The brain-mind-computer trichotomy: hermeneutic approach

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Abstract. A unifying framework, i.e. the brain-mind-computer trichotomy is suggested analyzed by by adopting hermeneutic approach. We argue that brain is a hermeneutic device, and hermeneutics is also necessary to understand situations and other's minds. Intentional dynamics is a possible method to set this unifying framework. Specifically, computational studies suggest that schizophrenia, as a "disconnection syndrome" can be interpreted as a result of broken hermeneutic circle.

1 Dichotomies

The term "brain" is often associated with the notions of "mind" and of "computer". The brain - mind - computer problem has been treated within the framework of three separate dichotomies, i.e. the brain-mind problem, the brain - computer analogy/disanalogy and the computational theory of mind.

1.1 The brain-mind problem

First, the brain-mind problem is related to the age-old philosophical debate among monists and dualists. Attempts to "solve" the brain-mind problem can be classified into two basic categories:

1) materialistic monism, leading in its ultimate consequences to some kind of reductionism; and

2) interactionist dualism, which is more or less some type of Neo-Cartesian philosophy.

The classification is, obviously, a crude oversimplification: a wide spectrum of monistic theories exist from Skinner' radical behaviorism [50] and Patricia Churchland eliminative materialism [14] through Smart's physicalism [51] to Bunge's emergent materialism [10] (see also the controversial book of Deacon [17]).

Interactionist dualism has always been an influential viewpoint since Descartes defined the interaction between the spatially extended body and a non-corporeal mind. Though the modern version of dualism was elaborated by two intellectual heroes of the twentieth century (Sir Karl Popper and Sir John Eccles [45]), still it has been criticized or even ignored by main stream philosophers of mind, both by functionalists, and as well as by biology-oriented thinkers. Bickle [8] suggested that philosophers should adopt a ”ruthless reductionist” approach by learning molecular and cellular neurobiology. The multiple realizability thesis (say [1]) emphasizes the importance of hierarchical organization from molecules to social interactions. Any non-reductionist physicalist theory should tell something about the mechanism of ”downward causation”.

“Downward causation” is a notion which suggests that higher level systems influence lower level configurations. Classical molecular biology deals exclusively with upward mechanisms of causation (from simple events to more complicated ones) and neglects completely the explanatory role of downward causation. Since we know that both molecules and genes form complicated networks or feedback loops, it is difficult to defend the concept that there is nothing else in science than a linear chain of elementary steps leading from cause to effects. [59]. The methodologically successful reductionism is never complete. As Popper suggested, there is always some “residue” to be explained.

”Downward causation” was suggested by Sperry [52, 53] to explain the brain - mind problem stating that mental agents can influence the neural functioning. Sperry was criticised by stating that the postulate that physiological mechanisms of the brain are directly influenced by conscious processes is unclear [19, 55]. Alternatively, it was cautiously suggested by János Szentágothai in a somewhat overlooked paper that the nervous system can be considered as being open to various kinds of information, and that there would be no valid scientific reason to deny the existence of downward causation, or more precisely, a two-way causal relationship between brain and mind [54].

On some similar way, Campbell and Bickhard [11] argues that ”organization principles” should have some priorities since our ”best physics tells us that there are no basic particulars, only fields in process. The relationship among free will, downward causation and the emergence of complexity is discussed in an edited book from a broad perspective [43].

Twenty years ago it was argued [22] that the philosophical tradition of hermeneutics, i.e., the ”art of interpretation”, which is a priori neither monist nor dualist, can be applied to the brain. Even more is stated: on one side, the brain is an ”object” of interpretation, on the other side, it is itself an interpreter: the brain is a hermeneutic device. In similar vein, in The Metaphorical Brain 2, Michael Arbib [2] argued that our theories of the brain are metaphors, while the brain itself represents the world through schemas, which may themselves be viewed as metaphors.

1.2 The brain-computer analogy/disanalogy

Second, the problem of the brain-computer analogy/disanalogy was a central issue of early cybernetics, in some sense revived in the era of the neurocomputer boom. More precisely, the two sides of the metaphor (”computational brain” versus ”neural computer”) should be the subject of a brief discussion. There are several different roots of the early optimism related to the power of the brain-computer analogy. We recall two of them. First, both elementary computing units and neurons were characterized as digital input-output devices, suggesting an analogy at even the elementary hardware level. Second, the (more or less) equivalence had been demonstrated between the mathematical model of the ”control box” of a computer as represented by the state-transition rules for a Turing machine, and of the nervous system as represented by the McCulloch-Pitts model. Binary vectors of ”0” and ”1” represented the state of the computer and of the brain, and their temporal behavior was described by the updating rules of these vectors. In his posthumously published book The Computer and the Brain, John von Neumann [44] famously emphasized the particular character of ”neural mathematics”: ”...The logics and mathematics in the central nervous system, when viewed as languages, must structurally be essentially different from those languages to which our common experience refers...”

Arguments for the computer-brain disanalogy were listed by Conrad (1989). Digital computers are programmed from outside; are structurally programmable; have low adaptability; and work by discrete dynamics; their physical implementation is irrelevant in principle; they exhibit sequential processing; and the information processing happens mostly at network level. Brains are self-organizing devices; they are structurally non-programmable; they work by both discrete and continuous dynamics; their functions depend strongly on the physical (i.e., biological) substrate; the processing is parallel; and information processing occurs for both network and intraneuronal information.

Though it was suggested more than two decades ago [3] still it looks useful to consider the brain as a metaphor for sixth generation computing. Instead of having a single universal machine, a computing device is ”composed of *different* structures, just as the brain may be divided into regions, such as cerebellum, hippocampus, motor cortex, and so on.”

We now know (as part of the collective wisdom, but see e.g. also [46]) that:(i) brains are not digital computers; (ii) brain does not have a central processing unit, but rather uses cooperative, distributed computation; (iii) memory organization is based on dynamical (as opposed to static) principles, (iv) uses the combination of discrete and continuous time dynamics, and (v) the synaptic organization of the brain is very unique, and may be the key element of the biological substrate of human intelligence.

1.3 The computational theory of mind

Third, the computational theory of mind (and classical cognitive science) holds that the computational metaphor is the final explanation of mental processes. The classical version of the theory suggests the mind executes Turing style (symbolic) computation. As is well known, the birth of the formal AI was the Dartmouth Conference held in the summer of 1956 (an important year, in many respects) and organized by John McCarthy. The goal was to discuss the possibilities to simulate human intelligent activities (use of language, concept formation, problem solving). The perspectives of the cyberneticians and AI researchers have not been separated immediately. Some of McCulloch's papers also belong to the early AI works, as the titles reflect: ("Toward some circuitry of ethical robots or an observational science of the genesis of social evaluation in the mind-like behavior of artifacts".Or this: "Machines that think and want").

"Connectionism" [49] emerged an ambitious conceptual framework for a general brain-mind-computer theory movement, but it is based on principles of "brain-style computation" that ignore many of the "real brain" data. The connectionist movement is thus directed more to the engineers of near-future generation computer systems and to cognitive psychologists. An attempt to integrate the symbolic and connectionist perspectives was given by Gary Marcus [41]

There are recent debates about the meaning of the concept, which states that "mind computes". "Embodied cognition" seems to be a radical alternative [13] to classical cognitive science. The central hypothesis of embodied cognitive science is that cognition emerges from the interaction of brain, the whole body, and of its environment. To relate classical and embodied cognition we should answer the question: what does it mean to **understand** a phenomenon? A pragmatic answer is to synthesize the behavior from elements. Many scientists believe if they are able to build a mathematical model based on the knowledge of the mechanism to *simulate* a phenomenon and predict some other phenomena by using the same model framework, they understand what is happening in their system. Alternatively, instead of building a mathematical model one may wish to *construct* a robot. Embodied cognitive science now seems to be an interface between neuroscience and robotics: the features of embodied cognitive systems should be built both into neural models, and robots, and the goal is to integrate sensory, cognitive and motor processes

It is not yet clear whether there is any reason to deny that (i) a more general computational framework would be able integrate the dynamic interaction of mind with its environment, (ii) it is possible to build neuromorphic and brain-based robots by combining computational neuroscience and traditional robotics [40].

2 Hermeneutics

Hermeneutics is a branch of continental philosophy which treats the understanding and interpretation of texts. For an introduction for non-philosophers. see [42]. One of the most important concepts in hermeneutics is the **hermeneutic circle**. This notion means that the definition or understanding of something employs attributes which already presuppose a definition or understanding of that thing. The method is in strong opposition to the classical methods of science, which do not allow such circular explanations. Hans-Georg Gadamer (1900-2002) writes [35]: "Understanding always implies a *preunderstanding* which is in turn prefigured, by the determinate tradition in which the interpreter lives and that shapes his prejudices. (The Nobel-prize winner physicist Steven Weinberg [60] wrote: "... A physicist friend of mine once said that in facing death, he drew some consolation from the reflection that he would never again have to look up the word "hermeneutic" in the dictionary).

2.1 Hermeneutics of the brain

Ichiro Tsuda [57, 58] applied the principles of hermeneutics to the brain processes by using chaos as a mechanism of interpretation. He suggested that (i) a particular chaotic phenomenon, namely chaotic itinerancy, may be identified with what he calls hermeneutic process; (ii) in opposition to the idea that ”the brain is a computer, the mind is a programmer”, ”...the brain can create even a programmer through the interpretation process expressed by chaotic itinerancy...” (Tsuda 1991).

In [22] it was asked: how, if at all, two extreme approaches to any living systems, i.e. the ”device approach” and the ”philosophical approach” could be reconciled. It was suggested by turning to the philosophical tradition that hermeneutics, i.e., the ”art of interpretation”, which is neither monist nor dualist *a priori*, can be applied to the brain. Further, it was stated that the brain is both the ”object” of interpretation as well as the interpreter: therefore the brain is itself a hermeneutic device. For our own dialog with Tsuda see [25].

2.2 The brain as a hermeneutic device

The brain can be considered as different types of devices. Among others the brain can be seen as a thermodynamic device, a control device, a computational device, an information storing, processing and creating device, or a self-organizing device.

The device approach is strongly related to the *dynamic metaphor* of the brain [23]. Dynamic systems theory offers a conceptual and mathematical framework to analyze spatiotemporal neural phenomena occurring at different levels of organization. These include oscillatory and chaotic activity both in single neurons and in (often synchronized) neural networks, the self-organizing development and plasticity of ordered neural structures, and learning and memory phenomena associated with synaptic modification. Systems exhibiting high structural and dynamic complexity may be candidates of being thought of as hermeneutic devices. The human brain, which is structurally and dynamically complex thus qualified to be a **hermeneutic device**. One of the characteristic features of a hermeneutic device is that its operation is determined by **circular causality**.

Circular causality in essence is a sequence of causes and effects whereby the explanation of a pattern leads back to the first cause and either confirms or changes that first cause; Example: A causes B causes C that causes or modifies A. The concept itself had a bad reputation in legitimate scientific circles, since it was somehow related to use “vicious circles” in reasoning. It was reintroduced to science by cybernetics emphasizing feedback. In a feedback system there is no clear discrimination between “causes” and “effects”, since the output influences the input. Roughly speaking negative feedback reduces the error or deviation from a goal state, therefore has stabilizing effects. Positive feedback, which increases the deviation from an initial state, has destabilizing effects.

Systems with feedback connections and connected loops can be understood based on the concepts of circular and network causality. Leaving aside the clear and well-organized world of linear causal domains characterizing ”simple systems” we find ourselves in the jungle of the complex systems [24]. Natural, technological and social systems are full with feedback mechanisms.

Circular causality (a key concept of cybernetics) was analyzed to establish self-organized neural patterns related to *intentional* behavior [34]. In many cases, specific neural circuits implement feedback control loops which regulate specific functions.

Analyzing the question of whether the technical or ”device approach” to the brain and the ”philosophical approach” can be reconciled, it was concluded that the brain is a physical structure which is controlled and also controls, learns and teaches, process and creates information, recognizes and generates patterns, organizes its environment and is organized by it. It is an ”object” of interpretation, but also it is itself an interpreter. The brain not only perceives but also creates new reality: it as a hermeneutic device [22].

2.3 Neural hermeneutics

Frith [32] is working on establishing a scientific discipline ”neural hermeneutics” dealing with the neural basis of social interaction. The key elements of this approach is the assumption that there representations of the external world can be shared with others, and this share representation may be the basis of predicting others actions during interactions, Recently active inference and predictive coding was offered [33] as the basic mechanisms/algorithms of social communication. Social communication is based on internal models about the each other, and appropriate updating this internal model implies reduction in the prediction error.

3 Towards the algorithms of neural/mental hermeneutics

Understanding situations: needs hermeneutic interpretation

– logic, rule-based algorithms, and similar computational methods are too rigid to interpret ill-defined situations,

– hermeneutics, ”the art of interpretation” can do it.

– hermeneutics: emphasize the necessity of self-reflexive interpretation and adopts circular causality

Biological systems contain their own descriptions, and therefore they need special methods. Hermeneutics: emphasizes the necessity of self-reflexive interpretation. Both natural science as ”objective analyzer” and (post)modern art reiterate the old philosophical question: What is reality? As it was mentioned, the human brain is not only able of perceiving what is called objective reality, but also can create new reality. It is a hermeneutic device.

There are only preliminary ideas about the algorithms of neural and mental hermeneutics. ”Can complexity scientists bridge, in the words of C. P. Snow, the two cultures of academia - the humanities and the sciences - to create a more thoroughgoing explanation of human cognition? More specifically, can the tools of hermeneutics, mathematics and computer simulation be integrated to assemble better and more useful models of human social understanding than currently exist? These are the two provocative and ambitious questions - the former the broader, and the latter the more specific - that frame the intent and focus of Klüver and Klüver’s recent book, Social Understanding”, see the review [12] about the boo [39].

Somewhat parallelly with the arguments of this paper the action-perception cycle, having been motivated by Walter Freeman’s findings and theory [34, 30] Robert Kozma is working on understanding the neural mechanisms the intentional perception-action cycle [38, 37]. It is stated that knowledge and meaning is created in the brain by a circular intentional dynamics, where ”meaningful stimulus is selected by the subject and the cerebral cortex creates the structures and dynamics necessary for intentional behavior and decision-making”.

4 Schizophrenia: a broken hermeneutic cycle

4.1 Hermeneutics, cognitive science, schizophrenia

Gallagher’s analysis implies: (i) Hermeneutics and cognitive science is in agreement on a number of things. An example is the way we know objects. The interpretation of objects needs ”schema theory” [4]); (ii) Hermeneutics can contribute to cognitive science. The basis of the argument is that understanding situations (as it was mentioned earlier) needs hermeneutic interpretation. The usual critique is that logic, rule-based algorithms, and other similar computational methods are too rigid to interpret ill-defined situations, but hermeneutics ’ can do it. (”Mental models”, which also helps to analyze situations also should mention. Mental models have played a fundamental role in thinking and reasoning, and were proposed in a revolutionary suggestion by Kenneth Craik (1914 - 1945) [16]. The idea that people rely on mental models can be traced back to Craik’s suggestion that the mind constructs ”small-scale models” of reality that it uses to predict events.) (iii) Cognitive science also has something to offer to hermeneutics, particularly to understand other minds. The most popular notion today is the *theory of mind* or more precisely ”theory of other’s minds”. The most effective method of cognitive science to understand other minds, i.e. to show empathy is to simulate other minds by using analogical thinking [9]. The neural basis of theory of mind now seems to be related to mirror neurons, which is the key structure of imitation, and possibly language evolution [5]. A failure of attributing self-generated action generated by the patient himself (what we may label as the lack of ability to close the hermeneutic circle) can be characteristic for schizophrenic patients [6].

Independently from my own interest in hermeneutics, in a collaborative project we adopted combined behavioral, brain imaging and computational approaches to associative learning in healthy and schizophrenia patients to explain their normal and reduced performance in an associative learning paradigm. The working hypothesis we adopted was that schizophrenia is a ”disconnection syndrome”, as was suggested among others by Friston and Frith [31] and our aim was to qualitatively and quantitatively understand the functional bases of these disconnections.

Control loops in chemical, network and regional levels might be the neural bases of the interpreting iterative mechanisms. Specifically, the impairment of cognitive control of the prefrontal cortex on hippocampal processes implies uncertainties in the task to be solved and will result in poorer performance in learning and recall processes. While the breaking of the circle may lead to schizophrenic symptoms, combined pharmacological psychotherapeutic strategies should act to repair the circle. For the technical details [18, 26, 28, 27, 7]

5 Conclusion

The brain-mind-computer trichotomy is suggested to be treated by a unifying framework based on the hermeneutic approach. We argue that brain is a hermeneutic device, and hermeneutics is also necessary to understand situations and other's minds. Broken hermeneutic circle may lead to pathological behaviours, such as schzizophrenia.

What we see is that the mathematics of hermeneutics must somewhat different from what we use to describe the physical world. Frameworks of mathematical models of complex systems and of cognitive systems should be unified by elaborating algorithms of of neural and mental hermeneutics. But this will be a different story.

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