POLISH ACADEMY OF ARTS AND SCIENCES

COMMISSION FOR THE PHILOSOPHY OF SCIENCE

Information and Computing in Nature
Philosophical Perspectives

Book of abstracts

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POLISH ACADEMY OF ARTS AND SCIENCES

INFORMATION AND COMPUTING IN NATURE PHILOSOPHICAL PERSPECTIVES

The Commission for the Philosophy of Science at the Polish Academy of Arts and Sciences (Polska Akademia Umiejętności) invites presentation proposals for the Conference on the Philosophy of Computing and Information. The theme of the conference will be *Information and Computing in Nature: Philosophical Perspectives.*

Potential topics include, but are not limited to:

- Non-Turing computational paradigms
- Computing and information in natural systems (e.g., cellular automata, cellular computing, neural computation, evolutionary computation, swarm intelligence, immune systems, membrane computing, amorphous computing, morphological computing, cognitive computing)
- The ontology of information in natural systems
- The epistemology and ontology of computer simulations of natural systems
- Biosemiotic inspirations in artificial autonomous systems
- Information and computation in autopoietic systems
- Information and computation in physical systems
- Natural information storage systems
- Information and computing in cosmology

This conference is being organized to advance our understanding of computing and information in natural systems. It is generally recognized that nature computes and processes information, but we need to continually explore how computing and information discloses itself in natural systems. This conference intends to bring together scientists and philosophers and create a forum for discussing philosophy in science. This dialog will in turn create opportunities for finding new forms of inquiry for understanding information and computing within nature itself.

Proposals for presentations should be submitted for anonymous review to: NatureCom.2022[at]gmail.com. On a separate page, the author(s) should provide their full name(s), affiliation(s), and a short CV/resume (up to 150 words). Proposals should not exceed 300–400 words (including references), and presentations should be given in English.

Important dates:

Nov. 14st	-	Deadline for abstracts
Nov. 18th	-	The authors of accepted abstract will be notified.
Nov. 21st	-	Program finalized
Nov. 25th	-	Zoom contacts sent out
Dec. 1st	-	Conference online (ZOOM)

The online part of the conference will be organized using the ZOOM platform, and there are no fees for attending the conference.

The list of accepted abstracts will be published prior to the conference, and the authors of selected abstracts will be invited to submit full papers (up to 6000 words with references) that will be considered for publication in the *Philosophical Problems in Science* journal in 2023/24.

Any inquiries should be sent to Paweł Polak or Roman Krzanowski, at: NatureCom.2022[at]gmail.com

OPENING LECTURE:

Gordana Dodig-Crnkovic,

Mechanisms of Cognition and Intelligence in Nature: Models of Cognitive Information Processing Beyond theTuring Model of Computation

Chalmers University of Technology, and Mälardalen University

Among some philosophers of mind and other people, there is a belief that humans are intelligent beings above nature and that naturalistic approaches never can adequately model human intelligence and cognition, particularly human feelings and emotions. It is believed that "higher level" intellectual and creative capabilities separate humans from the rest of nature. Historically, the first attempts to model human intelligence considered human language and the ability of logical reasoning and symbol manipulation as a basis. That is where the development of cognitive science has its roots. The first attempts to model intelligence relied on symbol manipulation and the corresponding Turing Machine model of computation. It took some time to understand that the Turing Machine model will not suffice if we want to computationally model intelligence, not only human intelligence but even the intelligence of the simplest living organisms. It turned out not to be sufficient for modeling robotic cognition either. The process of connecting the symbol-manipulation (language generation) layer of information processing with the signals and data that cognitive systems use for their gathering of information about the world, and communication and movements in the world, requires sub-symbolic computation which precedes the symbolic one in the information processing hierarchy. Thus, adequate computational models require models of sub-symbolic computation, distributed, concurrent and asynchronous.

The increased knowledge in the variety of research fields in the intervening years between the beginnings of cognitive science and artificial intelligence in the 1950s, concurrent with the emergence of the electronic computing machinery, can help us make missing connections between fundamental processes of nature and its cognitive parts on the highest levels of complexity. The Turing machine model of computation is one important part of the picture of the computing nature manifest in cognitive systems, but it is relevant to high levels of cognitive architectures, symbol-processing, sequential, recursive, and with unlimited resources. On the more basic levels, other computational models are needed.

Studying the emergence of cognition and intelligence in humans in the light of the natural evolution of information processing, from basic physics, through chemistry and biology, to human-level and social cognition is possible if we acknowledge the role of computation in nature at different levels of organization, including non-symbolic.

In this talk, I will present some of the controversies of computational (information processing) models of cognition and intelligence in the broader context of new scientific results supporting naturalist modeling of cognition and mind as property of all living, in the framework of computing nature. Different models of computation will be presented in the taxonomy of computation and their connections to computing nature, cognition, and intelligence.

Ulrich Stegmann,

On Shea's teleosemantic account of genetic information

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The idea that genes contain information for protein synthesis and development has been endorsed by many biologists since the mid-20th century. If taken literally, it implies that nucleic acids have a remarkable set of properties, i.e. semantic properties, such as truthfully representing the course of development. Although many historians and philosophers of biology have argued that this idea is a metaphor and should not be taken literally, some have defended it by invoking a prominent class of naturalistic theories of mental content, i.e. teleosemantics. In a series of papers, Nicholas Shea (e.g. 2007, 2013) has developed the most sophisticated teleosemantic account of genetic information, maintaining that genes literally carry semantic information, which is read in development and contains detailed instructions for ontogenesis.
The purpose of this talk is to evaluate Shea's "infotel" theory. Even if we accept the theory as a naturalistic account of representational content in general, I will argue that it ends up attributing the wrong sort of content to genes, both indicative and imperative. Conversely, it does not attribute one kind of content that proponents of genetic information routinely ascribe to genes, i.e. information about protein synthesis. The theory therefore fails to establish that genes carry semantic information. The talk will also deal with existing objections, especially those raised by Godfrey-Smith (2011), Griffiths & Stotz (2013), and Planer (2016).

Godfrey-Smith, P. (2011) 'Senders, Receivers, and Genetic Information', *Biol. Philos.*, 26, 177–81

Griffiths, G. & Stotz, K. (2013) *Genetics and Philosophy: An Introduction*, Cambridge: Cambridge University Press.

Planer, R. J. (2016) 'Are Genetic Representations Read in Development?' *Brit. J. Phil. Sci.* 67, 997–1023

Shea, N. (2007) 'Representation in the Genome and in Other Inheritance Systems', *Biol. Philos.*, 22, 313–31

Shea, N. (2013) 'Inherited Representations Are Read in Development', *Brit. J. Phil. Sci.*, 64, 1–31

Kristina Šekrst,

Taming of the shroom: fungi, computation and mycophilosophy

University of Zagreb

The purpose of this paper is to highlight the road less taken in natural philosophical investigations: the study of the fungi, or "a neglected megascience" (Hawksworth, 2009)). I will examine how mycelium networks might be seen as neural network analogues, and compare such a concept with connectionism and computationalism in the philosophy of mind.
Fungal networks were studied as real communication networks, in which the fungus can use electrical signaling to send messages between different mycelial parts regarding food sources, injuries, local conditions or presence of other individuals around it (Olsson and Hansson, 1995). According to Sheldrake (2020), Olsson was hesitant to call such a network "a brain", but we could observe electrical impulse regulation as "brain-like circuits, gates and oscillators".
In some cases, "decision gates" could be seen as a "flexible and adaptable network", where in some fungi, hyphae are divided into compartments by sensitively-regulated pores: opening or closing a pore changes the signal strength. I will also observe such "fungal logical computation" cases from the aspect of logic and computationalism, and compare it with plant cases that have been seen as *distributive networks* and *information processing systems* (Bassel, 2018). I will use these computation-like structures to also observe fungi from the standpoint of computational complexity, taking into account Boddy's experiment of encouraging mycelium to work out the most efficient routes between the cities of Great Britain (Sheldrake, 2020).

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Olsson, Stefan & Hansson, B. S. (1995) Action potential–like activity found in fungal mycelia is sensitive to stimulation. *Naturwissenschaften* 82:30–31. https://doi.org/10.1007/BF01167867

Sheldrake, Merlin (2020) *Entangled Life: How Fungi make our worlds, change our minds, and shape our futures*. The Bodley Head, London.

Karl Javorszky,

Ordometric Counting

Institut fuer Angewandte Statistik, Wien

We present a new technique of counting, which is a marked improvement and update to the current counting system, which we have inherited from the Sumerians. We use an etalon collection of simple logical symbols (pairs of natural numbers *a,b; a,b* ≤ *16, a* ≤*b*). These elements are *individuals.* The Sumerian concept treats logical elements, members of **N,** as possessing logical attributes *value, position,* that are a definition for each other, with no individuality of neither without the other. By splitting the *value, position* attributes of our elementary symbols we observe the *position* ranges connected with each individual unit, as the collection undergoes *periodic changes.* We establish a planar position for each element on a plane of which the axes are two sorting orders. The elements have different places among their peers under diverse order contexts.
During reorders, elements aggregate into *cycles.* Doing the reordering exercise in a systematic fashion, we find *10* such planes, of which *two Descartes-type spaces* can be constructed, which are transcended by *2* planes. The web woven by cycles is a web of places as such. Into this relatively stable web we place the transient elements. The procedure rules of transit (which elements, when, where) are an implication of numeric properties of the two natural numbers that make up each element *(a,b).*
The cycles being a *sequenced* collection of members that share a common *commutative* symbol, we find the logical syntax Nature uses when reading the DNA to be a fundamental property of periodic changes that reorder the etalon collection of alternatives of a whole to consist of two parts.
Information is rooted into the properties of natural numbers as their basic properties give rise to numeric extents of deviations ⊿ *(expected, observed).* The unit of discongruence is seen as an accounting entry and to be additive in a system that uses *predictability* as its core driving principle. Periodic changes being predictable, information is linked to the *certainty* that ⊿ *(expected, observed)* remains within a range of tolerance. Information can be compressed and expanded.
The basic crack in the Sumerian system is found in the way human neurology perceives, and therefore counts, contents of the *foreground vs. background.* There is a slight numeric discongruence within the numbering system. The resulting *Bazar* of translations from and into {*number of objects, number of similarity-related statements, number of diversity-related statements*} pictures very well constants and processes we recognize in Nature.

Andrzej Bielecki, Michael Schmittel,

Structural information and application to chemistry and biology

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Information, together with matter and energy, is contemporarily regarded as a fundamental component of the existing world. A theoretical framework for defining and analysing information encoded in the structure of a multicomponent ensemble is proposed [2]. It is a far-reaching extension of the context in which the problem of coding information with the use of physical structures is normally considered. It should be emphasized that the existence of this type of information results only from the fact that a given structure has such and no other form.
The proposed approach is based on the Hellerman proposal [3] that is dedicated to the analysis of the level of organization in structures as such, first of all, biological ones. Therefore, this proposal seems to be a proper starting point for working out the adequate biological information theory. The fact that information in organisms is encoded by biological structures [1] is the most important reason for the adequacy of Hellerman approach. In the current state of development of the presented theory, the simplest possible level should be used to test the efficiency of the proposed approach. The supramolecular cybernetics, including molecular machines controlled by molecular switches is the most appropriate level for testing the theory at its current level of development. On the one hand, there are a lot of examples of molecular machines that are relatively simple structures, at least in comparison with most biological structures. Such machines are suitable for testing the proposed theory at its current, initial stage. On the other hand, dynamic biological structures are molecular machines—the ribosome can be put as an example. The introduced formalization was applied to calculate amount of information contained in the molecular machines.
The presented approach is the realization of the first stage of the research program consists in introduction of formal definitions of the proposed terms and studying their properties and relations between them. This is related to creating the formalization which describes biological phenomena properly. It should be stressed that lack of such formalization was emphasized in [4].

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Łukasz Mścisławski,

Is Copehagen-like AI paradigm satisfactory?

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Today's information processing technologies are penetrating more and more deeply into almost all aspects of human functioning. Information processing methods based on natural computing are becoming more widely used. The most well-known example is the various applications of neural networks. In this context, quite a few questions arise at the meta-level. Within the framework of this paper, two particular areas will be presented that can, and indeed are, of particular interest to humanists. The first group of issues can be described as ethical, and includes issues of accountability and control of AI-based systems ([1], [2]). Interestingly, this group of issues unexpectedly merges with another group of issues that are more epistemological and methodological in nature. This group of issues concerns problems such as reconstructability, replicability or transparency of the results produced by the aforementioned data processing systems ([3], [4]). It is interesting to note that both groups of issues seem to be united by a very similar set of common issues, arising at the intersection of philosophy of science, philosophy of information and philosophy in technology. This set begs the question of how adequate (or not), it is to treat information processing systems based on neural networks as a kind of black box, which is basically only expected to deliver results that are simply to be acknowledged, without being too dissected. If this were the case, a strong association with the Copenhagen interpretation of quantum mechanics, or even a stronger parody of it, attributed to Feynman, comes to mind here. Perhaps some antidote to this kind of situation will be the insights provided by various philosophical disciplines.

Keywords: AI, philosophy, technology, paradigm

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Timothy Tambassi,

Perspectivism on Information System Ontologies

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The impact of digital technology on philosophical research (also) involves the emergence of new philosophical trends. Among them, perspectivism in information systems ontologies [PISO] has however received little attention from philosophy of science [PPS]. Moreover, its main formulation is from philosophers and ontologists who pays, in turn, little attention to the literature on PPS. Considering, for these reasons, PISO and PPS as independent of each other would not imply that:

[1] PISO and PPS cannot be (somehow) related to each other,
[2] PPS may not exert any influence on PISO,
[3] they cannot share any theses and/or claims,
[4] the debate on PISO cannot be regarded as being (a proper) part of the debate on PPS.

However, such an independence could also justify the chance of analyzing PISO without taking PPS into account (and *vice versa*), which is one of the reasons why this talk focuses (exclusively) on PISO. The other reason is that the (growing) diffusion of PISO within ISOs' debate does not correspond to a thorough analysis of what PISO specifically consists of. To fill this void, this talk aims to show that PISO explicitly deals with knowledge representations, maintaining that

T1. there are different ways to represent a domain (of interest),

T2. there can be multiple, equally valid and overlapping perspectives on a domain.

T3. a perspective is an act of cognitively partitioning a domain, an act that draws a mental division between those entities upon which we are focusing on and those which fall outside our (domain of) interest.

Then, we analyze the implications of those claims, by:

- concluding that the same definitions of information system ontology [ISO] – that is, PISO's area of concern implicitly assume PISO's (minimal) claims – or, in other words, that ISOs presuppose and maintain PISO;
- outlining how PISO affects information and computation in natural system.

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Roman Krzanowski, Paweł Polak,

The Concepts of Information and Computing in Swarms

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Swarms are self-organizing biological systems that exhibit complex, seemingly intelligent behavior despite them comprising simple elementary units. (Note that we limit this discussion to organisms such as bacteria, crustaceans, insects, fish, and birds.) At the foundations of complex swarm behavior lies the acquisition, communication, and processing of information, or in other words, computing [1][2][3][6][7]. Without information and its processing, no self-organizing biological system could exhibit such complex behavior [7][8]. We therefore ask this: What is the nature of information and its processing in swarms?

We do not learn much about information and its processing in natural swarms from computer models. In computational studies, information in swarms usually takes the form of mathematical abstractions with cursory references to more fundamental concepts like the information entropy of Shannon [6] (through a formal similarity to Boltzmann's entropy). It may also be equated with knowledge, stimuli, or signals—whether they are behavioral, physical, or chemical in nature [1]—as the means for organizing a swarm system [6:90], or it may simply be left undefined [2]. Some authors (e.g., Bouffanais [6]) conceptualize information in swarms as a state variable of an agent, changes in a state variable, or some other derived quantity from a state variable [6:96], or it may be perceived as a dynamic statistical quantity that is derived from a set of state variables [6:96]. Information in computational studies of swarms may also be classified according to its functional role, and Cruz and others [1][3][4] have identified three basic functions of information in swarms: public (freely available in the environment), private (individual knowledge), and social (social interactions). The role and mode of public, private, and social information differs between species, so in computer simulations, swarm information is mentioned but never precisely defined.

Observations of natural swarms reveal that swarms and their individual units operate (process information) on real, physical magnitudes, and information processed by these swarms is analog in nature (see e.g., [9][10][11][12][13][14]). Swarms do not seem to symbolize information that carries a stimulus or signal, and they certainly do not convert perceived physical or chemical phenomena into binary symbols for communication as information. An acquired or produced stimulus or signal is a modulated physical or chemical phenomena that is swarm-specific, so it has no meaning beyond a specific group of organisms. A stimulus or signal carrying information may also relate to the state of the swarm or the swarm units themselves. Consequently, the swarm itself and its individual units are carriers and processors of information simultaneously. Furthermore, information in swarms is transitory and temporary, because it not stored bur rather destroyed or allowed to dissipate, although some swarms learn from past experiences. Thus, information and its processing (i.e., computation) in natural swarms differs substantially from information and its processing in our current computing paradigm, which is based on processing symbolic binary information and dividing computing systems into software, data, and hardware elements. Furthermore, natural swarm systems, as computational systems, do not suffer from combinatorial explosion in the way that computer algorithms tend to. Indeed, depending on the species, swarms can scale up from a few dozen to billions of units (e.g., [15][16][17]), and they do not face non-computability barriers like the Halting Problem (a decision problem in computability theory for Turing Machines). Thus, the form of information and its processing, combined with the lack of computational problem characteristics for TM systems, suggest that natural swarms employ a different computation paradigm to that of current computing systems.

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Emanuel Diamant,

Data-driven Bioinformatics is a popular but wrong and misleading attempt to assess the information-handling abilities of natural biological systems

Independent researcher

Data-driven Bioinformatics is a popular but wrong and misleading attempt to assess the information-handling abilities of natural biological systems.

Bioinformatics is the name given to these mathematical and computing approaches used to provide the understanding of biological processes and the tremendous accompanying amounts of data, related to biological experiments. That is, the main goal of Bioinformatics is to manage and mine biological data for knowledge and information.

Despite continuous reports about successful bioinformatic achievements, real success is modest and timid. The reason for this uncertainty is – nobody knows what is information (that the bioinformatic processing of the biological data is supposed to unveil).

The founding fathers of Information theory (Shannon, Fisher, Renyi, Kolmogorov, Chaitin) have not defined "What is Information". They were busy with providing the measure for the amount of information rather than tools for analyzing information type, and that was enough to meet the requirements of a data communication channel. But recent advances in almost all sciences put an urgent demand for meaningful information inclusion into the body of a communicated message.

To meet this demand, I have proposed a new definition of information. Here is a short list of the definition and its consequential alterations:

- Information is a linguistic description of structures observable in a given data set.
- Structures in a given data set are usually of two kinds – primary and secondary data structures.
- Primary data structures are agglomerations of adjacent data elements with similar physical properties. Therefore, primary data structures could be called physical data structures.
- Secondary data structures are agglomerations of adjacent primary (physical) data structures.
- Secondary structures reflect the observer's view on the grouping of primary data structures, and therefore they could be called meaningful or semantic data structures.
- As was said, the Description of structures observable in a data set should be called "Information". In this regard, two types of information must be distinguished – Physical Information and Semantic Information.
- While the formation of primary (physical) data structures are guided by objective (natural, physical) properties of the data, the subsequent formation of secondary data structures is a subjective process guided by the observer's habits, customs, and agreements.
- Information processing in any natural or artificial intelligence system is fulfilled as semantic information processing. That is - Information processing always presumes Semantic information processing.

- Semantic information processing is a subjective procedure. For its successful accomplishment, a prototyping structure of an expected result must be preserved in the information processing system memory.
- Semantic information processing is accomplished at multiple levels of processing with the growing complexity of resulting information description on each subsequent higher level. Each level therefore must be equipped with its own prototyping (self-referencing) memory.
- Machine Learning and Artificial Intelligence tools are used only for data processing, therefore only physical information can be unveiled, and that is not enough for information handling.

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Luke Kersten,

Mechanistic Computation and its Problems: An Abstract Solution

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The mechanistic account of computation (MAC) says that computational implementation (the question of how to specify under what conditions a physical system can be said to compute) is best explicated within a mechanistic framework (Piccinini 2007, 2015; Fresco 2014; Milkowski 2013; Dewhurst 2018). For this view, computational explanation is a species of mechanistic explanation, and computational mechanisms are a special type of functional mechanism. A physical system implements a computation only if it processes medium-independent vehicles in virtue of being a functional mechanism. Computing systems are said to be a type of concrete computing mechanism. MAC represents one important answer to the implementation question.

Recently, a number of problems have been raised for MAC. One is that it appears conceptually confused to claim that physical entities manipulate or causally interact with abstract or medium-independent entities, given that abstract means non-concrete or non-spatiotemporal, what has been called the "abstraction problem" (Hutto et al. 2019). Another is that if the generality of a phenomenon is determined by its vertical position within a mechanistic hierarchy as MAC proposes, then it is unclear how computational and implementational descriptions can be said to fit together, as they cannot do so solely in virtue of relying on part-whole relations, what has been labelled the "generality problem" (Kersten 2020). Finally, if MAC is unable to determine the generality of computational descriptions, then there is no way of matching the two or tracking the computational properties back to their implementational counterparts, what has been labelled the "hierarchy problem" (Elber-Dorozko and Shagrir 2018).

The aim of this paper is to weigh in on each of the three problems. I argue that each can be resolved by attending to an important but overlooked distinction between "abstraction" and "idealisation" within computational explanations. Roughly put, 'idealisation' involves the modification of features of a target system, while 'abstraction' involves the omission of features. Failure to systematically mark this distinction, I argue, has led to a number of ambiguities within expressions of MAC, particularly an overemphasis on talk of 'levels'. The idealisation/abstraction distinction stands to not only help resolve each of the three outstanding problems facing MAC, but also help elucidate the nature of computational implementation more generally. I conclude by comparing the current proposal to a recent one from Kuokkanen (2022).

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David Thorstad,

Against the singularity hypothesis

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The singularity hypothesis is a radical hypothesis about the future of information-processing systems. The singularity hypothesis begins with the supposition that artificial agents will soon acquire the ability to improve their own intelligence. The result, it is held, will be an intelligence explosion in which artificial agents rapidly improve their intelligence and information-processing capacities until they become orders of magnitude more intelligent than the average human.
Despite the ambitiousness of its assumptions, the singularity hypothesis has been defended by leading philosophers (Bostrom 2014, Chalmers 2010) and artificial intelligence researchers (Solomonoff 1985, Russell 2019). In this paper, I argue that the singularity hypothesis rests on implausible assumptions about the growth rate of future artificial systems. In particular, I raise five challenges for the singularity hypothesis' ambitious growth claims: (1) extraordinary growth claims require a correspondingly extraordinary amount of evidence; (2) growth in artificial intelligence should slow due to diminishing research productivity, and (3) bottlenecks in the pace of improvement. (4) Growth in artificial agents will eventually slow due to physical resource constraints, and (5) rapid improvement in hardware capacities need not imply a correspondingly fast improvement in intelligence.
I show how leading philosophical defenses of the singularity hypothesis due to David Chalmers (2010) and Nick Bostrom (2014) fail to overcome the case for skepticism. I conclude by drawing philosophical implications for our understanding of consciousness, digital minds, moral longtermism and existential risk.

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Wiktor Rorot,

Counting on the Cilia: Morphological Computation and Morphogenesis

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Morphological computation is "computation obtained through interactions of physical form" (Paul 2006, 619). While there is some controversy about which processes constitute examples of morphological computation, this general definition is quite unproblematic. Müller and Hoffmann (2017) identify three distinct types of processes which are (in their view, incorrectly) subsumed under the notion of morphological computation: (1) morphology facilitating control, (2) morphology facilitating perception, and (3) morphological computation proper. This distinction results from constraining the definition of physical computation into one which requires the operation of encoding, decoding, and a user who treats the physical systems in question *as a computer* (Müller and Hoffmann 2017).

The purpose of the talk is to explore consequences of the mechanistic view on morphological computation. The case study will be the processes of bioelectrical communication which have been indicated both as the evolutionary origins of neural activity (Prindle et al. 2015), and as the principle tying together the activity of multicellular biological systems (Levin 2019, 2021). I will argue that the example provided by the role of bioelectric communication in morphogenesis (i.e., the development and maintenance of complex patterns in biological systems) provides an example of morphological information processing, morphological control and morphological computation proper, and as such can be taken to support the broad "computational enactivism" project and underscore the role that morphological computation may play in this framework.

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Nir Fresco,

Miscomputation and Computational Indeterminacy

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Miscomputation, much like misrepresentation, and misinformation, is a sort of malfunction—broadly construed. It is a deviation from a norm that is set for artificially designed physical systems (e.g., laptops, or autonomous cars), but, arguably, also for species and organisms. Miscomputation, to a first approximation, is the phenomenon by which a system computes a different function *g*, rather than computing the mathematical function, *f*, which is the norm. Not every case of computational malfunction is a miscomputation. When a desktop computer is out of electricity, say, due to a faulty design (Fresco & Primiero, 2013) it does not miscompute, because it does not compute (Tucker, 2018). Surprisingly, given the importance of explaining miscomputation as part of a complete account of physical computation, there are only a few works that deal with this phenomenon explicitly. These include Fresco and Primiero (2013), Dewhurst (2014), Piccinini (2015), Petricek (2017), Tucker (2018), Primiero (2020), and Colombo (2021). This paper will briefly focus on the relation between miscomputation and the indeterminacy of computation. The indeterminacy of computation is the phenomenon in which physical systems implement multiple mathematical functions simultaneously (Curtis-Trudel, 2022; Dewhurst, 2018; Fresco et al., 2021; Papayannopoulos et al., 2022). Accounts of computation are challenged to provide an account that explains how to single out (or not) the function that the system computes when it computes multiple functions simultaneously.

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Mariusz Stanowski,

Binary Model of Universe

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I would like to present the "Binary Model of Universe", which is described in my book: "Theory and Practice of Contrast: Integrating Science, Art and Philosophy" (Chapter 20). It is an alternative model to physical models of the universe such as the Big Bang, String Theory or Multiverse. Closer to it are concepts related to information processing, such as the universe as a computer or computer simulation.

What distinguishes the Binary Model is that it combines mental issues (their deep analysis) and physical issues and considers them to a similar degree, while existing physical models are based unilaterally on the physical realm of reality, external to the mind. The second distinguishing feature is its simplicity. Not only is it a simpler model than existing ones, but it is also the simplest theoretically possible one, which contains all the information necessary for understanding it, including consideration of every level of complexity of the universe.

It was created about 40 years ago as a by-product of aesthetic inquiry, while trying to solve the mystery of beauty. When I found a solution and considered it satisfactory, I looked for a concise and general form to demonstrate it. I decided to test the binary model, that is, the simplest one possible. Although it seemed unlikely, it turned out that binary structures can be evaluated aesthetically, just like sounds or visual structures, and it involves counting their features (information). These features-information in a binary structure are all distinguishable regularities that is distinguishable arrangements of zeros and ones. When comparing different structures with the same number of zeros and ones, those of them that contain more regularities/information are also more aesthetically appealing (for details, see Binary Model of Visual Interactions, page 16). From this model directly follows the general (abstract) definition of complexity, which defines the complexity of a binary structure as the number of information squared, divided by the number of zeros and ones (for details, see Abstract Complexity Definition, page 22). This is a new general definition of complexity, which is the only one among the existing ones that meets the intuitive criterion saying that "the complexity of an object is greater the more elements it has and the more connections there are between them."

At that time I did not yet know that binary structures can simulate any objects and processes of reality. This information I acquired later, after studying Bertalanffy's "General System Theory." and the so-called Digital Physics. However, I supposed that since the visual world (its interactions) can be modeled binary then perhaps all other structures of reality can be modeled as well, given that binary structures belong to both the physical realm (they can be visually evaluated) and the mental, abstract world. The binary structures used for simulation are binary waves (digital signals) with the appropriate energy and complexity. Since they simulate material objects and have energy, the question arises whether similar waves (but with much higher energy) could not be identified with material objects? Here de Broglie's theory comes with help, which says that all objects of reality are also waves. Thus, we have strong scientific arguments for the fact that reality is formed by binary structures of varying complexity: 1. the binary model of visual interactions and the possibility of binary simulation of all objects and processes of reality, 2. the Abstract Definition of Complexity and 3. de Broglie's theory. . On the basis of these we can also look for experimental confirmation. The experiment would consist in emitting laser impulse structures of appropriate frequency and complexity and subjecting them to observation (details are on page 185). Such confirmation would have far-reaching implications, including the possibility of designing and creating material objects using appropriate algorithms and structures of electromagnetic pulses.

Further considerations concern the genesis and mode of existence of binary structures. They show that the universe is an infinite and ever-increasing binary number formed by the fundamental (smallest) quanta of energy and the gaps between them (zeros). In this infinite binary structure are present all possible combinations of zeros and ones (and therefore all possible complexities) representing all objects of reality, including us. As the number grows, it still reorganizes itself and changes its complexity.

This hypothesis is based on the observation that each binary number with a certain number of zeros and ones (e.g., n = 8), at the very beginning (the smallest number) has a „single one” and then only „zeros” (e.g. 10000000), when growing exhausts all combinations of zeros and ones (e.g. 10000011) until it reaches the largest number consisting of only ones (11111111). The next numbers will already have one digit more (n = 9). Thus, we can see that during growth, the binary number is constantly reorganizing, and such reorganization - growth and disappearance of complexity is also observed in reality.

As for the genesis of the existence of zero and one, that is, the existence of something and nothing, the answer is astonishingly simple: there must be both because we would not be able to distinguish either of them separately. In general (which is easy to agree with), our reality is so constructed that we cannot isolate anything without juxtaposing it with something else. This is the basic principle (of contrast) on which our reality is based. It is also our (objective) limitation beyond which neither now nor in the future we will be able to mentally transcend. The realization of this limitation closes further possibilities of explanation and should be regarded as the solution to the riddle of being. It is also the answer to Leibniz's famous question: "is there something rather than nothing?". Only another question remains: is this limitation absolute or does it apply only to us? The necessity of the existence of both zero and one is also the possibility of the existence of the universe as their structure. The above model because it is theoretically the simplest possible, also sets the limits of our understanding of the universe. Further search for reasons (even simpler and more basic) for the existence of the universe makes no sense, because nothing simpler (in our reality) exists.

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Marcin Rządeczka,

A computational perspective on complex mental disorders. Are mental disorders just suboptimal algorithms?

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The main aim of Research Domain Criteria (RDoC) is to deepen the understanding of psychopathology through pathophysiology by building upon the advances in the computational neurobiological sciences. The RDoC hypothesizes that behaviours cannot be understood without taking into account the variety of individual developmental trajectories and environmental influences upon behaviour. Within this paradigm, each mental disorder is a dimensional construct from illness to health, without a specific well-defined demarcation line.

The Research Domain Criteria can serve as a basis for the nascent field of computational psychiatry. In theory, neural processes can be modelled by algorithmic representations that describe information processing in the complex multi-level neural system. Computational psychiatry describes the structures and mechanisms of the nervous system in terms of information processing. For example, impairments in the processes involved in predictive coding could, in theory, explain a variety of psychopathological phenomena, ranging from the impoverished theory of mind in autism spectrum disorder to peculiar abnormalities of smooth-pursuit eye movements in schizophrenia spectrum disorder.

Integrating computational modelling into psychiatry can facilitate research in several fundamental and novel ways. What are the fundamental biopsychological components involved in mental disorders and what are the mathematical relationships between these components? How do local dysfunctions of the endocrine or immune system create complex interactions with the nervous system and finally lead to some mental illness? Why natural selection has not eliminated many gene variants responsible for some of the most debilitating mental disorders, such as schizophrenia, autism, bipolar disorder or depression. These are only preliminary questions that require the computational paradigm due to their sheer complexity and the interdisciplinary nature of the research involved.

Last but not least, computational psychiatry creates an interesting opportunity for an epistemologist to revaluate computational theories of mind, which have been discarded due to the neurobiological turn. From such a research perspective mental disorders can be analysed as suboptimal algorithms running by the computational mind and resulting in dysfunctional behaviour.

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Louis H Kauffman,

Replication and Self-Reference in Formal Systems and in Biology

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This talk considers the structure of replication and reference in systems and in biology.
There are striking similarities between abstract constructions for fixed points (as in lambda calculus) and self-reference in relation to replication that occurs in biological systems. To illustrate this point, consider the formal structure of DNA replication. We write DNA = <W | C> to indicate the structure of a DNA molecule as the molecular binding of the Watson strand W and the Crick strand C. Each strand is a string of bases and they are paired by bonds to form the double helix <W|C>. In this description we, at first, ignore the geometry and the topology of the DNA. Reproduction of the DNA occurs when the binding between W and C is broken so that (locally) two bare strands of W and C are exposed to the cellular environment. This can be symbolized by <W|C> —> <W| E |C> where E denotes the environment. Interaction with the environment provides the extra base pairs needed to match a Crick strand to the bare Watson and to provide a new Watson strand to the bare Crick. The result is then <W|C> <W|C> where the inner C and W are the new strands. Thus we have the following formal description of DNA replication:
DNA = <W|C> —> <W| E |C> —> <W|C> <W|C> = DNA DNA.
What is of great interest here is that this form of replication actually does occur in Nature (helped by geometry, topology and biology) and it can be compared with notions of self-replication discovered by mathematicians and logicians. For example, the von Neumann building machine B (due to John von Neumann) takes a blueprint x for an object X and builds that object from its blueprint. We write B,x —> X,x to show the production of X from the machine B and the blueprint of code x. Since von Neumann's machine is a Universal Builder, we can give it a blueprint b for itself. Then we have B,b —> B, b and B produces a copy of itself and can continue to do so.
With these two examples before us, we can make a number of comparisons. In the DNA each of the strands W and C is the blueprint or code for the production of the other strand.
W + Environmnt produces W + C.
C + Environment produces C + W.
This is the key to the DNA replication and it is a special blueprint coding. There was no need for a universal machine. But we do have a machine that can be divided into two parts, each the code for the construction of the other part! The von Neumann machine is more general than the specific method of DNA reproduction, but it is fundamentally related to it. In both cases there is an interaction with an environment. In the case of DNA the environment is very special to the ambient vitality of the cell. In the von Neumann machine we can imagine many forms of environment that are appropriate. There are many points to expand upon in this comparison of DNA replication and logical replication. We will discuss a number of these avenues and we will discuss autopoetic models where the self-referential structure arises as a fixed point of molecular operations and where the replication arises as a consequence of rules of interaction and description. This is part of a larger project to understand the nature of autonomy in mind, mathematics, systems and biolog

Andrew Richmond,

Computational Externalism

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Computational Externalism

I argue that the brain does not have its computational structure intrinsically, but only in conjunction with the world outside of it. I understand this claim in one of its more extreme forms: it is not just that the brain's computational structure is *labelled* differently depending on its environment, e.g., because of what it represents or how it evolved, as many externalists argue (e.g., Egan 1999, Fodor 1981, Rescorla 2013, Sprevak 2010, Stich 2010). Instead, I argue that the brain's *causal structure*, insofar as computational explanations aim to capture it, is not something the brain posesses intrinsically. I support this with a case study concerning the evolution of from dichromacy to trichromacy (Mancuso et al 2009, Mollon 1984, Jacobs et al 2007), which involved minimal changes to the retina, and apparently no changes to post-retinal circuitry. Trichromacy and dichromacy require different computational structures, and the case study shows that the computational difference between a dichromat and her trichromat descendant cannot be fully explained by differences between the two organisms' internal structure. Rather, part of the explanation involves 'promoting' parts of the trichromat organism's *causal* structure to count as part of its *computational* structure, and which parts of its causal structure count as part of its computational structure depends on things external to it: particularly, its interactions with its environment, and the kind of patterns in its behavior we want to explain. I go on to connect this form of externalism to current debates within cognitive science.

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CLOSING LECTURE:

Mark Burgin, Rao Mikkilineni,

Information in the physical world:

A New Perspective from the General Theory of Information

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While volumes have been written on 'information', the following excerpts demonstrate that the majority of researchers do not know the coherent theory or an explanation that unifies various manifestations of information. For instance, Wang (Wang 2022) asks "What is information, then? This is still a problem for the philosophy of information. In this paper, I will recognize and define information from a new special perspective where information is understood or defined as the form of interaction between different layers of the material system. Moreover, I will demonstrate this idea in the following aspects based on the modern complexity system theory." Famously, Norbert Wiener (Wiener 2019) said, "Information is information, not matter or energy. No materialism which does not admit this can survive at the present day." This shows that information is something very special but does not even hint at what information is. Recently there were many publications in which it is claimed that information is a physical essence. One of the main claims in this direction is the mass-energy–information equivalence principle of Landauer. That is why it is so important to elucidate the true nature of information and its relation to the physical world eliminating the existing misconceptions in information studies. The mass-energy–information equivalence principle is postulated and used by some (Gasparini 2019; Vopson 2019) to claim that information is physical, has mass, and is the fifth state of matter. "For over 60 years, we have been trying unsuccessfully to detect, isolate or understand the mysterious dark matter," said Vopson. "If information indeed has mass," he continued, "a digital informational universe would contain a lot of it, and perhaps this missing dark matter could be information" (Vopson 2019). This is the statement of Vopson who claims that information is transformed into mass or energy depending on its physical state. In addition, the existence of the intrinsic information underpinning the fundamental characteristics of elementary particles in the universe implies that stable, non-zero rest mass elementary particles store fixed and quantifiable information about themselves (Gasparini 2019; Vopson 2019; Landauer 1991;

Landauer 1996; Landauer 1999; Landauer 2002; Hong et al., 2016). These so-called information conjectures also seem to imply that the information is a form of matter, which is called the fifth state of matter or the fifth element by Vopson. In this presentation, we use the general theory of information (Burgin 2010, 2016, 2012; Burgin, Mikkilineni 2022) to provide a comprehensive explanation of what information is, whether it is physical, and does it have mass. The general theory of information tells us that information is related to knowledge, as energy is related to the matter. Energy and matter belong to the material world and information and knowledge belong to the world of structures. Information is the bridge between the material and mental worlds which is represented in both worlds. The world of ideal structures provides the medium and the bridge between these representations.

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