

Towards a Unified Theory of Information

The Merging of Second-Order Cybernetics and Semiotics into a Single and Comprehensive Information Science

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The starting point for this paper is the fact that in societies which are entering the information age there is a lag of scientific development behind societal development, in that a science of the information society has not had time to develop. An information science may accomplish the task of serving as a suitable background for meeting the demand for governance vis-à-vis the challenges of the information age, if and only if it undergoes a transformation towards a single and comprehensive scientific undertaking. For this purpose, it has to be based upon a Unified Theory of Information (UTI) which, in turn, is made feasible by the merging of the concepts of self-organization and semiosis. Adjustments are necessary on either side. The well-known semiotic aspects will have to be rearranged so as to relate each of these to a certain system level, and to relate different types of sign processes to different stages in the evolution of systems, respectively. That is what I am going to deal with in the following.

The ordering of sign relations

We start with C. S. Peirce's concept of the triad of syntactic, semantic and pragmatic sign aspects which is to be reformulated in terms of evolutionary systems theory.

A sign is defined, then, as the product of an information process. An information process consists of drawing a distinction. It occurs whenever a system organizes itself, that is, whenever a novel system emerges or qualitative novelty emerges in the structure, state or behavior of a given system. In realizing novelty like this, a distinction is drawn. So information is produced. The information is embodied in the system and may then be called sign.

- Insofar as the distinction that is drawn is related to what it differs from, that is, to a different system or a different system structure, state or behavior from which it took its departure, a relation among signs is established. The new sign is not reducible to the old signs, but is nevertheless dependent on them, for these provide the range of possibilities from which one is chosen. This may be referred to as syntactic relations of signs.

- Insofar as the distinction that is drawn is related to an occasion on which it appears, that is, to some perturbation which is located outside the system and which played the role of the trigger of the self-organization process, a relationship between the sign and the environment of the system is established. It may be said that the sign represents something outside the system, so that the sign gains significance. This is what semantic relations of a sign are taken to mean here.

- Insofar as the distinction that is drawn is related to something to which it makes sense, that is, to a certain frame of reference which is provided by the self-organizing system there is a relation between the sign and the system's aims. It's the system which does the signification according to its aims. This is what shall be understood by pragmatic relations of a sign.

It is sensible to encapsulate the sign relations as follows: the sign-sign-relation is the innermost one; it is embedded in the sign-sign-object-relation which, again, is part of the sign-sign-object-subject-relation. The outermost relation shapes the preceding ones which, in turn, build the prerequisites of the higher levels, as is customary with nested hierarchies. Given the evolution of self-organizing systems, the appearance of signs and their syntactic, semantic and pragmatic properties have to be differentiated into as many types as types of systems may be distinguished. According to the familiar categorization of abiotic, living and socio-cultural systems, at least three stages of the evolution of sign manifestations will be sketched here.

The emergence of patterns

The most primitive sign manifestation is to be found with the most primitive kind of self-organization processes, that is in processes by which systems restructure themselves. Systems that are capable of self-restructuring are so-called dissipative systems. Thermodynamically speaking, they dissipate the entropy which is the byproduct of performing work when restructuring. In performing work they degrade energy and they succeed in getting rid of it which is necessary to qualify the building of the new structure as generation of a higher order rather than a degeneration of the system. The process of the structuration ends up in a spatial and/or temporal pattern. Since this process is an information process, pattern formation is the most rudimentary form of producing signs. The pattern is the distinction that is drawn by the system.

In the pattern in nuce all three semiotic relations can be found.

- First, concerning the syntactic relation, pattern formation is a kind of recursive process which builds upon the pattern which was there before, and selects one out of several possible new patterns. That is, the system is not able to assume any structure at any point of time. There is a kind of path dependency in this.
- Second, in as much as it is energy input into the system that enables it to change its pattern, the input becomes a signal that gives rise to the new pattern, though not completely determining it. The signal makes the state the system adopts when forming the pattern a representation of the input. Thus the semantic relation comes into play.
- Third, as pattern formation is the observable behavior in which the system expresses its activity, the pragmatic relation is thematized.

However, in the pattern the three semiotic relations coincide. They are not yet differentiated from each other. They form a (syntacto-semanto-pragmatic) bundle.

It may be said that forming patterns is the way self-restructuring systems reflect (some change in the) conditions in the environment of the system. They have the ability to reflect. Reflective, self-restructuring systems mark the leap in evolution where semiotic relations were distinguishable from material relations, but did not show any further distinctions among the members of the first group. Simple self-organizing systems in the physical and chemical domain are instances of this stage of evolution (see fig. 1).

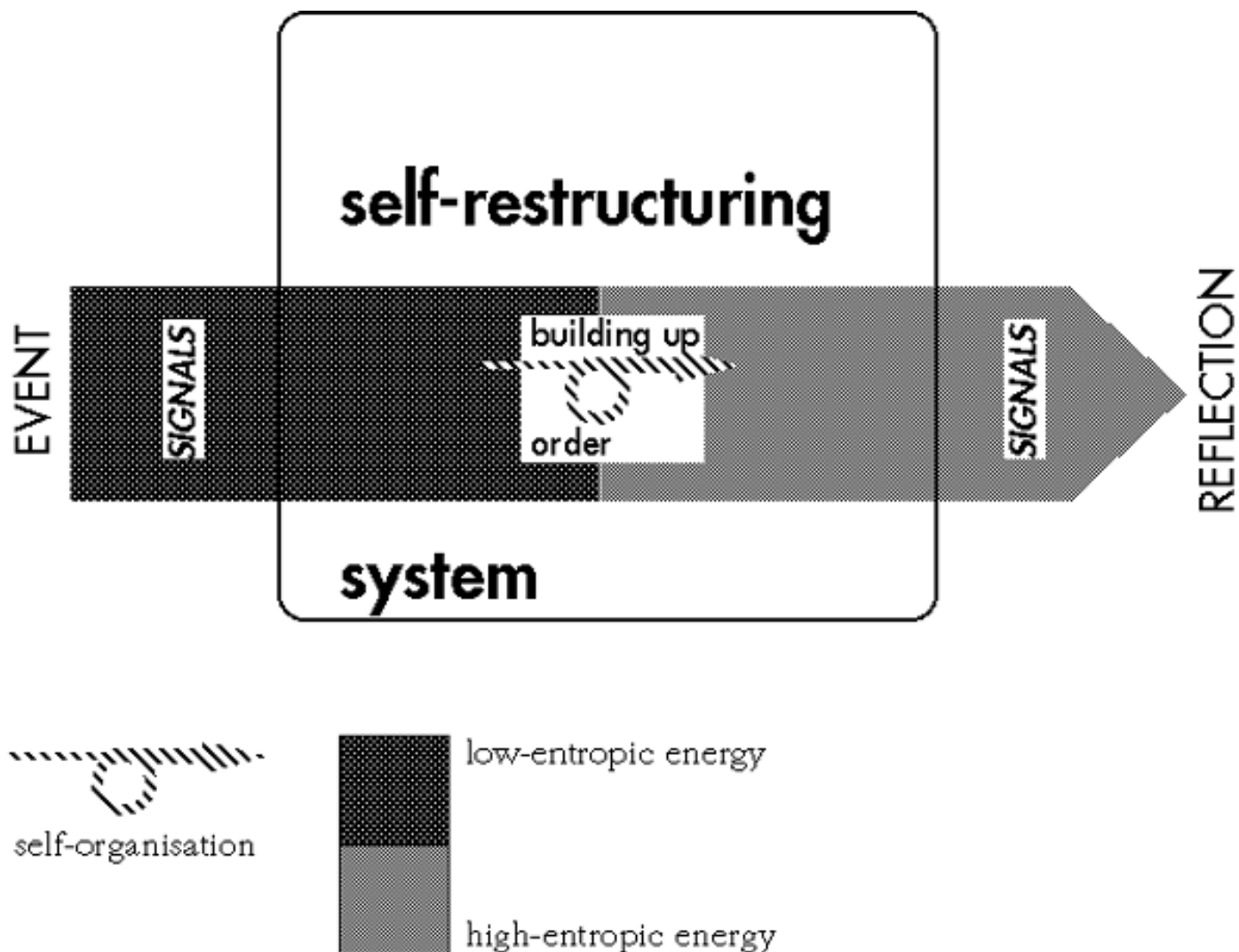


Fig. 1: Semiosis in dissipative systems: Pattern formation, reflectivity

The emergence of symbols

Another qualitative leap may be postulated to have occurred when chemo-physical systems refined the dissipation of entropy in that they exhibited the property of being able to maintain their order by producing the components which they were composed of, that is when dissipative systems turned to autopoietic ones. Autopoietic systems perpetuate the throughput of energy to such an extent that they may be called not only self-restructuring, but also self-reproducing. They not only change their structure in a way which they, more or less, choose by themselves; they also introduce these changed structures in a broader context, namely in the context of how to let the structures contribute to maintaining their existence. Self-reproduction requires structures to be functionalized for survival. Functionalized structures are not plain patterns any more, but something that contains a meaning. This something shall be called symbol here. Thus sign production on this stage of evolution, in living systems, turns from pattern formation to the formation of symbols.

The tree of the evolution of semiotic relations hereby shows a ramification. The former syntacto-semanto-pragmatic line splits up into a more syntactic one and a more semanto-pragmatic one.

- The first of these refers to what is known as sensations in living systems. Sensations are self-organized restructurations which are evoked by perturbations from the outside, but are not determined by them, and therefore not reducible to them. Sensational restructuring joins on the structures which were provided by the sensorium before. This is a recursive process in which symbols are produced and which has a syntactic implication again.

- The second of them refers to the effectorium of living systems and to the process in which actions are carried out according to given sensations. Living systems act in response to what sensations are meaning. That is, they assign a meaning to the sensations, they interpret them in terms of survival relevance. The

sensational structures may mean that the stimulus they represent (that is the semantic aspect of the sign relation) is either beneficial or detrimental to the survival of the system or neutral (that is the pragmatic aspect of the sign relation). Sensations become a means to effectuation. The syntactic dimension of the difference between the old and the new structures is supplemented by the fact that this difference makes a difference regarding the goal of maintaining the system and a semantic-pragmatic dimension is added by means of which symbols emerge. Symbols are signs that symbolize the attitude of the systems towards conditions in the environment.

It can be said that self-reproducing systems show intended reactions on stimuli they take up. By means of sensing and reacting they are able to improve their adaptation to the environment. Sensitivity and reactivity constitute intelligence (see fig. 2).

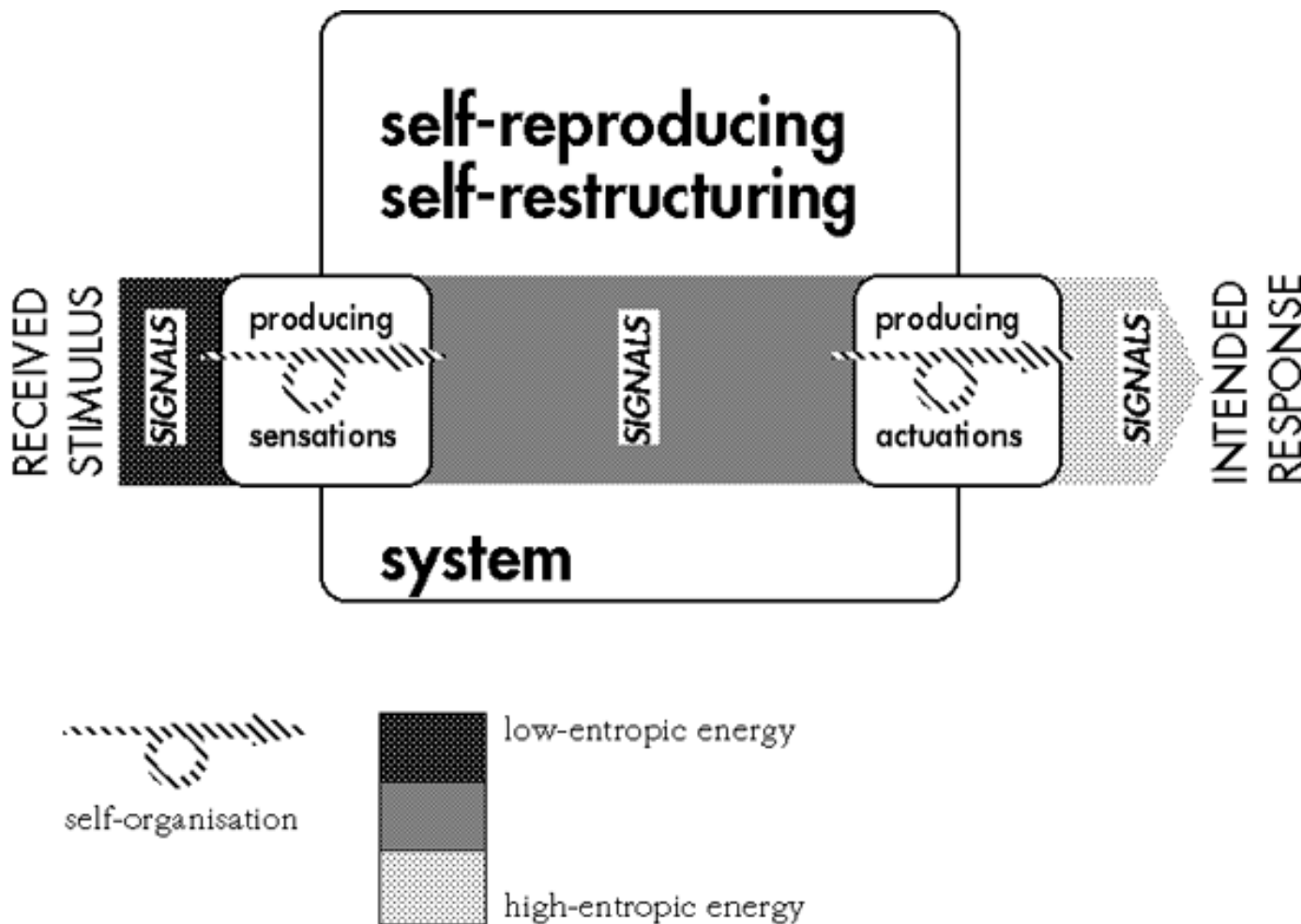


Fig. 2: Semiosis in autopoietic systems: Symbolization, intelligence

The emergence of ideas

Social systems formed by humans are the instances of a third stage of evolution of self-organizing systems and semiosis as well. Social systems are autopoietic systems which do not merely (re)produce themselves and strive for survival, but in doing so seek additional goals, which they are committed to and they have chosen on their own. While they aim at realizing these goals they aim at realizing themselves and when they succeed they can be said rather to have created or re-created themselves – they are re-creative systems. They can create the conditions necessary not only for their reproduction, but also for creating themselves according to the goals they have determined. As they alter their environment to suit themselves, they exhibit even greater adaptability than mere biotic systems. They can be classified as self-determining because due to the self-organization approach it is supposed that when they face a variety of options which are possible under certain circumstances it is for them to decide which option they select. This selection takes the shape of a decision which is made under the condition of an irreducible freedom of choice, and by this characterizes an emergent quality which separates the pragmatic from the semantic. Consequently, at the stage of social, re-creative, self-determining systems another symmetry is broken, and the semiotic relations unfold into the well-known three levels of sign production, which will be described

here as the formation of ideas.

The formation of ideas comprises three steps: first, the perception of signals from outside the system which makes a sign emerge that is a modification of the system structure; second, the interpretation of perceptions by which the state of the system is modified and another sign emerges which signifies something that is given to the system as its object; and, third, the evaluation of the interpretations which lets another sign emerge, by which the system as subject completes the signification in that it makes the object an initial state for reaching some final state, and affects the behavior of the system so that it may be modified. At the first level, the sign may be called data; at the second, knowledge; and at the third, wisdom. Data is what experience of various sides produces. Knowledge is insights. And wisdom is attained in the course of instructions and orientations of actions according to self-set aims. From one step to the next, there is a leap in self-organization. Each step is the base from which another may or may not follow. A fully developed idea has walked across all of them.

Perceiving, interpreting and evaluating altogether are the features of consciousness. Consciousness is the capability of self-determining systems to take some perturbations as initial or side conditions for reaching a goal which is set by the systems themselves. In order to reach the goal, the system defines purposes to be served, and in order to serve the purposes it designs means.

Unlike pre-human biotic systems, which are marked by awareness of the environment and by having models of the environment at their disposal, consciousness is a characteristic of social systems that has requirements on the level of the elements of the system, that is, individual actors. Here models must be built that cover the relation between the system and the respective element, that is, include the system as a whole and the element which builds the model as a part of the whole as well. The model contains what a certain element expects other elements to do and what the element in question assumes other elements to expect from it. Consciousness is by that self-consciousness (see fig. 3).

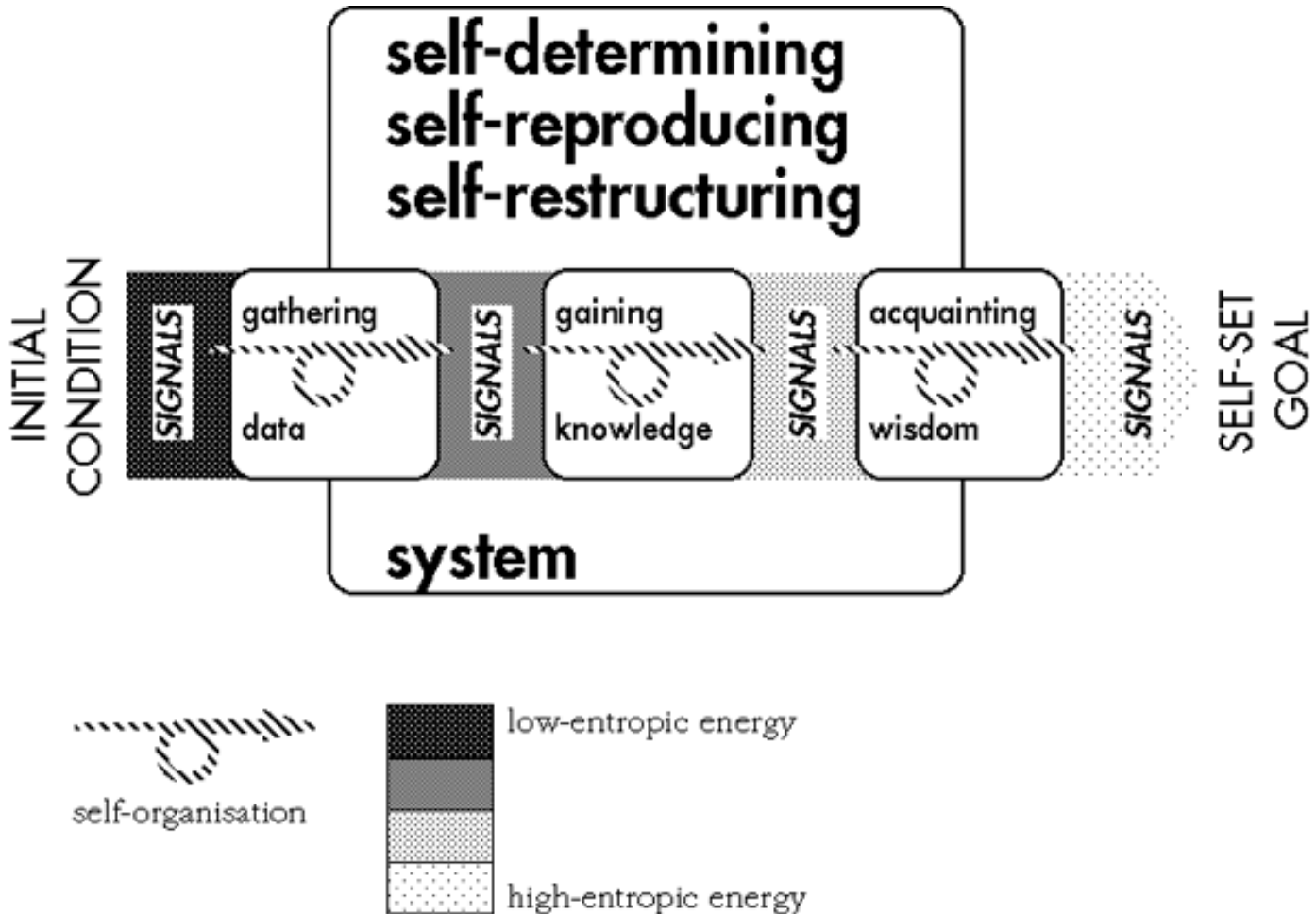


Fig. 3: Semiosis in re-creative systems: Formation of ideas, consciousness

The indeterminacy of sign processes

Reflective pattern-formation in dissipative systems, intelligent symbolization in autopoietic dissipative systems, and conscious formation of ideas in re-creative autopoietic systems represent but three stages in the evolution of sign processes, and it goes without saying that they may be differentiated into a much wider variety of types of semiosis. The hypothesis of semiotic evolution presented here is taken as an offer for a frame which could guide future work.

A hypothesis like this tries not only to make consistent several approaches to self-organization, and self-organization approaches with semiotic considerations, but also to overcome mechanistic assumptions underlying many naturalist stances, especially the so-called information-processing paradigm in cognitive sciences, artificial intelligence, and so on, which is criticized widely (Brier 1997). Mechanistic shortcomings are due to the clockwork view of the universe which was made explicit by the well-known idea of Laplace that a demon who knew the world formula, plus all data describing a certain state of the universe, would be capable of predicting and retrodicting any state of the universe. According to this theory, causes and effects are related in such a way that each cause is related to one effect and only one effect so that equal causes have equal effects and distinct causes have distinct effects. In this view all events are determinate – fully determinate. Failures to explain or predict some events are at the expense of the subjective side only, that is, there is knowledge missing – knowledge of the natural laws or knowledge of all of the initial or side conditions both of which are required to draw conclusions with compelling logic.

It is, however, at the expense of the objective side when investigations into self-organization phenomena reveal that determinism is hardly complete. It is complete (and therefore, in principle, discoverable) in systems at or near thermodynamic/chemical equilibrium only, but not in systems exposed to fields in which the uneven distribution of energy density exceeds a critical level. In these systems, in fact, there are no transformation mechanisms which unambiguously turn the causes into the effects; on the contrary, causes and effects are coupled in a way that allows different causes to have the same effect, and the same cause to have different effects. This is to say that nature itself is capable of spontaneously producing events which are not describable in a mechanistic way, and that besides and beyond clear-cut one-to-one cause-effect-relations there are more flexible causal connections in the real world, too. These connections are due to the fact that self-organizing systems have the freedom to choose between several alternatives, compared with mechanical systems where there is only one possibility. Connections like this are meant by the relationship of reflecting some event in the environment in the case of a pattern-producing system, by the relationship of some taken-in stimulus and the intended response to the stimulus in the case of a symbol-producing system, and by the relationship of finalizing some event as an initial condition for pursuing a self-determined goal in the case of an idea-producing system. Along this typology, causes and effects are more and more mediated via self-organization cycles, none of them leading to plain results which are foreseeable in detail, but providing the base for the emergence of qualitative novelty.

References

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