Minimal Information Structural Realism

Roman Krzanowski
Pontifical University of John Paul II in Krakow

Abstract

This paper presents Minimal Information Structural Realism (MISR), that claims that information (signified by I) is an ontologically and epistemologically objective entity (signified by R) and is apprehended as, but not identical to structures perceived in nature (signified by S). Two informal arguments are presented in support of this claim. One argument is based on the conclusions from models of quantum mechanics (QM) and cosmology, while the other argument is referred to as incompleteness of epistemic definitions of information. MISR is not associated directly with the structural realism (SR) of the ontic or epistemic kinds, and is only remotely related to the concept of information structural realism (ISR) defined by Floridi.

Keywords

information; information ontology; structure; structural realism; information structural realism

1. Introduction

This paper presents Minimal Information Structural Realism (MISR). MISR claims that information (signified by I) is an ontologically and epistemologically objective physical[1] entity[2] (signified by R) and is perceived as a structure[3] (or form)[4] of na-

[1] "Physical" as understood, e.g., in *Vocabulaire technique at critique de la philosophie*, A. Lalande, Press Universitaires de France, 1956 – "belonging to the world of perceptual phenomena and may be the subject of experimental research" – (fr. *artenant au monde phenomenal, qui peut etre objet de connaissance experientielle*) (p.780).

[2] These claims are about the mode of existence (apart from the type of knowledge). Epistemic (or having to do with knowledge) objectivity means that the object of knowledge is/exists independently of the mind. Ontological (ontology or having to do with existence) objectivity means that the object is/exists as observer independent. Epistemic and ontological objectivity in the case of information means that information is not dependent on the existence of the mind. The statements like 'this is a beautiful painting' are epistemicaly subjective. Tectonic plates exist in this sense objectively. The examples are from Searle lecture (2005). See lecture at Google Academy by John Searle (2015) for the detailed explanation.

[3] 'Structure' is notoriously difficult to define. One way tackle this is to understand structure as "Configuration of parts forming some whole" after *Vocabulaire technique at critique de la philosophie*, A. Lalande, Press Universitaires de France, 1956 (p. 1031). However, this is a very general definition and does not reflect the multifarious role the term 'structure' plays in the philosophy of science. Please refer also to ft 9.

[4] In some SR papers the term 'form' is used exchangeable with 'structure'. For example Worrall writes: "There was continuity or accumulation in the shift, but the continuity is of form or structure..." (Worrall, 1989, p. 117). Such examples may be found in other papers on structural realism.

ture[5] (signified by S). The term minimal (M) is added to ISR, meaning that no other claims, epistemic, ontic, or others, are associated with MISR. MISR may be seen as a version of Structural Realism (SR). However, MISR goes beyond structures conceived in SR[6] and postulates that behind them lies information. MISR is not a claim about pancomputationalism though, along the views of, for example, Fredkin (1991), Lloyd (2007), or Muller (2008). The paper is not a comparison of MISR with SR but rather an explication of MISR and SR is providing solely the context for the discussion.

The paper is organized as follows. First, the basic claims of SR are reviewed. Second, the concept of information is discussed. Finally, the basic assumptions of MISR are explicated. Finally, the conclusion collects the claims formulated in the paper and suggests some areas for further work.

Structural Realisms (SR)

SR, as explicated in the works of Psillos (2004), Brading and Laundry (2006), Frigg and Votis (2010), Ladyman (2016), and

[5] "Nature" as understood, e.g., in *The Oxford Companion to Philosophy*. T. Honderich. OUP, 1995: "…everything that there is in the physical world of experience, very broadly constructed. The universe and its contents, in short" (p. 607).

[6] This concept of structure obviously assumes that it is a representational or abstract (or abstracted) structure.

many others[7], claims that nature is structural (roughly speaking because structure is what seems to be invariant in scientific models of nature; it is what survives theory changes). The two main currents in SR are ontic and epistemic. Ontic Structural Realism (OSR), as defined by Ladyman (1998) and French (1998), embodies the view that structure is the ultimate reality and ontologically basic. In the strong version of OSR structures are "all the way down" (Frigg and Vostis, 2010). Epistemic Structural Realism (ESR), defined by Worrall (1989), claims that structures are all that we can and may know about nature. There can be more to nature than structures but ESR does not say what this "more" could be. The differences between ESR and OSR go much deeper but they are omitted here as having no importance for this discussion. Another version of SR that is interesting from the perspective of MISR is Information Structural Realism (ISR).

ISR has been defined by Floridi (2004, 2010). It does not change basic SR_S claims, rather it admits that nature is structural, but structures are informational objects or information structures. Information structures supervene upon data (or data structures). Data structures, in order to be information structures, must have meaning, which in turn depends on the presence of the scient agent[8]. Elementary data structures form "in-

---

[7] SR and related ideas extend well into last century and traces of it can be found in much earlier works (for example, see Ladyman, 2016).

[8] Dependence of informational structures on the mind gives to Floridi's ISR a Berkeleyan touch, so it seems.

fons" or "elementary information particles" (Floridi, 2010). At the core of ISR is the General Definition of Information (GDI) which describes the foundational assumptions behind data, infons, and information structures (a more detailed description of data and infons is given in the following sections). ISR, because of its epistemic claims, can be seen as a variant of ESR[9].

2. Information

Most of the definitions of information relate it to knowledge, belief, or a communication process (for example, see Burgin, 2003; Capurro, 2009, Floridi, 2010, or Nafria, 2010). This makes information epistemically and ontologically subjective; information exists if someone recognizes it as such, it exists specifically in and for the mind of the receiver or an originator, or it exists when communicated (such as created, sent, and received). Epistemologically and ontologically subjective information is the one specified by General Definition of Information (GDI) elaborated by Floridi (2010) or information defined by Bar-Hiller and Carnap (1953), Brooks (1980), Loose (1998), Sveiby (1998),

[9] The problem for SR is that the definition of structure and its ontological meaning are open; SR structure is often left unspecified (Vostis, 2010; Floridi, 2004), or assumed to be logical, physical, or mathematical in nature, or claimed that it is an information object of the sort defined in the OOP paradigm (Floridi, 2005), but there is no single version of a structure accepted in SR.

Dretske (1999), Casagrande (1999), Burgin (2003), and Lenski (2010), to list just a few examples. Shannon's concept of information as being a measure of the probably density function (PDF) over some probability space (Shannon, 1948; Shannon and Weaver, 1964; Pierce, 1968), may have subjective or objective properties depending on how probability is defined (Gilles, 2000). If we accept Shannon's information[10] for what it is (a moment of (PDF)), we may think of it as some measure of patterns, which may be natural or man-made. However, how Shannon's concept is related to other definitions of information is disputable (see, for example, the discussion of Shannon's information by Shannon Weaver, 1964; Pierce, 1968; Cherry, 1978; Casagrande, 1999; Hidalgo, 2015; Krzanowski, 2016; and Schroeder, 2017)[11].

In recent decades, the perception of information as a ontological[12] element of nature, has become quite widespread in

[10] To be precise Shannon never explicitly defined information. However, his concept of measure of information was later interpreted (correctly) as the definition of it, so there is not much inaccuracy in saying 'Shannon's information' as most of those working in the field understand this term for what it is – a mental shortcut.
[11] For example, Hidalgo writes: "…the interpretation of entropy and information that emerged from Shannon's work was hard to reconcile both with the traditional use of the word information and with the interpretation that emerged from Boltzmann's work" (Hidalgo, 2105, p. 15).
[12] 'ontological' means here pertaining to ontology or 'things in themselves' (fr. '…*les chose ells-memes*…') following *Vocabulaire technique at critique de la pilosophie*, A. Lalande, Press Universitaires de France, 1956.

physics, cosmology, computing sciences, biology, and other sciences. Information seems to be a unifying concept connecting these diverse domains. The success of computing models of natural phenomena can be explained by postulating that computing models and nature share a common element – information (see for example Polak, 2017).

One may argue that the concept of information as an ontological element of nature goes back as far as the pre-Socratic Greeks and Ancient China (Curd, 2011; Oldstone-Moore, 2011). However, it is safer to focus on the twentieth century authors; the incomplete, selective, and rather idiosyncratic list would include[13] Zuse (1970), von Weizsäcker (1970), Turek (1978), Wheeler (1982), Heller (1987, 2014), Collier (1989), Batenson (1979), Stonier (1990), Toffoli (1990), Thagard (2000), Barwise and Ethemendy (2000), Steinhart (2000), Jadacki and Brożek (2005), Seife (2006), de Castro (2007), and Hidalgo (2015). These authors claim in some way or another that information is at the center of nature (Dodig-Crnkovic), as energy is (Seife), and is related somehow to structure of nature (Collier), patterns (Dodig-Crnkovic) or physical order (Hidalgo). Collier (1989) writes, "Physical things have properties that give them a definite structure and causal capabilities. If information is an intrinsic property of physical objects, then it seems likely that it is contained in their physical structure" (p. 6). Hidalgo (2015) states,

[13] Dates of publication refer to the edition cited, not to the original date of publication of the work.

"Information…understood broadly as a physical order" and further "… information is not restricted to messages. It is inherent in all physical objects" (p. 6). Seife (2006) claims that "…there is something about information that transcends the medium it is stored in. It is a physical entity, a property of objects akin to energy or work or mass" (p. 57). Stonier (1990) writes that "… information exists… information has physical reality and constitutes an intrinsic property of the universe" (p. 12). Dodig-Crnkovic (2012) states "The universe is, from the metaphysical point of view, nothing but processes in structural patterns all the way down. Understanding patterns as information, one may infer that information is a fundamental ontological category" (p. 228). For Hidalgo, Seife, and others quoted above, information is as real as any physical phenomena can be; it is objective, it is structural.

3. Why Minimal Information Structural Realism?

Presented here are two informal arguments for MISR. The arguments propose that interpreting natural structures as information or representing information is consistent with the findings of physical sciences and that epistemic interpretation of information and structures (as in ESR and ISR) is not sufficient for the description of nature, thus postulating ontological interpretation (of information and structures) may be more constructive.

Isomorphism of mathematical models of nature. The research in physics and cosmology provides evidence that different mathematical structures of natural phenomena support the same experimental results (Heller, 2014, p. 85). This would suggest that behind different mathematical models, or structures, there is an unchanging physical reality, and mathematical models are just reflections, or approximations, of this reality. Heller, a cosmologist and a philosopher, gives the example of how the evolution of quantum states is modeled by three different mathematical representations: those of Schrödinger, Heisenberg and Dirac[14].

Heller observes that, as these three models support the same experimental results, they must then refer to another invariant structure, to which we do not have access, but that is representing a true reality or is a reality in itself. Heller (2014) also writes, "This is not an exceptional situation in physics" (p. 65), meaning that multiple mathematical structures describing successfully the same physical phenomena exist, as well, in other areas of physics than just QM. Further, Heller (2009) writes that "…every (natural) structure has certain information; more constraints (by laws of physics) given structure imposes more infor-

[14] "There is a proof that these (Schrödinger, Heisenberg, Dirac) mathematical models are unitary equivalent, meaning that they lead to the same empirical predictions. To say it differently, there is an isomorphism between these models with respect to all observables. Thus, it is not the case that one mathematical structure corresponds to something we would call the structure of the world" (Heller, 2014, p. 64).

mation it contains. As the world is a structure, it contains certain information, or (we may say) the structure of the world encodes certain information" (p. 63). Still, in a different work, Heller (1995) observes that "…the modern physics suggests that the world does not have a structure but is a structure. This structure contains in itself certain information (or is information). Science decodes its fragments by fitting mathematical structures to the structure(s) of the universe" (p. 170)[15].

Epistemic incompleteness. In epistemic definitions, information always supervenes on datum or data. The existence of data in addition to information is what may be called epistemic incompleteness. Epistemic incompleteness means that epistemic definitions of information recognize the necessary existence of something beyond epistemic information itself for the complete description of nature. An exemplary case for epistemic incompleteness is offered by the GDI. In GDI, data are primary "stuff" of the universe and occur prior to informa-

15 "…even if a real world contain something more than a form, with the methods of modern physics we are unable to touch it: this something intangible escapes through gaps of the mathematical models and experiments…. If information may be conceptualized as constraining options, every law of physics is information, as it constrains nature. It may be suggested that the stuff of the world is information. However, following Shannon's definition of information, information is a structure and not what possibly can this structure fill in. In this view the structure of the world is an information encoded. The role of science is to break this code and reveal information" (Heller, 1987, 1963, p. XX). It seems that Heller's interpretation of Shannon's information should not be taken literally but as a heuristic device.

tion (Floridi, 2010, p. 84). Data are denoted as "lack of uniformity", diaphora de re, didomena, or "a fracture in a fabric of being" (Floridi, 2010). Information forms structures composed of data in a certain, specific way that is meaningful to some observer. As Floridi (2010) writes, "…General Definition of Information (information is defined) in terms of data + meaning" (p. 83). Thus, information supervenes on data structures. In addition, between information structures and data, Floridi includes *infon* – an elementary particle of information; as Floridi (2010) writes, "the parallel with fundamental particles of physics the electrons, protons, neutron, photons, and so forth" (p. 85). Infon is a strange concept, as on one hand it is conceived to be similar to elementary, physical particles and objective ontologically, while, on the other hand, it has an epistemic, subjective quality.

4. Minimal Information Structural Realism

MISR combines intuitions about the structural character of reality and the ontological and foundational role of information in nature. Structures in MISR are the order behind the abstract structures of ESR or OSR. Information in MISR is not something awaiting to be recognized by the mind, but rather an organizational principle pervading nature. This view of structures and information is not present in current strands of SR (ESR, OSR, and ISR).

MISR claims also that information is an objective aspect of reality and it is perceived or apprehended through (or as) patterns or structures. No data and no infons are necessary to define what information is.

MISR is not associated with ESR and OSR directly, but it does not contradict them. MISR is somewhat related to the concept of Floridi's ISR, in that both ISR and MISR attribute importance to the role of information in nature, yet do so in different ways. Floridi's ISR claims that structures perceived in SR strands are informational structures, or can be interpreted as informational, similar to informational structures modeled by the Object Oriented Programming (OOP) paradigm (Floridi, 2004). MISR claims that structures in SR reflect, or approximate, the structure of nature that contains information.

Versions of MISR may support more nuanced versions of MISR along ontic, epistemic, mathematical, quantum, or computational perspectives. Of course, each of these versions of ISR must be refined and evaluated for its logical coherence and correspondence with the facts of physics[16].

---

[16] One would have to mention the differences in the understanding of *realism* in SR and MISR. In SR, realism denotes the position of science and scientific theories towards nature (realism vs. anti-realism). In MISR, realism denotes the objective character (mind-independent) of information. Both realisms, in further interpretations, do, however, converge on the same claim that there is an objective (mind-independent) reality that we can study. Realism is a polysemic concept that splits various versions of scientific realism (see for example Chakravartty, 2007). It seems that MISR may add (regrettably) still another interpretation to what is real.

5. Conclusions and open issues

SR and MISR take two different, but not completely contradictory, views of nature and our knowledge of it. SR claims structures are what is or what can be known[17], but that they have nothing to do with information. In Floridi's ISR, information is epistemic and it emerges over structures composed of data. MISR sees structures that we conceive as representations, or approximations, of the structure of nature, which is what is invariant behind SR structures. This structure of nature may be thought of as information or composed of information.

Acknowledgement

I would like to thank Prof. Paweł Polak for his constructive comments on the early draft of this paper. All the errors, faulty conclusions and logical and factual mistakes are of course of my doing.

[17] A big problem for SR is how structures in ESR and OSR translate into the objects of nature. This problem seems to be so far unsolved, despite many propositions.

Bibliography

Bar-Hiller, Y., Carnap, R., 1953. Semantic information. *The British Journal of Philosophy of Science*, *4(14)*, pp. 147–157.

Barwise, J., Etchemendy, J., 2000. Computers, visualization and nature of reasoning. In: T. Bynum, J. Moor (eds.), *The digital phoenix*. Oxford: Blackwell Publishing, pp. 93–136.

Bateson, G., 1979. *Mind and nature.* New York: E. P. Dutton.

Brading, K., Landry, E., 2006. Scientific structuralism: Presentation and representation. *Philosophy of Science*, *73*, pp. 571–581.

Brooks, B., 1980. The foundations of information science. Part I. Philosophical Aspects. *Journal of Information Science*, *2*, pp. 125–133.

Burgin, M., 2003. Information: Problems, paradoxes, and solutions. *TripleC*, *1(1)*, pp. 53–70.

Casagrande, D., 1999. Information as a verb: Reconceptualizing information for cognitive and ecological models. *Georgia Journal of Ecological Anthropology*, *3*, pp. 4–13.

Chakravartty, A., 2007. A metaphysics for scientific realism. Cambridge: Cambridge University Press. 233.

Capurro, R., 2009. Past, present, and future of the concept of information. *TripleC*, *7(2)*, pp. 125–141.

Cherry, C., 1978. *On human communication.* 3rd ed. Cambridge, Mass.: The MIT Press.

Collier, J., 1989. Intrinsic information. In: P.P. Hanson (ed.), *Information, language and cognition: Vancouver studies in cognitive science*, Vol. 1. (originally University of British Columbia Press, now Oxford University Press, 1990). pp. 390–409.

Curd, P., 2011. *A pre-Socratic reader.* Indianapolis: Hackett Publishing Company.

De Castro, L., 2007. Fundamentals of natural computing: An overview. *Physics of Life Review*, *4*, pp. 1–36.

Dretske, F., 1999. *Knowledge and the flow of information.* Cambridge: CSLI Publications.

Dodig-Crnkovic, G., 2012. *Alan Turing's legacy: Info-computational philosophy of nature.* [Online] Available from http://arxiv.org/

ftp/arxiv/papers/1207/1207.1033.pdf [Accessed October 7th 2015].

Feynman, R., 1971. *The Feynman lectures on physics.* Vol. I. http://www.feynmanlectures. caltech.edu/[Accessed May 10th, 2017].

Floridi, L., 2004. *Informational realism. Computing and philosophy conference.* In: J. Weckert, Y. Al-Saggaf (eds.), *Conferences on Research and Practice of Information Technology.* Canberra: 37.

Floridi, L., 2010. *The Philosophy of information.* Oxford: Oxford University Press.

Fredkin, E., 1991. Digital mechanics: An informational process based on reversible universal automata. In: H. Gutowitz (ed.), *Cellular automata; Theory and experiment.* Cambridge, Mass.: The MIT Press.

French, S., 1998. On the withering away of physical objects. In: E. Castellani (ed.), *Interpreting bodies: classical and quantum objects in modern physics*. Princeton: Princeton University Press, pp. 93–113.

Frigg, R., Votsis, I., 2011. Everything you always wanted to know about structural realism but were afraid to ask. *European Journal for Philosophy of Science*, *1(2)*, pp. 227–276.

Gillies, D., 2000. *Philosophical theories of probability.* New York: Rutledge.

Heller, M., 1987. Ewolucja pojęcia masy. In: M. Heller, A. Michalik, J. Mączka (eds.), *Filozofować w kontekście nauki.* Kraków: PTT, pp. 152–169.

Heller, M., 1995. *Nauka i wyobraźnia.* Kraków: Znak.

Heller, M., 2009. *Filozofia Nauki. Wprowadzenie.* Kraków: Petrus.

Heller, M., 2014. *Elementy mechaniki kwantowej dla filozofów.* Kraków: Copernicus Center Press.

Hidalgo, C., 2015. *Why information grows.* London: Penguin Books.

Krzanowski, R., 2016. Shannon's information revisited or Shannon's redux. Presentation at XII Zlot Filozoficzny, Białystok, 4–6 VII 2016.

Ladyman, J., 1998. What is structural realism? *Studies in History and Philosophy of Science*, *29*, pp. 409–424.

Ladyman, J., 2016. Structural realism. *The Stanford Encyclopedia of Philosophy*, Winter 2016 (Edition), Edward N. Zalta (ed.) [Online] Available from https://plato.stanford.edu/ archives/ win2016 /entries/structural-realism/ [Accessed October 10th 2016].

Lloyd, S., 2007. *Programming the universe: A quantum computer scientist takes on the cosmos.* New York: Vintage Books.

Loose, R., 1998. A discipline independent definition of information. *Journal of the American Society for Information Science*, *48(3)*, pp. 254–269.

Lensky, W., 2010. Information: Conceptual investigation. *Information*. [Online] pp. 74–118. Open Access Journal. Available from www. mdpi.com/ journal/ information [Accessed October 6th 2015].

Jadacki, J., Brozek, A., 2005. Na czym polega zrozumienie w ogóle a rozumienie informacji w szególności. In: M. Heller. J. Mączka (eds.), *Informacja a zrozumienie.* Tarnów: Biblios.

Muller, V., 2008. Pancomputationalism: Theory or metaphor? In: R. Hagengruber, U.Riss (eds), *Philosophy, computing and information Science. History and philosophy of technoscience*, 3. Chattoo: Pickering & Chattoo, pp. 231–221.

Nafria, J., 2010. What is information? A multidimensional concern. [Online] *TripleC*, *8(1)*, pp.77–108. Available from http://www. triple-c.at [Accessed October 6th 2015].

O'Connell, C., 2016. *What is energy. cosmos.* [Online] Available from https://cosmosmagazine.com/ physics/what-is-energy. [Accessed April 2nd 2017].

Oldstone-Moore, J., 2011. *Understanding taoism.* London: Watkins Publishing.

Psillos, S., 2001. Is structural realism possible? *Philosophy of Science*, *68*, (Supplementary Volume), pp. 13–24.

Polak, P., 2017. Does everything compute? Philosophical implications of pancompuationalism interpretation of natural computing. (in Polish). *Studia Metodologiczne*, *38*, Poznań, Adam Mickiewicz University.

Searle, J., 2015. *Consciousness in Artificial Intelligence.* [Online] Talks at Google, Available from .https://www.youtube.com/ watch?v=rHKwIYsPXLg [Accessed January 15th 2017].

Stonier, T., 1990. *Information and the internal structure of the universe.* New York: Springer-Verlag.

Shannon, C., 1948. A mathematical theory of communication. *The Bell System Technical Journal*, *27*, pp. 379–423.

Shannon, C., Weaver, W., 1964. *The mathematical theory of communication.* Urbana, Ill.: The University of Ilinois Press.

Schroeder, M., 2017. Spór o pojęcie informacji. *Studia Metodologiczne*, *35*, pp. 11–37. [Online] Adam Mickiewicz University, Poznan. Available at http://studiametodologiczne. amu.edu.pl/vol-34/ [Accessed April 2nd 2017].

Sveiby, K-E., 1994. *What is information.* [Online] Available at http://www.sveiby.com/articles/ information.html [Accessed April 20th 2016].

Thaggard, P., 2000. Computation and philosophy of science. In: T. Bynum, J. Moor (eds.), *The digital phoenix.* New York: Blackwell Publishing, pp. 48–61.

Weyl, H., 1949. *The philosophy of mathematics and natural science.* Princeton: Princeton University Press.

Worrall, J., 1989. Structural realism: The best of both worlds? *Dialectica*, *43*, pp. 99–124.

Zuse, K., 1970. Calculating space. MIT Technical Translation AZT-70-164-GEMIT, Cambridge: Massachusetts Institute of Technology (Project MAC).