Paper presented at Doctoral Congress in Philosophy 22.–24.10.2018, University of Tampere, Finland
Juho Rantala (juho.rantala@tuni.fi)

The Notion of information in early cybernetics and in Gilbert Simondon's philosophy

Introduction

In everyday use, the information is most likely seen as a synonym for a fact, a collection of facts, data and sometimes even knowledge. The term information has, as John Durham Peters points out, colourful history[1]. In history, etymologically and philosophically the term derives from the concept of form (in-form). Soon, this dimension disappeared from the common use. In summary, Pieter Adriaans presents three historically different meanings for information: information as the process of being informed ("informative process"); information as a state of an agent ("result of process of being informed"); information as the disposition to inform ("capacity of an object to inform an agent").[2] All of aforesaid meanings are usually present at the event of communication.

Today there are usually two notions of information, personal (semantic) and objective (technical). The latter means, typically and in practice, symbols that are used to transmit a message. In addition, the information is always connected to transmission and code (or coding).[3] Luciano Floridi has written extensively about the philosophy of information. He has listed at least seven different approaches to information: information theory, algorithmic, probabilistic, modal, systemic, inferential and semantic.[4]

This paper will examine the notion of information in the early cybernetics and in Gilbert Simondon's philosophy. First, we will be outlining the notion of information of early (or first-order) cyberneticians. Secondly, we will summarize Simondon's concept of information. Finally, the last part of the paper will be dealing shortly with the present understanding of information which has expanded since the beginning of the 20th century.

Early Cybernetics and Information: Mathematical Theory of Communication

The cybernetics, the study of communication, information and control, understood the concept of information mostly according to the "mathematical theory of communication" (MTC) or as Shannon-Weaver model[5]. This still widely used model describes the *communication* of information and not, for example, the semantics (or quality) of information, or how different types of information interact together[6]. Claude Shannon presented MTC in his 1948 article, and it was revised in the book with the same name year later. The book had introduction by Warren Weaver who represented MTC in layman terms. Weaver also brought up "three levels of communication problems" which seems to be connected to three different views on information[7]. These were:

1. *Technical problem*: How accurately can the symbols of communication be transmitted?

[1] Peters 1988.
[2] Adriaans 2018.
[3] Baeyer 2003, 19, 21, 25. For modern concept and uses of information, see Burgin 2010; Lash 2002, 1–5.
[4] Floridi 2011.
[5] Shannon 1948; Shannon & Weaver 1964 and e.g. Day 2001; Pickering 2010. It is important to note, that the point of MTC *was not* to describe the semantics (or quality) of information, or how the different types of information are interacting together. (See e.g. Iliadis 2013, 5; Faucher 2013, 11–12.)
[6] See e.g. Iliadis 2013, 5; Faucher 2013, 11–12.
[7] Shannon & Weaver 1964, 4.

2. *Semantic problem*: How precisely do the transmitted symbols convey the desired meaning?
3. *Effectiveness problem*: How effectively does the received meaning affect conduct in the desired way?

As Weaver points out, Shannon's MTC applies only to the first problem[8]. Subsequently, Weaver presents summary of the concept of information in MTC. In his view, the information must not be confused with meaning, as information "heavily loaded with meaning" and "pure nonsense" can be equivalent. Weaver continues that "the information is a measure of one's freedom of choice when one selects a message" in a certain situation.[9] The information, thus, is a concept which applies to the situation as a whole, and the amount of information for a situation can be mathematically calculated. This calculation is carried by probability and entropy, or to quote Weaver extensively:

> "That information be measured by entropy is, after all, natural when we remember that information [in MTC] is associated with the amount of freedom of choice we have in constructing messages […] Having calculated the entropy (or information, or the freedom of choice) of a certain information source, one can compare this to the maximum value this entropy could have […] If the relative entropy of a certain source is, say 0.8, this roughly means that this source is, in its choice of symbols to form a message, about 80 per cent as free as it could possibly be with these same symbols."[10]

MTC then is, in one way, connecting entropy and information together. But on the other hand, the theory produces "sense" of the effectiveness of information source. And by mathematical formulation, it introduces order in chaotic entropy.[11]

The golden age of cybernetics was, roughly, from 1940s to 70s, but this set of different fields continues to live in the 21st century. At the end of the 20th century, most of the cybernetic research divided into different fields of study, for example, robotics, cognitive sciences, philosophy, psychology, organizational theory, economics, computer science and biology. The break was only natural as the early cyberneticians came together from different fields. To understand some of the starting points of cybernetics (as a whole), we must turn to Andrew Pickering, who points out that the ontology of cybernetics is considerably "unmodern" as it understands humans and things similarly: as *information and feedback systems*. Cybernetics sees world as becoming and dynamic process; thus, its view of the world is "performative".[12]

The cybernetics is not one homogenous field. Usually it is divided to the *first-order* and the *second-order* cybernetics[13]. These different orders can be separated by, for example, their relationship to systems. The first-order do not bound observers (or subjects) as a part of the observed system. Second-order, then, observers these systems from "metalevel" where the observer is seen as a part of the system (the observer is situated). Former also handles the information only from the view point of its transmission, or is only interested the quantification of information. First-order did not see the concept of information as relevant as it were mostly interested only in communication (like e.g.

---

[8] Ibid, 6.
[9] Ibid, 8–9. "[…] information is […] to be measured by the logarithm of the number of available choices."; and: "If one has available say 16 alternative messages among which he is equally free to choose, then since $16 = 2^4$ so that $\log_2 16 = 4$, one say that this situation is characterized by 4 bits of information." (ibid, 9–10.)
[10] Ibid, 13.
[11] Cf. Chapouthier 2013, 22. For MTC, see also Dretske 1981, 1–10; Mingers 1997.
[12] Pickering 2010, 18–20. The unmodernistic side is underlined as Jean-Pierre Dupuy pointed out that cybernetics contributed to the rise of antihumanism (Dupuy 2018).
[13] See e.g. Pickering 2010; Foerster 2003. The first-order is coarsely dated to c. 1940–1950 and to the pioneering work of W. Ross Ashby and others. Second-order also starts already around in the 1950s, and important example is the work of Gregory Bateson. One of the first meetings of the researchers of cybernetics, see Foerster 1952.

Shannon). Second-order, for example the likes of Gregory Bateson and Norbert Wiener, thought otherwise: information grew up to be one of the most important aspect of their theories.

In addition, one of the main differences between the first and second orders were their relationship to a system as a *black box*: former thought it was important to "open the box" and understand the system's concrete mechanisms of input, output and feedback, and create models of its operation. Second-order wanted to understand the performance of the system, without troubling their minds with the concrete wiring inside the black box.[14]

Almost everything could be seen as an information system. Cybernetics view was to move from the cause and effect to *circular causality* and *negative feedback*. Systems, then, came to be understood as a *circuit* (circular process). A man steering a ship was a system with feedback. A machine itself could be a system (e.g. autopilot), but most of the time cybernetics were interested in machine-organism systems.[15]

We must now return to the concept of information. As there is no one understanding of information among the cyberneticians, we can take, as an example, Norbert Wiener's position. He is probably one of the most famous representatives of cybernetics. To him, the information was an increase of order or organization, i.e., *negentropy* (as opposed to entropy). The nature has tendency to degrade the organized, Wiener writes. Thus, information is "name for the content of what is exchanged with the outer world as we adjust to it" and "make our adjustment felt upon it"[16]. The importance of information is evident as Wiener connects it to "living effectively within the environment"[17]. Though, in the end, Wiener does not differ from the classical MTC: effective use of information and probability are the keys to understand information.

French cybernetician Raymond Ruyer was more interested in the origin of information. Ruyer criticized cybernetics but did not abandon completely their models, starting points and assumptions[18]. Especially he criticized basic conception of information which was not clear enough about, to quote Andrew Iliadis, "the distinction between the information types and the different ways that information can be processed"[19].

Ruyer wrote, for example, about machines that "inform themselves and each other"[20]. He returned the idea of information as *in-forming*, and criticized especially Wiener's view of the information. Ruyer pointed out that Wiener had two theses that prevented realizing the origin of information. Firstly, to Wiener, information machines cannot "gain information": there were always more information going into the machine than coming out (with the message). Secondly, the brains and nervous systems are information machines (or from the "same order" as these machines) which do not contain any transcendental property that is impossible to imitate by a mechanism. This leads to, as Ruyer states, situation where it is impossible to say how information originates, as the machine does not preserve the information that is composed by human being.[21]

The primary idea of Ruyer's conception of cybernetics and information – as well as the notion of the origin of information – is the connection between human consciousness and information (and

[14] Heims 1991, 97; Hui 2015, 32; Pickering 2010, 25–28.
[15] Heims 1991, 15–16.
[16] Wiener 1989, 17.
[17] Wiener 1989, 18. "To live effectively is to live with adequate information" (ibid).
[18] E.g. in Ruyer 1954.
[19] Iliadis 2015, 137.
[20] Ruyer 1954, 7.
[21] Ibid, 11–12.

technological system). As Mark Hansen proposes, there are two kinds of consciousness in Ruyer's thinking: organic and human. This creates shared, non-empirical domain or "transpatial"[22], which means that any technical system (circuit) requires always consciousness ("or the form of conscious life") that "first produced it". This transpatial dimension of consciousness is that which *enframes the information*; and at the same time Ruyer understands this enframing as meaning.[23]

What then is the information for Ruyer? As Georges Chapouthier points out, along with consciousness, the form and the structure are probably the most important concepts for Ruyer. These two concepts are connected: the form is in space and in time defined by its structure (a *form-structure*).[24] The information comes to mean, in the process of transmission, a certain pattern that is transferred from one machine to another machine (or from one part to another part of the same machine). This pattern transfers form(-structure) *as a signifying unit* because *a conscious being can become aware of a final result as a form*. Or, to put it differently, conscious being apprehends this pattern as a whole and, thus, makes it to a form.[25]

Ruyer seems to use information synonymously with the concepts of structure and organization. As there is always circulation of signals (or energy) between different beings, the human consciousness is a frame that modulates the circulating signals or energy to forms and creates structures and organization in the flow, that is, the information. He even goes as far as pointing out, that the information comes from trans-mechanical source (i.e. human consciousness) and from metaphysics.[26] Ruyer took seriously the classical connection of in-form and information.

Ruyer, along with for example anthropologist André Leroi-Gourhan, influenced greatly another French man, Gilbert Simondon, one of the most interesting 20th century philosophers of technics and technology[27]. Simondon extended Ruyer's and cybernetics' ideas by connecting information to process of morphogenesis[28].

Gilbert Simondon – From Individuation to Information

Obviously, it is not possible to summarize here in detail Simondon's philosophy. In the early writings, he wrote on the modes of existence of technical objects and, later, the way all beings are individuated from constantly changing or becoming (*devenir*) heterogenous material reality.[29] He sought to understand how *the principle of individuation* could be formed without the problems of atomism (or substantialism) and hylomorphism[30]. Simondon used extensively ideas of cybernetics (especially Wiener's and Ruyer's) but thought that these were not sufficient views of organisms and society, or of the information.

Simondon aspired to understand the formation of being, whether it was living, organic, physical or technical, from a multidimensional view. The individuation is the product or event that created the being *as process*. Furthermore, a perception, formation of an idea in the mind, thinking, growth of a flower, politics all are individuations of different speeds and lengths. Every individuation is a part of bigger individuation and is an assemblage of smaller ones. In general terms, individuation is a

[22] Or, as Chapouthier expresses it, "trans-géométrico-mécanique" (2013, 25).
[23] Hansen 2004, 81–83; Ruyer 1954, 9–10, 23, 29; also Gagnon 2017, 547.
[24] Chapouthier 2013, 26. It is important to note that, from the philosophical viewpoint, the form is more general term than the structure (ibid, 27).
[25] Ruyer 1954, 9–10. Interestingly, Ruyer says, that this apprehension leads easily to the illusionary understanding of the function of the machine, which is just a collection of "step by step" functions (ibid, 10).
[26] E.g. Ruyer 1954, 138–146, 215.
[27] See e.g. Bontems 2018.
[28] John Durham Peters has later pointed out that the early meaning of information should be translated to morphogenesis (1988, 11).
[29] E.g. Simondon 2013; 2017. (Simondon 1989 is published also as a first part in Simondon 2013.)
[30] Or "hylemorphism". Sadly, we cannot go here to the problems (as Simondon sees them) of these classical views.

mediation that is realized between different (disparate) and polarized systems. It is a "resolution" between these systems and, at the same time, it answers to the problems that rises with the environment (or medium[31]). Individuation leads to the communication and stabilization of these systems, and to the new individuations. There is always something *pre-individual* in the individuated individual: it does not exhaust completely the potentials and energy of prior individuation – it is in dynamic metastable state. At the centre of this theory, and of individuation, is information, its exchange and flow.[32]

The information is a sort of pattern for individuation or, as Yuk Hui points out, Simondon strives to reform the concept of information in order to explain individuation[33]. Hui continues, that the Simondon defines the individual as a result from three conditions: the energetic condition, the material condition and informational condition. The informational condition is that which allows resolution between the energetic and the material. Information, then, positions itself as a pattern that produces resolution. For Simondon, there is no formal difference between sender and receiver, because the communication between systems – and their insides and outsides – is simultaneous.

Following Ruyer's view, information is not a form or set of forms, but a "variability of forms".[34] As early cybernetician Nicolas S. Tzannes pointed out, information is operative[35]. Simondon follows this and understands information as operation of a thing that is arriving into a system *and* producing transformation.[36] The problem of this conception is its complexity. As Andrew Iliadis summarizes, information is connected to concepts of *metastability*, aforesaid individuation and *transduction*.[37]

Information, metastability and transduction

Simondon criticizes Wiener's identification of information and negentropy: this explains information only in quantitative terms, without realizing its relational or differential value. Also, the identification of signal and information "reduces information exchange to a deterministic process which leaves substantially untouched the identity of the systems involved"[38]. As Andrea Bardin summarizes, to Simondon the transmission of information does not need any external intervention to introduce new information to the system, because, as default, communicative systems are metastable and they emit signals.[39] The signal (or energy) is information when it alters the system.

For Simondon, the information presumes the metastability of a system or systems that are in communication with each other. The systems are in differentiative states, but as operation the information always refers to the prior state(s) from which it emerges. The information has no unity, it is an operation of exchange between these different states of systems. As said above, information also produces transformation. This transformation is *transduction* which can be summarized as *encounter between differentiative systems*. Information exchange, transduction, can amplify and create regulatory (modulatory) structures in a system, or the activity, i.e. the operation, spreads from one system to another. The structural changes will lead to a more higher-level organization, and also to the inner structural transformations in the system or systems.[40]

[31] Originally *milieu*.
[32] This short summarizing paragraph is derived from Simondon 1989; 2013.
[33] Hui 2015, 33.
[34] Ibid, 35; Simondon 2017, 150.
[35] See e.g. Hayles 1999, 56.
[36] Hui 2015, 41; Simondon 2010, 159.
[37] Iliadis 2013, 10–11; see summary of the connection between individuation and information, e.g. Hottois 1993, 36–37, 43.
[38] Simondon 2013, 222–224; see also Bardin 2015, 29.
[39] Bardin 2015, 30.
[40] Simondon 1989, 22, 29, 32, 234; also Iliadis 2013, 12.

Transduction is operation that produces the preservation of metastability by creating a synthesis from the structure that connects the differences between individual and environment (or two systems).[41] The origin of information, for Simondon, is in the encounter of partial indeterminacies of different systems. To put it shortly by following Bardin, metastability of the system means also that it has indeterminacy, which makes it open to information, whether external or internal[42].

There is a probabilistic element here: the divergence or difference between the communicating systems modulates the amount of information. If the disparation is "non-existent, the signal exactly transmits the form and information is non-existent".[43] Simondon presents that the least possible lost requires a sacrifice of energy efficiency to avoid reduction of range of possibilities. Also, differing from Shannon and others, he says that, in order to be transmitted, the information must be above the pure random phenomena (e.g. white noise). Information is then "that which possesses regularity, localization, a defined domain and a determined stereotypy through which it distinguishes itself from pure chance". Information is "halfway between pure chance and absolute regularity".[44]

Unlike Ruyer, Simondon thinks that there can be information without the consciousness but *not without a system*. As said above, the information is "variability of forms", which means that a single form is a temporal order in the flow of transforming information circulation.[45] The system must be a circuit. This system works as, to use Hui's words, "situation of information"[46]. To Simondon, system enframes (as a situation) the information. Other difficult idea is that, to Simondon, in contrast with cyberneticians, *significance* and *meaning* are two different things. As information reaches certain intensity it produces meaning. For example, the homeostat can regulate the thresholds of intensity (of meaning), but it cannot deal with significance which Simondon describes as *discontinuity*, a sort of "quantum leap" in a system circuit[47].

Simondon distinguishes the living and the machine, among other things, according their use of information or forms. The living being, like human, needs information but the machine uses forms, and it is constituted with forms. The living transforms information into forms – "*a posteriori* into *a priori*". But this *a priori* is "always oriented toward the reception of information to be interpreted", and the forms are "deposited" into machines. The operation of machines "does not give rise to information, but is simply an assemblage and a modification of forms". And thus, "a living being is required as mediator in order to interpret a given functioning in terms of information, and in order to convert it into the forms for another machine."[48]

Consequently, we can say that in Simondon's notion of information there are elements from Shannon's, Wiener's and Ruyer's understanding of information. In addition, there also elements from one of the more known second-order cyberneticians, Gregory Bateson's thinking, who we shall discuss shortly in the next chapter.

The concept of information at the turn of the century

After the "golden age" of cybernetics, the discussion of information has only increased. For example, Fred Dretske has provided important semantic theory of information and, at the end of the century,

[41] Simondon 1989, 28; 2010, 161–162; Flaucher 2013, 43.
[42] Bardin 2015, 30.
[43] See e.g. Scott 2014, 58.
[44] Simondon 2017, 148.
[45] Simondon 2017, 149–150.
[46] Hui 2015, 44.
[47] This is Hui's formulation (Ibid, 43).
[48] Simondon 2017, 150.

Luciano Floridi has written extensively about the philosophy of information[49]. Aforesaid Bateson, who worked after the second half of the century, had thoughts close to Simondon. The unit of information was "a difference that makes a difference", or in other words, information "that which excludes certain alternatives".[50] As Bateson writes, even the zero point or absence of indicative event can be a message, thus the context of information and the formulation of this context are important. Information always "comes out of a context into a context".[51]

As this "unit" that makes a difference is a bit, it is not hard to see the connection to digital binary code. Bateson had more philosophical foundation for the "difference-unit": he referrers to Immanuel Kant who said that the most elementary act is a selection of fact. As the thing itself (*Ding an sich*) can have infinite number of potential facts, the idea of the thing is always reduced to a certain fact (or facts) of the thing. This fact is, at least to Bateson, information.[52]

Alexander Galloway has brought up, with the help of Francois Laruelle's philosophy, digital as a fundamental ontological category. For him, digitalization is the process of alienation, it is the differential relation of two states (symbolized by one and zero), from which only one can (and must) be chosen. Alienation is brought up by the dividing act of breaking One (or the Whole) into different separated units.[53] Simondon's theory also considers these elements. "The fundamental division" is inherent in the individuation of disparate systems. And without this division, there would be no information.[54]

Conclusion

As to conclude, after reviewing the early cybernetician notions of information and presenting the outline of Simondon's conception of information, we can now present shortly the scope of Simondon's theory. Thus, it includes:

1) The elements of probability and quantity of information (Shannon)
2) Information circuit and machines / organism-machine system (Wiener)
3) The concept of form, structure and, also in some part, place for human consciousness (as a signification); human as mediator (Ruyer)
4) Information as difference or disparation (Bateson)

In addition, the information as well as the individuation is based on the fundamental division. The difference "makes" information circulate and at the same time, in a sense, *is* the information. It is no wonder that more famous French philosopher, Gilles Deleuze, used Simondon's ideas, especially individuation and disparate systems, in his magnum opus *Différence et répétition*[55].

Simondon's notion of information is topical in the age of digital technology ruled by algorithms and big data. Further elaborated, Simondon connects the circulation of information to the physical individuation, that is, the physio-biological formation of individual being. This theoretical framework, thus, provides tools to understand how algorithms and modern technologies mediate our experience, our perception of the world, each other and ourselves. And on the other hand, how these technologies are "human" – or at least created and interpreted by humans – starting at the most fundamental level.

[49] Dretske 1981; Mingers 1997; Floridi 2011. Yuk Hui also points out that Simondon's "organizing amplification" resonates with the concept of the autopoiesis of Francisco Varela and Humberto Maturana (Hui 2015, 33; cf. Maturana & Varela 1980).
[50] Bateson 1979, 99; 1987, 276, 386.
[51] Bateson 1979, 47; 1987, 404.
[52] Bateson 1987, 459–460.
[53] Galloway 2014, xix, 12–13.
[54] For criticism of Simondon, see e.g. Stiegler 2018a; 2018b.
[55] Deleuze 2011.

Bibliography

Adriaans, Pieter, Information. *The Stanford Encyclopedia of Philosophy*. Ed. Edward N. Zalta. 2018. URL: https://plato.stanford.edu/archives/fall2018/entries/information/.

Baeyer, Hans Christian von, *Information – The New Language of Science*. Weidenfeld & Nicolson, London 2003.

Bardin, Andrea, *Epistemology and Political Philosophy in Gilbert Simondon. Individuation, Technics, Social Systems*. Springer, Dordrecht 2015.

Bateson, Gregory, *Mind and Nature. A Necessary Unity*. E. P. Dutton, New York 1979.

Bateson, Gregory, *Steps to an Ecology of Mind. Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology*. Jason Aronson Inc., New Jersey & London 1987.

Bontems, Vincent, On the Current Uses of Simondon's Philosophy of Technology. In *French Philosophy of Technology. Classical Readings and Contemporary Approaches*. Eds. S. Loeve, X. Guchet & B. Bensaude Vincent. Springer 2018. [Epub]

Burgin, Mark, *Theory of Information. Fundamentality, Diversity and Unification*. World Scientific Publishing, Singapore 2010.

Chapouthier, Georges, Information, Structure et Forme dans La Pensée de Raymond Ruyer. *Revue philosophique*. Vol. 138, No. 5, 21–28.

Day, Ronald E., *The Modern Invention of Information. Discourse, History, and Power*. Southern Illinois University Press, Carbondale & Edwardsville 2001.

Deleuze, Gilles, *Différance et répétition*. PUF, Paris 2011.

Dretske, Fred I., *Knowledge and the Flow of Information*. Basil Blackwell, Oxford 1981.

Dupuy, Jean-Pierre, Cybernetics is an Antihumanism. Technoscience and the Rebellion Against Human Condition. In *French Philosophy of Technology. Classical Readings and Contemporary Approaches*. Eds. S. Loeve, X. Guchet & B. Bensaude Vincent. Springer 2018. [Epub]

Faucher, Kane X., *Metastasis and Metastability. A Deleuzian Approach to Information*. Sense Publishers, Rotterdam 2013.

Floridi, Luciano, *The Philosophy of Information*. Oxford University Press, Oxford 2011.

Foerster, Heinz von (ed.), *Cybernetics. Circular Causal and Feedback Mechanisms in Biological and Social Systems*. Josiah Macy, Jr. Foundation, New York 1952.

Foerster, Heinz von, *Understanding Understanding: Essays on Cybernetics and Cognition*. Springer, New York 2003.

Gagnon, Philippe, Ruyer and Simondon on Technological Inventiveness and Form Outlasting its Medium. *Deleuze Studies*. Vol. 11, No. 4, 2017, 538–554.

Galloway, Alexander R., *Laruelle. Against the Digital*. University of Minnesota Press, Minneapolis & London 2014.

Hansen, Mark B. N., *New Philosophy for New Media*. The MIT Press, Cambridge & London 2004.

Hayles, N. Katherine, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. The University of Chicago Press, Chicago & London 1999.

Heims, Steve J., *The Cybernetics Group*. The MIT Press, Cambridge & London 1991.

Hottois, Gilbert, *Simondon et la philosophie de la "culture technique"*. De Boeck-Wesmael, Bruxelles 1993.

Hui, Yuk, Simondon et la question de l'information. *Cahiers Simondon*. Vol. 6, 2015, 29–46.

Iliadis, Andrew, Informational Ontology: The Meaning of Gilbert Simondon's Concept of Individuation. *Communication+1*. Vol. 2, 2013.

Iliadis, Andrew, Mechanology: Machine Topologies and the Birth of Philosophy of Technology in France (1932–1958). *Systema*. Vol. 3, No. 1, 2015, 131–144.

Lash, Scott, *Critique of Information*. Sage Publications, London 2002.

Malaspina, Celine, *An Epistemology of Noise*. Bloomsbury Academic, London 2018.

Maturana, Humberto R. & Varela, Francisco J., *Autopoiesis and Cognition. The Realization of the Living*. D. Reidel Publishing, Dordrecht & London 1980.

Mingers, John, The Nature of Information and its Relationship to Meaning. In *Philosophical Aspects of Information Systems*. Eds. R.L. Winder, S.K. Probert & I.A. Beeson. Taylor & Francis, London 1997, 73–84.

Peters, John Durham, Information: Notes Toward a Critical History. *Journal of Communication Inquiry*. Vol. 12, 1988, 9–23.

Pickering, Andrew, *The Cybernetic Brain*. The University of Chicago Press, Chicago 2010.

Ruyer, Raymond, *La cybernétique et l'origine de l'information*. Flammarion, Paris 1954.

Scott, David, *Gilbert Simondon's Psychic and Collective Individuation. A Critical Introduction and Guide*. Edinburgh University Press, Edinburgh 2014.

Shannon, Claude, A Mathematical Theory of Communication. *The Bell System Technical Journal*. Vol. 27, 379–432/623–656, 1948.

Shannon, Claude & Weaver, Warren, *The Mathematical Theory of Communication*. The University of Illinois Press, Urbana 1964.

Simondon, Gilbert, *L'Individuation psychique et collective*. Aubier, Paris 1989.

Simondon, Gilbert, *L'Invention dans les techniques. Cours et conférences*. Éditions du seuil, Paris 2005.

Simondon, Gilbert, *Communication et Information. Cours et Conférences*. Les Éditions de la Transparence, Chatou 2010.

Simondon, Gilbert, *L'Individuation à la lumière des notions de forme et d'information*. Éditions Jérôme Millon, Grenoble 2013.

Simondon, Gilbert, *Sur la technique (1953–1983)*. PUF, Paris 2014.

Simondon, Gilbert, *On the Mode of Existence of Technical Objects* (Du mode d'existence des objets techniques). Trans. C. Malaspina & J. Rogove. Minnesota University Press, Minneapolis 2017.

Stiegler, Bernard, *The Neganthropocene*. Trans. Daniel Ross. Open Humanities Press, London 2018a.

Stiegler, Bernard, Around the "Notion of Information". Trans. Daniel Ross. Presentation in conference "Culture & Technics: The Politics of Simondon's *Du Mode*" at the University of Kent, Centre for Critical Thought, 13.–15.9.2018b.

Wiener, Norbert, *Cybernetics, or Control and Communication in the Animal and the Machine*. The MIT Press, Cambridge 1962.

Wiener, Norbert, *Human use of Human Beings. Cybernetics and Society*. Free Association Books, London 1989.