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Emergent Information. When a Difference Makes a Difference…

Wolfgang Hofkirchner

Vienna University of Technology, Vienna, Austria, wolfgang.hofkirchner@tuwien.ac.at, http://hofkirchner.uti.at

Abstract: Gregory Bateson's famous saying about information can be looked upon as a good foundation of a Unified Theory of Information (UTI). Section one discusses the hard and the soft science approaches to information. It will be argued that a UTI approach needs to overcome the divide between these approaches and can do so by adopting an historical and logical account of information. Section two gives a system theoretical sketch of such an information concept. It is based upon assuming a co-extension of self-organisation and information. Information is defined as a tripartite relation such that (1) Bateson's "making a difference" is the build-up of the self-organised order; (2) Bateson's "difference" that makes the difference is the perturbation that triggers the build-up; (3) Bateson's difference that is made is made to the system because the perturbation serves a function for the system's self-organisation. In semiotic terms, (1) a sign (= the self-organised order) relates (2) a signified (= the perturbation) (3) to a signmaker (= the system). In a third section, consequences of this concept for the knowledge about techno-social information processes and information structures will be focused on.

Keywords: Objectivism, Subjectivism, Materialism, Idealism, Externalism, Internalism, Subject-Object-Dialectics, Emergentist Materialism, Perspectivism, Self-Organisation, Sign, Unified Theory of Information, Computing, Meaningful Technology, Global Sustainable Information Society

1. Introduction

Gregory Bateson's famous saying about information as a "difference which makes a difference" (Bateson 1972, 453) itself makes a difference. It can not only be applied to questions such as whether computers are able to process differences that make a difference and therefore qualify as meaningful technology, as will be dealt with in section 4, but it can also be considered a step toward a Unified Theory of Information (UTI) as discussed in section 3. As it is based upon a systemic view, Bateson's approach is able to bridge the gap between hard and soft science.

The basic argument why Bateson makes a difference is as follows. The gap between hard and soft science approaches to information forestalls an integrative perspective. The absence of an integrative perspective results in a lack of scientific criticism of research into, and encourages the development of, meaningless technology and its diffusion in society. In particular, a mechanistic view of evolution facilitates the production of Information and Communication Technologies (ICTs) for reasons other than for empowering the people to master global challenges. The course of technological development needs to be directed. It ought not to be left to an alleged technodeterminism.

Before Bateson is interpreted in that way, it is helpful to look at the gap between hard and soft science approaches to information in more detail.

2. Hard and Soft Science Approaches to Information Forestall an Integrative Perspective

The mainstream approach is affiliated to science and technology, including mathematics, and approaches information as a "hard" fact, as a given to whatever discipline, as one single thing. It is characterised by objectivism, materialism and externalism (Hofkirchner 2011b).

Objectivism refers to how information is treated. Information is treated as the object of any type of practical action by humans, i.e., in the context of social (cultural, political, economic) steering and intervention; in environmental management; and in the usage and the design of technology. It is a something that can be handled, in particular stored, retrieved, distributed, transmitted, received, and processed. In short, it is an object of action.

Materialism refers to the ontology of information. This object of action named information is conceived of as an object of the real-world, be it in the realm of human society or in the wider physical world. It need not necessarily be a substance in its own right (like matter is said to be) in order to qualify for a materialistic ontology. It is sufficient to consider it as a derivative of matter, that is,

as a property of matter (such as structure), which holds for signal transmission as well. Either way, it is considered a material object.

Externalism refers to how information is researched. This material object named information is the object of inquiry by empirical and formal-scientific methods, all of which are carried out in the so-called third-person perspective, i.e, from the point of view of an outside observer. Formalisms are developed to measure the structure of matter or signals. In short, it is an objective study to which the object is subjected.

Each of the three characteristics is reductionist. It reduces the treatment of information to the treatment of a thing; it reduces information to a thing; it reduces the research into information to methods suitable for to researching things.

The, 'soft', approach, an alternative to, and in opposition to, the 'hard' approach, is characteristic of the social sciences and humanities. It is characterised by subjectivism (as opposed to objectivism), by idealism (as opposed to materialism), and by internalism (as opposed to externalism) (Hofkirchner 2011b).

There are two varieties of the soft approach: projectivist and disjunctivist. In the projectivist variety, by analogy to subjective action carried out by human actors and considered to be an information process, subjective activity of the same kind is postulated to be carried out by any agents that populate the world. In this variety subjectivism is a projection of human subjectivity in information processes onto processes with nonhuman entities; idealism is a projection of a presumed intentional nature of human information processes onto the nature of processes caused by nonhuman entities; and internalism is a projection of subjective methods of gaining insight into the phenomenon of information in humans onto the study of nonhuman information processes.

In the second, disjunctivist, variety of the soft approach, a distinct category is reserved for the subjective (human) action of information. Information is defined only in the context of a social discourse involving humans; as a human phenomenon only; and as subject to subjective interpretation only.

In both cases, though, subjectivism interprets information as subjective action (of agents including or excluding nonhuman ones); idealism makes information an ideational action (again of agents including or excluding nonhuman ones); and internalism means research is interpretive action only.

An integrative view cannot be satisfied by such one-sided views. An integrative view has to consider both the objective, material, external, and subjective, ideal, internal aspects of information and at the same time overcome reductionism, projectivism and disjunctivism. An integrative view needs to overcome these divides and can do so by doing justice to the reasonable propositions found in both the soft and hard approaches.

The hard (objectivistic, materialistic and externalistic) outlook is correct in stating that information is an objective matter of fact in the real world and not merely human imagination. The soft (subjectivistic, idealistic and internalistic) outlook is correct insofar as it states that information occurs only if there is freedom of choice in the generation and utilisation of information so that the generator or user of information is a subject. In the hard outlook, however, we have to limit the scope of objects within which information is said to be found to those objects exclusively that take the role of subjects. In the soft outlook, we have to enlarge the scope of subjects from that of humans exclusively and include non-human ones, too, as quasi- and protosubjects.

Through the integrative approach we adopt an historical and logical account that is characterised by a subject-object-dialectics (instead of objectivism and subjectivism); by an emergentist materialism (instead of materialism and idealism); and by a certain kind of perspectivism (instead of externalism and internalism) (Hofkirchner 2012).

Subject-object-dialectics means: objects and subjects are defined by (1) mutual exclusion as opposites (2) depending on each other (3) in an asymmetrical relation. Objects are subject to subjects, while subjects subject objects. Objects do not exist unless subjects exist, and *vice versa*. Objects and subjects are bound together by the process in which subjects interact with objects. Then we can state: on the one hand, the object bears significance for the subject in so far as its objective properties suit subjective functions. On the other hand, the subject designates the object for serving it one way or another because it needs to reach out for that which it makes into an object and it needs to approach the object in a subjective way. It is this relationship by which a subject relates itself to an object via its own activity, from which information emerges. This very relationship harbours the origins of information: because subjective appetence relates to objective affordance, we have subjective signification designating objective significance. Information is an emergent that mediates the relations between subjects and objects. It is objective and subjective at the same time when being (part of) the subject's relation to the object.

Emergentist materialism means: matter and information, like ideas, belong together as objects and subjects do. Matter is the common ground but leaves room for emergent properties and events. This is a monist answer, but a dialectical one. Dialectics concurrently recognises identity and difference of matter and information: it recognises identity, given the difference, because this identity enables these different sides to interact; and it recognises the difference, given identity, because this makes it possible to differentiate matter and information as different specifications of an identical, common genus. A subject never relates directly to an object. Its relation to the object is always mediated. It construes the means of mediation. In the course of the subject's acting upon the object, the subject gives rise to something new by which it mediates itself with the object – the sign. The process of information generation generates information, that is, it produces, and ends up in, an information structure (the sign) that remains genetically linked to its production process. That structure, in turn, functions as a frame for another process when utilised. Information is a relation, not a material entity or an ideational event; it is an "ideational" assignment that makes a "material" sign emerge. The information structure is material in that it exerts pressure through downward causation on the informational agent(s); it emerges from the information process(es) driven by the informational agents.

Perspectivism[1] means: repeated shifts in taking perspectives are ineluctable. This is because information emerges in the field of subject-object dialectics, in which the subject's material appetence relation to the object provides the possibility of being converted into a signification relation and in which the object's material affordance relation to the subject provides the possibility of being converted into a significance relation. This is also because information is a material emergent that, firstly, realises these conversion possibilities through designation (mediation via a sign structure); secondly, represents a relation that is of a more complex materiality than that relation from which it emerged; and, thirdly, keeps oscillating between process and structure. Subjects and their information processes and structures might be studied from both an external and internal perspective. Indeed, in order to grasp the whole phenomenon and not omit any essential feature, they must be studied from both perspectives. Objects of study are subjects in themselves that can be studied as objects and as subjects as well. Objects and subjects are two sides of the coin. Switching back and forth between the inside stance and the outside stance reveals emergent qualities of the information phenomenon. It reveals at the same time that processes and structures of information transmute into one another.

The historical and logical account of information that ensues aims at comprehending both what different manifestations of the phenomenon of information have in common and what is unique to them. Historical manifestations of information descend from earlier manifestations but do not derive from them logically. With each historical manifestation that is to be conceived of, the concept of information is enriched by features not characteristic of it so far and extended so as to make the universal and the concrete unify in order to include the manifestation in the extension of the meaning. No concrete concept of information can be deduced from a more abstract concept, but an abstract concept can be deduced from a more concrete one.

3. A UTI View – Bateson Revisited

A Unified Theory of Information (UTI) as proposed here is a system theoretical concretisation of the integrative view developed above in philosophy-of-science terms. The core of it is the assumption that the process of self-organisation coincides with the process of information-generation (sign-production). The respective results (self-organised order and information or sign) also coincide. The concepts of self-organisation and information (denoting both the process and the result of the process) turn out to be co-extensive (Hofkirchner 2012). What does that mean? –

Self-organisation is the spontaneous build-up of order of, or in, complex systems far from thermodynamical or chemical equilibrium. Self-organisation is the way systems come into existence or change their structure, state or behaviour and the way they maintain themselves (their structure, state or behaviour). Self-organising systems are complex systems in between cosmos and chaos, that is, self-organising systems find their way between determined order and indeterminate disorder to exhibit a behaviour that is the most flexible, adaptable and creative. Self-organising systems have the freedom to choose between several alternatives which make up a non-empty space of possibilities. This contrasts with mechanical systems, in which there is only one possibility.

Self-organisation stands at the beginning of all information insofar as the system selects one of a number of possible responses to a causal event in its environment, shows preference for the

[1] Ludwig von Bertalanffy called the epistemological stance of his General System Theory "perspectivism" (1965), which I draw upon.

particular option it chooses to realise over a number of other options, and decides to discriminate. Every system acts and reacts in a network of systems, elements and networks, and is exposed to influences mediated by matter and/or energy relations. If the effects on the system are fully derivable from, and fully reducible to, the causes outside the system, no informational aspects can be separated from matter/energy cause-effect relations. However, as soon as the effects become dependent on the system as well (because the system itself contributes to them), as soon as the influences play the role of mere triggers for effects becoming self-organised by the system, as soon as degrees of freedom intervene and the reaction of the system is unequal to the action it undergoes, the system produces information. Information is created if the number of effects exceeds that of causes in a system. Information occurs during the process in which the system exhibits changes in its structure, state, or behaviour (Fenzl and Hofkirchner 1997), i.e., changes brought about by the system. Information is created by a system if it is organising itself at any level.

The paradigm shift from the mechanistic worldview cognisant of objects only toward a more inclusive view of a less-than-strict, emergent, and even creative universe inhabited by subjects too, gives us the tools to connect the notion of information to the idea of self-organisation. The idea of systems intervening between input/cause and output/effect and thus breaking up the direct cause-effect-relationships of the mechanistic worldview facilitates, if not demands, the notion of information. This is because information is bound to the precondition of subjects and their subjective agency. Self-organising systems that transform the input into an output in a non-mechanical way, that is, in the context of an amount of degrees of freedom undeniably greater than that of a one-option only, are subjects. And each activity in such a context, each acting *vis-à-vis* undeniable degrees of freedom, equates with the generation of information: the act to discriminate, to distinguish, to differentiate, is information.

Information might then be defined as a relation by which, from the perspective of a self-organising system (that maintains itself *vis-à-vis* its environment), a spontaneous build-up of order corresponds to a perturbation in the environment. Information is generated if self-organising systems relate to some external perturbation by the spontaneous build-up of order they execute when exposed to this perturbation. In the terms of triadic semiotics, the self-organising systems, by doing so, assign a signification to the order and make it a sign which stands for the so signified perturbation.

The subject-object-dialectical stance is concretised by taking information as mediation of the interaction of self-organising systems (subjects, quasi-subjects and protosubjects) with their environment (objects). The emergentist-materialist stance is concretised by looking upon information as the building up of order (an “ideational” process) as well as the order itself (a material structure) that stands for some perturbation in reference to the system’s maintenance conditions or goals. And the perspectivistic stance is concretised by a methodology that shifts the perspective from the (interior) emergence of information to the (exterior) emergent structure, state or behaviour of the system (order) and back.

According to a quote from Bateson, which advanced to his famous definition of information, information is “a difference which makes a difference” (1972, 453). In the framework of a UTI as developed above, this saying might be reformulated as follows: we can speak of information if there is a difference in the environment of a self-organising system that makes a difference to this very system; a difference in the environment might be instantiated by an event or an entity, and the difference made to the system might manifest itself as a change in its structure, state or behaviour, which might be observable or otherwise intelligible. Information is a tripartite relation such that (1) Bateson’s “making a difference” is the build-up of the self-organised order; (2) Bateson’s “difference” that makes the difference is the perturbation that triggers the build-up; (3) Bateson’s difference that is made is made to the system because the perturbation serves a function for the system’s self-organisation. In semiotic terms, (1) a sign (= the self-organised order) relates (2) a signified (= the perturbation) (3) to a signmaker (= the system).

In system-theoretical terms, a perturbation is an objective event or entity that, potentially, might make a difference to a system’s requirements or goals. It actually makes a difference only if its objective significance is subjectively responded to by the system and a process (self-organisation) is implemented by which a signification (the build-up of order; the making of a sign) designates the perturbation from the system’s point of view. The bipartite signification-significance relation between the system and the perturbation is replicated, becomes independent, takes on a life of its own, when becoming reified in the sign and thus upgraded to a tripartite relationship.

Thus the very process of self-organisation fulfils Bateson’s definition. This is so because self-organisation refers to an event or an entity in the environment of the system which represents a difference; it is a creative activity of the system in the course of which novelty is produced in its

structure, state or behaviour that is related to the difference and marks a difference in the development of the system. In that vein, self-organising systems display information generativity. Information is produced in each self-organisation process. And, the other way round, Bateson's idea can be interpreted as a step toward a complex systems view of information.

4. Do Computers Make a Difference? The Limits of Computation and the Quest for Meaningful Technology

The UTI notion of information which is a universal notion can be differentiated to cover the whole universe of information. Information processes and information structures of different self-organising system types in intrasystemic, intersystemic and suprasystemic dimensions can be illuminated. The universe is populated by informational agents of the same kind and of different kinds as well. All of them are related according to their origin, which makes them form lineages, and according to an all-encompassing architecture, which makes them form encapsulations. Each stage of information generation and utilisation has a preceding one that builds the foundation from which it emerges in the course of evolution; and each layer of information generation and utilisation rests upon a lower one that builds the foundation from which it emerges along the hierarchy.

The lineages and the architecture are contingent. One stage is only the necessary condition for the following stage and one layer is only the necessary condition for the next higher layer. However, they do not represent a sufficient condition. This is so because information is a valid concept in situations where the deterministic connection between cause and effect is severed, a system's own activity comes into play, and the cause becomes the mere trigger of self-determined processes in the system, which finally lead to the effect, and the system makes a decision and a possibility is realised by an irreducible choice. That is, information generation is a process that allows novelty to emerge. For that reason, it goes beyond a mechanical process that can be formalised, expressed by a mathematical function, or carried out by a computer (Hofkirchner 2011a).

Formalisation makes it possible to apply intellectual methods provided by formal sciences such as formal logic, mathematics, or computer science; these methods involve deducing a conclusion from its premises or calculating a result or a computer operation (Krämer 1988). Due to their nature, however, these methods of mental transformation lead unequivocally from something that is given in the mind (as a starting point) to something that follows from it in the mind (as an end point). What works as a starting point is interpreted as a model of the cause in a real-world process; what plays the role of an end point is taken as the model of the effect. The whole transformation in the mind functions as a model of a causal relationship that is so by necessity and not contingent. These formal methods apply only in the case of a mechanical process. Mechanical processes can be mapped onto algorithmic procedures that employ clear-cut and unambiguous instructions conducted by computers as universal machines. Like the underlying deduction procedures, mathematical operations on computers cannot reveal emergent processes in the object. Deductions, by definition, do not yield novelties. By definition, neither do algorithms or computation. The distinction between the property "deterministic" and the property "probabilistic" concerning automata is, in this context, misleading. Probabilistic machines also rely completely on strict deterministic mechanisms in the sense defined above and are thus mechanistic. This is true despite their inclusion of, e.g., "random numbers", which are, in fact, pseudo-random numbers produced by strict deterministic mechanisms (Fuchs-Kittowski 1976, 193). Machines do not choose. Claiming that they do would blur the distinction between the way mechanical devices work and the way systems endowed with subjectiveness (self-organising systems) act. At best we can say that probabilistic computing is a way to simulate less-than-strict deterministic processes of real-world systems; nonetheless, it is not exactly the way these processes work in the real world.

Hence the limits of computation. Information processing as it is done in computers cannot be considered to be the role-model for information processes going on in the universe. Computers cannot generate information, since information generation involves emergence.

However restricted, computers nevertheless can make a difference. They can play an essential and indispensable part within self-organising (natural and social) contexts. Current computations find their *raison d'etre* in assisting, augmenting, supporting human information generation. We are in urgent need of tools that help intervene in the world we inhabit, for we have lost control of it (if we ever had it). Given that complete control is out of reach, the aim is to regain the steering capability at least to the extent that a breakdown is avoided; this is to be achieved by keeping the frictions in, among and in between the social, natural and artificial subsystems of the emerging world society below the threshold of causing a breakdown. The scientific-technological revolution we are witnessing provides the technology to decrease frictions appearing in the functioning of all systems. This opens up a new dimension when interpreting "the global problems […] as frictions in the func-

tioning of the information generation of those systems that make up world society", as the author wrote in a paper more than a decade ago (published as Hofkirchner 2000). Those systems are physical, biotic or social systems that are made into subsystems of the overall societal suprasystem of humans. Humans, by way of the suprasystem, are constantly engaged with those systems and they can do nothing but intervene in those systems. This intervention might be in accord with the self-organisation capacities of the systems or might be dissonant, tending to disable their self-organisation capacities. In the first case, frictions will be decreased or, at least, not increased, whereas in the second case such frictions are not decreased, eventually running the risk of damaging the system. Information technologies, knowledge-based technologies, and technologies for co-operation all can support self-organisation processes and thus ease the frictions occurring in systems they are applied to.

The UTI perspective understands information structuration processes as activities conducted by self-organising systems. These systems have the information structure – which is a sign – on their macro-level; on the micro-level they have the information process as the generation and utilisation of the information structure by their elements – which are informational agents themselves. These systems reside on different levels of the societal build-up – on the social level (cultural, political, economic systems), on the environmental level (natural systems of all kinds with which social systems interact), and on the technological level (artificial systems by which social systems interact with natural systems). The object of investigation is the nature of these information varieties and their friction reduction potentialities, whose study can help optimise their synchronisation, safeguard social, environmental and technological compatibility.

This approach provides an effective warranty that turns information society into what shall be called a "Global Sustainable Information Society (GSIS)". A GSIS signifies the socio-political framework necessary for tackling the global challenges. It can be defined as a society that is (1) existent on a planetary scale only, because it is (2) able to act upon the dangers of anthropogenic breakdown, because it is (3) capacitated to generate and utilise knowledge that serves that function (Hofkirchner 2011c).

In human systems, self-organisation is mediated via consciousness which is the special form that information processes assume in human systems. Conscious intervention can optimise human self-organisation as well as self-organisation in other systems in which it intervenes, and reduce frictions. ICTs inhere a potential for enhancing human collective intelligence that is needed to cope with the global challenges by reducing imminent frictions. ICTs, however, can also be used to prolong exclusions and hinder the advent of a GSIS. The inclusion of stakeholders in the genesis of technology makes the design process a participatory one and ensures a discourse that will marginalise minimise exclusions.

The vision of the GSIS has implications for the study of ICTs and society. The vision of the GSIS does not orient itself towards a utopian "nowhere", but searches for real possibilities, i.e., possibilities anchored in reality. They are concrete and demonstrate that the search for a better society is not in vain.

Ultimately, social frictions, which tend to multiply and propagate throughout the subsystems of the societal suprasystem and become manifest in frictions of all kinds – social, biotic, physical – in the subsystems, can be reduced by reducing the social frictions on the suprasystem level. Sustainability can be achieved by reducing frictions.

Note that only a vision of a good society such as the GSIS provides a defensible reason for technological developments that are senseless in themselves unless coupled to humane values. Such values make them a proper means to a justifiable end.

This calls for examining the following three developments that represent the spearheads of the ICT-shaped infosphere. These three are classified according to the realms of prebiotic matter, non-human life and human society:

1. pervasive or ubiquitous computing or ambient intelligence: technologists promise to make our human habitat smart, that is, equipped with chips linked to a net to become, in a tailored way, responsive to individual needs such as switching off the light and turning on music;
2. in analogy to this Internet of Things, an internet of living beings, of organisms, that are inhabitants of our *umwelt*: in this type of artificial web of life, we would no longer lose our pets; and
3. the internet on the level of the networked individuals of a Facebook society, a society of self-advertisement.

Each of these developments is devoid of sense. As such, each resembles the gadgets we know from our experiences as participants in the network society, unless safeguards are installed to en-

sure that they serve a humane purpose. Applying a GSIS perspective can, however, set the stage for the development of meaningful technologies in an evolutionary context. Meaningful technologies are technologies that help reduce the frictions in the systems making up the edifice of our world today. Technological applications are to be questioned, and the question is: are they likely to serve the purpose of a GSIS? Actually, the process of design is to start with identifying a societal problem and to be continued with the search for appropriate applications and not the other way round as is done under technocratic premises. Research and development, starting with the last quarter of the last century, have been streamlined world-wide according to neoliberal economic policies of liberalisation, privatisation, and deregulation rather than to the general statement that science at any time is part of society and thus responsive, be it in a direct or an indirect manner, to historically developing societal needs. It is the short-sighted economic interest that has been taken command in scientific affairs. Given the confines of economic profitability and competitiveness, the credo of technocracy is in force that runs "realise everything that is feasible". Thereby it is falsely presupposed that everything feasible (again, taken for granted it is economically reasonable) is desirable too and hence a reflective, theoretical, deliberation of norms, values, morals is not needed or, at best, is replaced by *a posteriori*, empirical, inquiries about the acceptance of technology by users. In fact, this detracts from taking into account problems that are more fundamental than those of rentability (Bichler and Hofkirchner 2009).

5. Conclusion

Bateson's saying that information is a difference that makes a difference can be re-interpreted in system-theoretical terms such that self-organising systems qualify for being agents that are capable of (re)cognising differences that make a difference to the agents themselves.

Such an assumption as held in a Unified Theory of Information aims at bridging the gap between hard and soft notions of information.

Computers, however, do not qualify for being agents capable of dealing with differences that make a difference to the computers themselves, since computers are artificial and mechanical systems and not natural or social self-organising systems in which emergence of novelty can take place. Yet computers can make a difference to human-dominated systems if they help reduce the frictions in natural or social systems and contribute to a Global Sustainable Information Society.

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About the Author

Wolfgang Hofkirchner
Associate Professor for Technology Assessment, Vienna University of Technology. Tries to promote a new science of information that comprises studies in information, information society and information technology.