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EXTENSION OF CRITICAL PROGRAMS OF THE COMPUTATIONAL THEORY OF MIND

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ABSTRACT

Technological advances in computer science have secured the computer metaphor status of a heuristic methodological tool used to answer the question about the nature of mind. Nevertheless, some philosophers strongly support opposite opinions. Anti-computationalism in the philosophy of mind is a methodological program that uses extremely heterogeneous grounds for argumentation, deserving analysis and discussion. This article provides an overview and interpretation of the traditional criticism of the computational theory of mind (computationalism); its basic theses have been formed in Western philosophy in the last quarter of the 20th century. The main goal is to reveal the content of the arguments of typical anti-computationalist programs and expand their application to the framework of the semantic problems of the Classic Computational Theory of Mind. The main fault of the symbolic approach in the classical computationalism is the absence of a full-fledged theory of semantic properties. The relevance of considering these seemingly outdated problems is justified by the fact that the problem of meaning (and general problems of semantics) remains in the core of the latest developments in various areas of AI and the principles of human-computer interaction.

Keywords: anticomputationalism, computational theory of mind, Chinese room, finite automata, symbolic semantics, language of thought.

CRITICAL PROGRAMS OF COMPUTATIONALISM: A CLASSIC SET OF ARGUMENTS

This article analyses critical programs of various forms of the computeristic paradigm at various stages of its formation. The main goal is to identify key methodological trends in critical programs, to supplement existing classifications and consider possible responses from modern cognitive sciences and the engineering theory of artificial intelligence.

Today, review papers on various versions of the computational theory of mind offer the so-called typical list of critical programs:

- Variations of John Searle's Chinese Room argument,
- the triviality argument,
- Kurt Gödel's incompleteness theorem argument,
- the limits of the computational modeling argument,
- the temporal argument,
- the embodied cognition argument.[1]

Let us consider in more detail each of the above-listed positions, accompanied by our own commentary and interpretation.

The Chinese Room Argument

Essentially, this argument is based on three assumptions: 1) computations have the properties of multiple realization, whereas the mental does not; 2) intentionality, as opposed to a computer program, is determined by means of content, not syntactic structures; 3) a program is not a product of a computer (it is written by an intelligent coder), while the mind is generated by the brain, where the content of the mind is presented. It is characteristic that Searle's arguments correlate with the problem of information ontology in computing systems, where the translation of regular syntax into arbitrary semantics and vice versa remains extremely relevant.[2]

Today, computationalists have counterarguments based on the newest advances in computer technology only for the judgment number 3. It should be noted that the cyclical and recursive structures of algorithms, in which a program generates other programs, have been known for a long time. Most often, their use was associated with the translation of expressions from a programming language into a low-level language of machine instructions. Today, there is a type of automatic machine learning, when algorithms themselves write sub-programs and train neural networks. We should mention that the code created by a machine surpasses the code written by a programmer in a number of parameters.[3] Of course, the artificial program generation has nothing to do with the products of the mental realm. However, here the very structure of the so-called machine supervisor (observer) is important, during its functioning the autonomy of the entire machine system's behavior increases. As the result of this increasing the complexity of the processed data and the relevance of responses to the user or the physical environment requests increase. All this brings machine intelligence closer to the functional benchmark of the Turing test. In this case, the functional sig-

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[1] M. Rescorla, *The Computational Theory of Mind*, in: The Stanford Encyclopedia of Philosophy, E. N. Zalta (Ed.), 2017; https://plato.stanford.edu/entries/computational-mind/

[2] J. R. Searle, *Minds, Brains, and Programs*, Behavioral and Brain Sciences, 3 (3), 1989, pp. 417–424.

[3] T. Simonite, *AI Software Learns to Make AI Software*, 2017; https://www.technologyreview.com/2017/01/18/154516/ai-software-learns-to-make-ai-software/

nificance of the fact that the machine does not think is leveled—an adequate action is sufficient. There are statistical models of natural language that calculate the probabilities of the distribution over the sequence of tokens. After the stunning results in the generation of natural language texts obtained during the work on the GPT-3 autoregressive transformer, the arguments based on the principle of the "Chinese room" argument can be considered untenable. GPT-3 generates coherent human-like texts by extracting content from a vector representation of a gigantic number of sequences. "GPT-3 was writing articles, penning poetry, answering questions, chatting with lifelike responses, translating text from one language to another, summarizing complex documents, and even writing code."[4] The issue of syntax translating into semantics becomes irrelevant. The issue of the connection between meaning formation and probabilistic statistical models becomes more significant.

Triviality Argument

Triviality as an extreme degree of simplification in describing a certain system underlies the thesis, which is often found in the works of anti-computationalists of the mid-20th century. Essentially, this thesis is about the fact that any physical process can be represented as a computational function, since a quantitative measure is applicable to all properties of matter. "Every ordinary open physical system implements every finite-state automaton."[5] An open system is understood here as a system that has continuous interaction with the environment. This interaction can take the form of information, energy or material transformations due to the permeability of the system boundary. Thus, the Classical Computational Theory of Mind is recognized as trivial, since it represents mind as an open system described by the functions of a finite-state machine. In a simplified form, an abstract finite-state machine starts its operation from the initial state and then changes its internal states in accordance with the transition function. The transition function is defined in terms of the set of states that can be transitioned from the current state. It is important that this set is finite. The admissibility of a transition is determined by regular events that correspond to a finite set of internal states. It is obvious that the complexity level of the interaction between the organism and the environment (not to mention the meaningful properties of mental states) exceeds the executive capabilities of the finite automaton. Computationalists' counter-arguments are based on various modifications of the computational theory, including semantic,

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[4] S. Tingiris, B. Kinsella, *Exploring GPT-3*, Packt Publishing Ltd., Birmingham 2021, p. 3.

[5] H. Putnam, *Minds and Machines*, in: Dimensions of Mind, S. Hook (Ed.), New York University Press, New York 1960, pp. 148–180.

causal, and other aspects. In other words, the triviality argument sounds like this: if any physical systems are described by the properties of a finite automaton, then computationalism is trivial; if not, then computationalism is not complete.

Gödel's Incompleteness Theorem Argument

Considering that a voluminous set of works is devoted to this problem, let us give a brief (interactive) description of the argument and counter answers.

- Anti-computationalists: human mathematical abilities are superior to the computational capabilities of a Turing machine, because a person is able to understand the meaning of the Kurt Gödel's incompleteness theorem[6] (Lucas, 1961; Nagel et al., 2001).
- Computationalists (and philosophers supporting this position): the anti-computationalist understanding of the Gödel's formal systems incompleteness theorem is based on mathematical errors and false premises.

For example, in his comments to Roger Penrose's *Shadows of the Mind*, David Chalmers points to the absence of a direct connection between the Gödel's argument and the non-computability of physical elements in the theory of quantum gravity.[7] Chalmers emphasizes that if each physical component of the brain has a finite number of relevant states, then these causal relations between the states of the brain are representable in a discrete computational form, despite the continuity of natural processes. In other works, he denies the persuasiveness of external and internal critical arguments and points to the universalism of computational models in the reproduction of the causal structure of the mental.

Limits of Computational Modeling Argument

This anti-computeristic "line of defense" is built on the intuitive assumption that there are many aspects in human activity that go beyond the explanatory capabilities of formal systems: creativity, development, understanding, heuristics, planning, etc. The rigid logical limitations of computer models do not allow reflecting the flexibility, stability, and adaptability of many cognitive processes. Criticizing the Classical Computational Theory of Mind, Jerry Fodor points out that Turing-type computer modeling explains

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[6] J. Lucas, *Minds, Machines and Gödel*, Philosophy, 36, 1961, pp. 112–127; E. Nagel, J. R. Newman, D. R. Hofstadter (Rev., eds.), *Gödel's Proof*, New York University Press, New York. 2001, p. 129.

[7] D. J. Chalmers, *Facing up to the Problem of Consciousness*, Journal of Consciousness Studies, 2, 1995, pp. 200–219.

only local fragmentary processes and is not able to adequately represent the abductive elements of probabilistic knowledge and conditional experience.[8] Note that when criticizing the early version of the language of thought hypothesis, Fodor's follower S. Schneider opposes to his arguments the idea that, firstly, Turing computations are sensitive to the properties of an integral system, and secondly, abductively derived knowledge is computable within the framework of a formal pragmatists.[9]

Temporal Argument

The key thesis defended by this argument is that mental processes take place over time. In addition, the human mind is capable of solving complex problems in a non-trivial way. The main emphasis of the proponents of this argument is that the classical model of sequential computation cannot cope with the explanation of the temporal characteristics of cognition processes. An abstract Turing machine does not take into account the resource constraints (time and energy) imposed on computations by the physical world. It is important to emphasize that this argument is used not only by anti-computationalists but also by proponents of alternative computational approaches.[10]

Various types of neural models or parallel computing are proposed to reproduce the elements of mental processes. It is argued that an abstract computational model can be equipped with temporal properties because each discrete step of computation can formally correspond to a certain moment in time or other physical parameter. The technological interpretation of the representation is of interest. A computer is an artificial system capable of correlating scalar values with analog physical signals. For example, when digitizing sound, the compressed waves are sent to a transducer (microphone diaphragm), which transmits them in the form of voltage fluctuations. These fluctuations are then encoded into a digital bit rate (the number of bits used to transmit data per unit of time). It turns out that at any moment of time the state of the system represents the spatio-temporal states of physical waves.

However, technological comparisons of the operation of neurons with an analog-to-digital converter (ADC) inherit the entire set of engineering complexities. The imperfection of the ADC is due to the fact that when digitizing the analog signal's continual function of the time, distortions and errors are inevitable, to which the limitation of the frequency spectrum is added.

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[8] J. A. Fodor, *The Mind Doesn't Work That Way: The Scope and Limits of Computational Psychology,* MIT Press, Cambridge, Mass. 2000, p. 126.

[9] S. Schneider, *The Language of Thought: A New Philosophical Direction,* MIT Press, Cambridge, Mass.–London., 2011.

[10] G. Piccinini, *Physical Computation: A Mechanistic Account*, Oxford University Press, Oxford 2015.

Therefore, according to the Kotelnikov-Shannon theorem, a complete digital restoration of an analog signal is impossible.[11] Thus, any digital representation of analog physical processes is always an approximation.

There are analytic computational counterarguments of the following type: the fact that the physics of cognitive processes has continuity does not mean that computational models must include this continuity. Physical states exist in continuous time, but this is not reflected in any way in the digital logic of the device itself. As a result, the idea is substantiated that computational models of mind should not describe absolutely all physical processes in the brain. The question remains open as to whether the continuity of physical processes entails the necessary continuity of cognitive processes. This is not obvious to the supporters of computationalism.

Embodied Cognition Argument

The concept of embodied cognition was formed as a result of the perceptual studies of Maurice Merleau-Ponty and James J. Gibson, who developed an ecological approach. The essence of this approach is to study the unity of cognition and bodily action "built-in" into the challenges of the environment. With this formulation of the issue, the processes of mind cannot be regarded as abstract manipulations of symbols. Computationalism is opposed by environmentalism, in which the unity of mind, body, and environment is described in terms of the theory of dynamical systems.[12] Computationalists, in turn, argue that the computational approach is sufficient to represent the dynamic relations of the organism and the environment in the form of a system of incoming signals and outgoing motor-communicative actions.

Summarizing the so-called typical set of critical anti-computational programs, we can point out that, despite the variety of arguments, they are all united by the same logic of reasoning. This logic is based on the following principle:

- — mental processes are derived from physical ones,
- — physical processes causative of mental content have computational properties,
- — physical processes in computational models do not cause mental content,
- — therefore, computationalism is false, or at least incomplete (does not explain all the variety and complexity and mental content).

In our opinion, the main problem here is that the methodology of computationalism as such is criticized, not its particular applications. The heuristici-

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[11] V. A. Kotel'nikov, *On the Throughput of "Ether" and Wire in Telecommunications,* Uspehi fizicheskih nauk, 176 (7), 2006, p. 762 (in Russian).

[12] F. J. Varela, E. Thompson, E. Rosch, *The Embodied Mind: Cognitive Science and Human Experience*, MIT Press, Cambridge, Mass. 1991.

ty of the computer metaphor in cognitive sciences and the philosophy of mind is so high that it is rather difficult to identify the weaknesses of computationalism in general. Criticism can be strengthened by narrowing the methodological field.

ANALYTICAL CRITICISM OF THE COMPUTATIONAL THEORY OF MIND

Next, we present the arguments aimed precisely at the classical Fodor's program of the Computational Theory of Mind in the framework of the provisions of the language of thought hypothesis (LOTH). The term "analytical" in the title of the paragraph is associated with the method of conceptual analysis of the main criticism arguments, which is used by a number of authors.[13] Some examples from the "typical list" also overlap with analytical criticism. The key problem here is related to the semantic properties of mental states. Therefore, special attention is paid to clarifying the meaning of the terms used and the contexts of their use. The specificity of the analytical approach also lies in the fact that the thematic area shifts from the problem of computability and logical representability to the problem of meaning, which inevitably brings the research focus to the field of philosophy of language.

Here, it is important to point out the key concept that will be used in constructing the criticism of the CTM—derived intentionality. Intentionality in modern analytical philosophy is interpreted very broadly. In this context, intentionality is understood as the inherent ability of mental states to be aimed at some object or some content. Derived intentionality is understood as the content of linguistic expressions inherited from the primary intentional states of mind used for purposes that lie outside the propositional content of the expression.

There are two different lines of the CTM criticism, but both use the concept of derived intentionality. Each of these critical lines presents difficulties for the computational approach, but the essentially these difficulties differ. The first line is Causal Derivation Objection. The problem with the CTM is that the intentionality of linguistic symbols (prescriptions, illocutionary acts) causally depends on the intentionality of mental states and acts of meaning assignment. The second line of criticism is Conceptual Dependence Objection, which puts forward the following thesis: the conventional concept of "symbolic meaning" conceptually depends on the concept of "mental meaning," which has an internal a priori content.[14] Thus, the first line states

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[13] S. W. Horst, *Symbols and Computation. A Critique of the Computational Theory of Mind*, Minds and Machines, 9 (3), 1999, pp. 347–381; K. M. Sayre., *Intentionality and Information Processing: An Alternative Model for Cognitive Science*, Behavioral and Brain Sciences, 9 (1), 1986, pp. 121–138.

[14] S. W. Horst, *Symbols and Computation* ..., op. cit., p. 354.

that there is nothing inherent in the semantic properties of symbols, depending on mental states, representations, and discursive symbols. The second line, on the contrary, indicates two types of meanings (symbolic and mental), which cannot be reduced to the same ontology. Let us take a closer look at each of the criticisms.

Causal Derivation Objection

Causal intentionality is a problem that constitutes the most popular criticism of the CTM. A typical representative of this type is the Chinese Room argument. The semantic properties of intentionality can be inherent in both mental states and linguistic tokens (inscriptions, illocutionary acts). The illocutionary act expresses the semantic characteristics of the mental state. This expression takes place when the speaker performs the act of assigning a meaning that fills the sounds of speech or forms of writing with the content of the intentional state. Intentional causation is possible when the speaker's intention (aimed at making the tokens express a state) causes the utterance to have intentionality. In fact, in order to realize a causal explanation of language tokens, it is necessary to distinguish between two states of the speaker:

1. mental state expressed by a linguistic act;
2. an intentional act, by which the content of this mental state is communicated to the spoken sounds.

These clauses contain inconsistencies for the CTM. The semantic properties of symbols are causally derived from mental states, although the semantic properties of mental states are not derivatives. Therefore, it would be false to explain the semantics of mental states through the semantics of symbols, because:

1. The semantics of mental states is not derivative.
2. Any explanation of significant (relevant) symbols requires an explanation of the semantic properties of symbols, which in turn require an explanation of the semantic properties of mental states.

The argument consists of two statements and looks very convincing:[15]

A. All symbols with semantic properties have to have these properties derivatively.
B. None of the semantic properties of mental states is derivative.

The latter statement directly contradicts the CTM, which states that the semantic properties of mental states are derived from the semantic properties of mental representations.

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[15] S. W. Horst, *Symbols, Computation, and Intentionality: A Critique of the Computational Theory of Mind*, CreateSpace, Charleston, SC 2011.

Taking an extreme position, Daniel Dennett argues that the semantic properties of high-level cognitive processes are derived from low-level cognitive states (from the intentions of genes).[16] Objection A looks surmountable if we prove that all tokens (inscriptions, sayings, computer symbols) are derivative. Fodor points out that the only way symbols can acquire semantic properties is by inheriting dependence on certain entities that have meaning, or as a result of the act of assignment. However, if Searle asserts that the semantic properties of speech causally depend on the intentional states of the speaker, then Fodor points out that the semantic properties of symbols of mentalism (the language of thought) are inherent. Consequently, the symbols of mentalism have a special nature, different from the symbols on the tape of the Turing machine. This raises the question of the nature of mental computation and its relationship to traditional computationalism.

Conceptual Dependence Objection

This objection is based on the violation of the identity of terms in the analysis of the semantic properties of mental states and symbols. The terms "intentionality," "semantics," "meaning," "reference" are used concurrently both when discussing the semantic properties of mental states and when discussing the semantic properties of symbols. However, these terms may have different content, which depends on the context of the subject area. In the expression "A means ..." the verb "mean" will have certain content if A is a mental state and different content if A is a symbol. Horst connects such a vague semantics with the paronymy of terms, giving examples of the below type:

(1) *Healthy body / Healthy food.*

or

(2) *Many of John's thoughts have been about Mary of late. / The inscription of the name "Mary" in John's dairy are about Mary.* [17]

It is interesting to consider an example which demonstrates the differences in the semantic intentional properties of mental states and symbols through the contextual differences in the meaning of the preposition "about."

The term "derived intentionality" has similar paronymy. Derived intentionality for symbols (especially in the computer memory tape) does not overlap with the intentionality of mental processes. GO symbols can be interpreted within the lexical convention of the English language (in which case it would be the verb of movement "to go"); can be interpreted in the convention

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[16] D. C. Dennett, *Consciousness Explained*, Penguin, London 1991, p. 74.

[17] S. W. Horst, op. cit., *Symbols and Computation* ..., 1999, p. 350.

of the Japanese language (then it will be a noun meaning a board game). Although, it is worth pointing out that here we only talk about phonetic symbols, since graphically in the Japanese convention, the game should be indicated by the hieroglyph 碁. Without interpretive conventions (compilation algorithms), these symbols—GO or 碁—mean nothing.

Thus, the CTM semantic problem has two separate interpretations: in terms of mental states and in terms of symbolic operations. In this case, it is important for the CTM proponents to indicate in which interpretative convention the term "meaning" is used and whether it relates to the content of mental states. As a result, conceptual dependency can be expressed by the following simple statement:

Concept X is conceptually dependent on concept Y only if an adequate analysis of X includes the mention of Y.

Based on the conceptual dependence thesis, S. Horst summarizes the provisions of his criticism of the CTM approach to intentionality in ten statements:[18]

1. Semantic terms like "intentionality," "semantics," "meaning," "reference" are paronymic and used in different meanings in relation to mental states and symbols.
2. It is necessary to distinguish between the ways of using these terms in relation to the semantic properties of mental states and symbols.
3. Expressions applicable to the semantic properties of symbols are conceptually dependent on expressions applicable to the semantic properties of mental states.
4. Analysis of the attributes of the semantic properties of symbols reveals this dependence, since in the CTM, the semantic properties of symbols refer to the semantic properties of mental states.
5. Any attempt to represent the semantic properties of mental states in terms of the semantic properties of symbols will regress and form a vicious circle.
6. When the CTM claims that mental representations have semantic and syntactic properties, the question arises whether it is about (A) the semantic properties of mental states, (B) the semantic properties of symbols, or special computational semantics (C).
7. Acceptance of interpretation A does not make sense.
8. Acceptance of interpretation B leads to regression.
9. Accepting C, we get convinced that there is no adequate theory of semantic properties in the CTM.
10. The explanatory weakness of the CTM stems from an unclear "vocabulary" of semantic terms.

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[18] Ibidem, pp. 354–355.

It is necessary to point out that Horst's argumentation is further strengthened by the fact that a symbol in the traditional semiotic sense differs from the abstract symbols that are manipulated by the "printer" on the Turing machine tape. Here we go back to the metaphorical origins of computationalism. A semiotic symbol in any sign system is a conventional designation of a concept, idea or phenomenon, the content of which is attributed conventionally. In computing systems, a symbol is comparable to a quantitative representation of information. That is, symbolic elements (for example, in the ASCII standard) are structural units of information, the semantic properties of which are exhausted by its specification reflecting functions, information and control relations. At the same time, a symbol in the computing system does not indicate anything other than its own functional properties. What is the specificity of the computer program symbols semantics, and to what extent is this semantics comparable to the semantics of mental states? In other words, does the CTM have sufficient explanatory power in mind-related issues?

In computer science, semantics is the meaning of an abstract syntax (sic!), expressed in terms of a rigorous mathematical model. Semantics in one case represents the set of admissible transformations over the syntactic model. For example, the compiler translates the program language into an equivalent machine language description. In another case, semantics is a description in the metalanguage of permissible transformations, as, for example, in the case of the line-by-line work of the interpreter.

The essence of the computer programs semantics is to create rules for assigning values to the symbolic components of these programs. The specificity of the semantic properties of computer symbols is expressed in the definition of some effectively computable relation as a denotation. This is a basic prerequisite for the adequate functioning of a computer. There are three types of programming languages semantics, the properties of which are really difficult to compare with the content side of mental states (operational semantics, propositional semantics, and denotational semantics). The semantic properties of computer symbols are reduced to the consistent computation of syntactic structures within the constraints of computation theory. Due to the fact that computations are carried out on the physical components of machines, hardware restrictions related to the amount of RAM, processor clock frequency, physical time, etc. are imposed here too.

Thus, we come to the conclusion that the main function of symbolic semantics is the consistency of program syntax with opcodes, addressing modes, and numeric equivalents that will be implemented in the physical states of the machine. Despite the fact that this definition intersects with the functionalist interpretation of mind/brain, it is necessary to recognize the following: if we recognize the content side of phenomenal experience, then the computational understanding of semantics in this matter looks useless.

Machine procedures do not have phenomenal content; therefore, the truth of semantic computations depends not on conformity to the "extra-linguistic" world but on the consistency of syntax within the framework of computation theory. If cognitive sciences have not yet discovered a strong relationship between the limitations of formal models and the limitations of cognitive processes of the brain and mind, then computationalism in a broad sense may be considered a heuristic but not a universal scientific metaphor.

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