of perceptual-cognitive-metacognitive processes that ensure effective speech communication at different periods of human development. The importance of the studies of the neural architectural solutions related to the processes of natural speech and language communication for the development of IT technologies which can fulfill the communicative needs and expectations of individual is emphasized.

INTRODUCTION

Artificial systems, which are currently quite close to imitation of speech-language communication, are still unable to conduct it in dialogical modes which are common for humans. At the same time, there are already interesting and promising solutions to communicative problems at the level of auditory, visual, multimodal perception of social scenes, speech and language analysis, metacognitive processes. We still have a long scientific path ahead of us: in order to develop artificial intelligence close to the possibilities of flexible communication by an individual, it is necessary to join external monitoring of human social goal-setting, recognition and control of intentions, strategies and tactics of communicative partners, highlighting social priors that are not expressed in the language, to teach intelligent systems to recognize them, etc. And this is the level of tasks that the human brain is already able to comprehend and solve for active and multitasking communication in early ontogenesis. The analysis of human behavior and speech to a large extent (and so far, perhaps more accurately than the methods of neurobiology) allows us to describe biologically inspired cognitive architectures in the processing of natural social and other information by humans.

MATERIALS AND METHODS

The material of this study is the records of children's speech communication. Age of children: second and third years of life. All children are Russian-speaking. A random sample represents 200 situations from a database of more than 10,000 cases. Methods: content analysis, qualitative analysis, and reconstruction.

CASE ANALYSIS (a)

Situation. (a) Children – the twin boys (1.0.0.) to the adult's questions "Where is the teddy bear?", "Where is the lamp?" etc. point at the objects. (b) When they point at another object instead of the named one, they laugh. (a) Psychological analysis showed that the trigger for the specific mental and behavioral activity of children is an adult's request, which they well recognize as directed at a child (children) and is understood as the task of identifying and showing an object. Children already have differentiated image 1) of situations of speech interactions; 2) the intentionality of speech directed at them; 3) of the meanings of words that form this request. At each step of interaction with an adult, the child shows decisions whether to maintain the contact in the mode of controlled activity of the child that was set by the adult. These decisions, which are a socio-cognitive fact and characterize the type of connection between mental images of "I" and "other", formulate the goals of interaction, and the ability to focus on these social and non-social goals organizes specific mental activity and architectures of distributed metacognitive processes that are interconnected with specific complexes of process objects. Mental activity associated with the task of identifying an object by a verbal stimulus arises after choosing a strategy for interacting with an adult and setting goals, which is caused by a whole complex of cognitive and emotional processes and their results. This mental activity is presented in at least three vectors - focusing on one's mental states, on an adult, and on objects; the fourth vector in this case is determined both by the existing images in the memory about the images of interactions with the second twin child, and by the actual images of their states and forms of their behavior that are significant for the dynamics of the situation. All these communication systems are subject to monitoring and controlling simultaneously, concurrently and in their time dynamics. Monitoring of the adult's state occurs in the cycles "adult question - child's answer - adult's assessment of the result". The images of mental states of the child himself are formed and monitored in the dynamics of each cycle, which, along with the behavior of partners (the adult and the second child) determine the subsequent motivation for cooperation or, potentially, refusal to cooperate. Therefore, the controlling aimed at oneself in the aspect of maintaining or changing behavior is determined by evaluating the effectiveness of the process of solving the problem and its result, heuristics already used and arising, assessing their mental states, and attitude to other forms of behavior of other participants in the situation. Monitoring and controlling the behavior of the second child in relation to all participants in the situation, objects set by adults and other (background) objects are also a component of this meta-process system.

CASE ANALYSIS (b)

Situation (b), in addition to what has been said, demonstrates: a) the emergence / reproduction of a method for solving the proposed task, which, on the one hand, contains a semantic shift, and on the other hand, transmits to an adult an intellectual position that does not coincide with their expectations, which is understood by children. Laughter in this case is a sign of a false signal (intellectual and language game), forming the cognitive distance between "correct" and "incorrect", the social distance between "I think and answer correctly" and "I answer incorrectly as if I think incorrectly", and also a new balance of relations with adults in violation of the norm of intellectual activity (the normative way of solving a task) and the social norm of interaction with an adult; b) the coordination by both children of their communicative goals, aimed both at the adult who expects the correct solution to the intellectual-language task, and at each other, when it is important to support the selected behavior in the microgroup and confront the adult.

Of particular interest in this case are the heuristics of the semantic shift (a word / sound / gesture can be resemantized), a false signal and its intended use, here - for the purpose of socio-psychological distance from an adult (a language game serves these goals of a child well throughout their subsequent childhood, to which we have many recorded examples), finally, a heuristic of group action, which reinforces the position of the children in distancing from the adult, but within the boundaries of the communicative situation.

GENERALIZATION

Based on the speech communication of children of the second and third years of life (200 communicative situations), we also obtained data on the speech representation of the simulated activity and related tasks in relation to oneself and others, which organizes concentration and structure of perception; testing hypotheses about the status of a partner; monitoring the state of the system "child - adult"; speech management of others to achieve their goals, assessing the effectiveness of speech and choosing a more effective speech and language signal; verbalization / awareness of social (behavior and speech) technology influence on another person; basic social priors - images of the qualities of "I", "the other" and the relationship between them.

DISCUSSION

Such intellectual and social activity is provided by distributed cognitive architectures that make a specific contribution to the formation of many agreed goals and objectives of communication, the ways to solve them. We consider metacognitive processes to be an integral property of the human cognitive system. We also believe that social priors and the development of social knowledge are crucial for the structure of cognitive processes and their dynamics. F. Chollet's ideas about early social priors need to be clarified. Previously, we found 120 social representations in children of the second and third years of life. Some of these social concepts are "basic", but formed in social interactions. Behaviors and speech are representative systems, i.e. they represent the level of inference in the information and cognitive system. Therefore, the psychological analysis of natural communication provides a good opportunity to understand what cognitive architectures and in what dynamics provide effective communication.

CONCLUSIONS

1. Social-cognitive architectures differ from architectures that provide solutions to non-social narrow-subject intellectual tasks, however, they make up a completely integral hierarchy with the predominance of first-type architectures in this case.
2. The fundamental is the system of metacognitive processes that are specifically aimed at processes-objects (perception, various types of long-term and working memory, cognitive processes in their operational specifics and tasks, emotional processes), cyclically reorganize them, as well as themselves - setting new goals, self-evaluating metacognition, evaluating the effectiveness of the behavior aimed at the social partner (partners).
3. We see the prospects of neurophysiological research of speech as the most significant communicative system for humans in organizing systemic studies of neural cognitive architectures of the discussed complexity on the basis of naturally communicative tasks solved by a human in various situations in the dynamics of psychosocial development.

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