

EMERGENCE AND THE LOGIC OF EXPLANATION AN ARGUMENT FOR THE UNITY OF SCIENCE

Wolfgang Hofkirchner

Social Cybernetics Group
Institute of Design and Technology Assessment
Vienna University of Technology

Abstract

It does not come as a surprise that, due to the rise of self-organization concepts, the concept of emergence has been revisited. Actually, the latter may serve as a proper philosophical foundation of the former, if the self-organization paradigm is understood as a turn away from the mechanistic world view and if the philosophy of emergence gets rid of its idealistic heritage as well. The paper outlines the basic pattern of emergence set up in such a way as to comprise the diachronous dimension of evolution along with the synchronous dimension of hierarchical systems. Having recapitulated these ontological premises it discusses how explanations are supposed to work. Since indeterminacy is deemed here to play a vital role in emergentist arguments, dialectical reasoning is proposed to augment considerations that are based on formal logic only. Thus the old logic of explanation à la Hempel/Oppenheim turns out to be just a special kind of argumentation which applies to mechanical systems instead of evolutionary systems. The paper concludes by showing that – contrary to the naturalistic misunderstanding which assumes an extension of methods of natural science to the domain of social science – it is, in fact, by virtue of taking indeterminacy into account that the new logic of emergence and downward causation prepares the grounds for unifying natural and social sciences.

Keywords

Evolutionary systems, determinism, explanation vs. understanding, reductionism, holism, dualism, emergentism, dialectics, social science

Introduction

Since the sixties and the seventies, when for the first time in science theoretical considerations and experiments were carried out in terms of self-organization, the replacement of system theory I and cybernetics I with system theory II and cybernetics II and the overcoming of the restricted Darwinian model of biological evolution have set the stage for synthesizing systems thinking and evolutionary thinking, and for elaborating on a general theory of evolutionary systems – a theory which is to comprise the interweaving and the rise and fall of real-world systems whatsoever. This paradigm shift affects not only the disciplines of science one by one. It is so profound a change that it affects philosophy and world view as well.

In this paper I will focus on the following ontological and epistemological implications of evolutionary systems thinking:

- (1) How is self-organization supposed to work in real world systems?
- (2) What kind of explanatory power does the formula of self-organization contain?

Self-organization and emergence

In order to do justice to the revolutionary potential inherent in the new way of thinking it is obvious that we should link self-organization to emergence and to clarify the ontology of emergence. It will be shown that emergentist thinking does not make sense unless it dismisses mechanistic and idealistic presuppositions.

Self-organization may be looked upon as the way evolutionary systems come into existence or change their structure, state or behavior and the way they maintain themselves or their structure, state or behavior. In either case it is a process in which a difference is produced or reproduced, in that a quality, which differs from the qualities that existed before a certain point of time is made to appear or, from that point on, is sustained vis-a-vis and by virtue of co-existing qualities from which it differs. That is, in either case emergence is the underlying process. Thus a philosophy of emergence seems the proper background theory of evolutionary systems thinking.

Emergentist philosophy has to tackle both the dialectic of old and new and the dialectic of parts and wholes. The first of them refers to the diachronous aspect of reality processes which show a sequence of consecutive phases, and the second of them refers to the synchronous aspect of reality structures in which layers are built upon each other and form a kind of hierarchy. And emergentism should be in a position to couple these aspects and embed them in a single perspective.

Roughly speaking, there are three fundamental alternatives in theorizing the relations of old and new and of parts and wholes.

The misperception of the dialectic of old and new

As to the first relationship, evolution may be conceived in two controversial but likewise unsatisfactory ways.

First, evolution is said to be nothing other than unfolding of something folded. In this concept everything that appears at a certain point of time was only hidden before that point, but,

actually, it has been existent from the very beginning and it does so necessarily. Emergence would be interpreted as coming to the surface only of what is pre-existent ever since. This view is the basis of preformation theories, according to which germs inhere completely what will represent the outcome of its development.

This concept is a monism. It may be materialistic, in the sense that it is laws of nature that it believes determine what happens, or idealistic if the determining role is ascribed to perennial principles incorporated in the processes in question. Due to the monism the new is not new at all because it does not differ from anything old, but in the point of time of becoming observable. Therefore this assumption is unable to grasp the nature of the old-new-relationship.

Second, it is assumed that at any moment any event may occur either by blind chance or by the will of some supernatural power (in a materialistic or idealistic meaning, respectively, again). Then emergence denotes emergencies taking place like the bolt from the blue. Evolution is nothing more than a contingent scattering of separate and unforeseeable events along a time-scale. Determinism is denied.

This concept is dualistic (pluralistic). It postulates an unbridgeable divide between the existence of the old and the existence of the new. New events are deemed in no way commensurable with older ones. Therefore this understanding is unable to solve the problem of interrelatedness of old and new, either.

The misperception of the dialectic of parts and whole

The same holds for the second relationship. Thinking identity and thinking duality in the same strong version represent, again, two unacceptable options of conceiving the systemic ordering of the processes of structuration.

The monistic view overlooks the different qualities at the different system levels which

are, in turn, made an absolutum by the dualistic (pluralistic) one. While the first levels down the whole to a mere composition of its parts (that is: reduces the qualitative property of the whole to that of the parts) or levels up the parts as being perfect mirrors of the whole (that is: projects the qualitative property of the whole onto that of the parts), the second hypostasizes the dichotomy of the parts and the whole in stating that any parts whatever may compose one and the same whole or that the same parts may compose one or another whole.

In the end, the differentiation between parts and wholes either is blurred or makes up two modes of description which cannot be reconciled. On the one hand, the parts determine the whole or the whole determines the parts supposedly to such an extent that any difference is wiped out. On the other, independence of existence is postulated and any possibility of translation of one side in the other is denied.

Either view can be interpreted in materialistic or idealistic terms again.

Dialectical emergentism as a philosophy of self-organization

Contrary to that, dialectical reasoning in applying the Hegelian figure of sublation („Aufheben“) with its three connotations tries to think continuity and discontinuity in one and, beyond that, to establish a relation between the processual and the structural. The first connotation means that the old is suspended by the new in that the latter puts an end to the former in its role as the dominant factor in the functioning of a whole. The second connotation means that the old is, additionally, preserved, that is, when it ceases to play the decisive role it is not totally eliminated, but kept in store to form a part of the new whole without being number one. The third connotation means that the old is, finally,

raised to another stage, that is, when forming a part of the new whole it is forced to undergo a change so as to fit the new whole and represent the proper base on which the new is building up.

To put it in other words: continuity is taken into account, because the evolution of the new does not cut the system free from the old and the whole of the system does not evade the composition of its parts. At the same time, discontinuity is considered in saying that in evolution the new and the old strive for dominance of systems or within systems and that in a system hierarchy the whole and the parts influence each other without gaining full control of each other. This interplay of continuous and discontinuous factors reflects the path dependency of systems in evolution for which there is evidence in science.

Regarding the concepts of evolution and development respectively, the new emerges from the old, it originates in the old system or within the old system conditions, but has the potential to transcend it or its conditions. Regarding the system concept, having realized this potential a new system has evolved, or a new system behavior, a new system state or a new system structure has developed which exerts a pressure on the remaining old to make it parts of itself or its conditions, and thus emergence turns into dominance. By this a link is established between the dynamic and the static as two sides of one coin and a comprehensive foundation for theorizing self-organizing systems and their development and evolution is prepared.

Thus a general scheme of self-organization may be sketched. It may look like figure 1: the arrows indicate processes of structuration (in which the structural moments are produced, namely not only the system itself but also the elements) and the ordering of the entities between the arrows at the bottom and the top indicates the structure of the processes (the differentiation of a micro- and a macro-level).

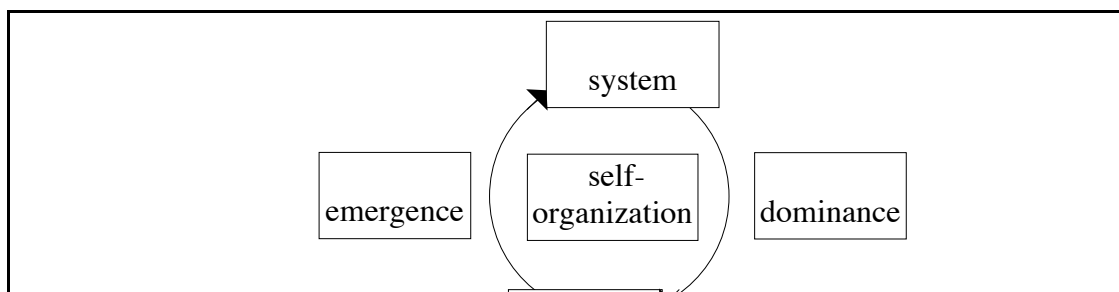


Fig. 1: Self-organization

Emergence and determinism

The interpretation of emergence of entities, properties, relations in dialectical terms seems the only fruitful and convincing one. This setting of emergentism, however, entails a revolutionary attitude towards determinism.

That is, if it is pointed out that one side of the correlations in question – the new, the whole – has its roots in the other and one side – the old, the parts – is shaped by the other, then each side depends on the other in another respect. And if each side depends on the other in another respect, then each side is determined by the other, though – and this is the important point – not fully, not totally, not completely; incomplete determinism – this is the ontological consequence which follows from the formula of self-organization introduced above and is supported by research into real-world self-organization phenomena.

The clockwork view

This thesis of incomplete determinism at first glance contradicts the thesis which underlies the mechanistic world view inaugurated by Newton, 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, and which in Popper's terms may be called the clockwork view of the universe (Popper, 1972).

The mechanistic view originated with science as we know it, that is with science in modernity, when empirical analysis replaced the ancient way of thinking.

The thesis of complete determinism can be characterized as follows (cf. Heylighen, 1990, Weingartner, 1996, 187–189):

(1) There are transformation mechanisms that unequivocally transform causes into effects;

that is to say, 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.

(2) Little changes in the causes lead to little changes in the effects.

(3) There are only repetitions. Each state of a system will return in the future.

In this sense *causa aequat effectum*, or – as Newton's dictum was interpreted elsewhere (Fleissner and Hofkirchner, 1997) – *actio est reactio*.

This assumption is visualized in figure 2 where the set of causes is mapped to the set of effects in a bijective way.

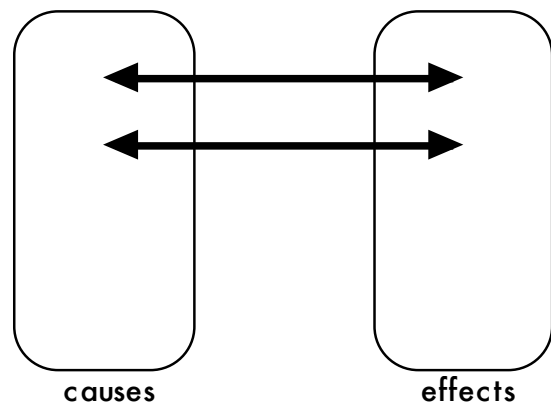


Fig. 2: Complete determinism

Incomplete Determinism

The thesis of complete determinism accounts for the clockwork view if its claim is to be valid universally. But, as science has made clear, it holds for systems at or near at thermodynamical/chemical equilibrium only. This does not hold for systems exposed to fields in which the uneven distribution of energy density exceeds a critical level. Such field potentials force energy to flow in non-linear and interdependent ways. And here the systems are showing self-organization, that is

the build-up of order out of fluctuations via dissipation of entropy.

And in this case determinism is not complete:

(1) There are no transformation mechanisms which unambiguously turn the causes into the effects; 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.

(2) Little changes in the causes may lead to big changes in the effects.

(3) The more complex a system, the less probable the return of a certain state in the future.

Thus *causa non aequat effectum, actio non est reactio*. This is the thesis of incomplete determinism. This is what ensues ontologically from findings in self-organization research. It is presented in figure 3.

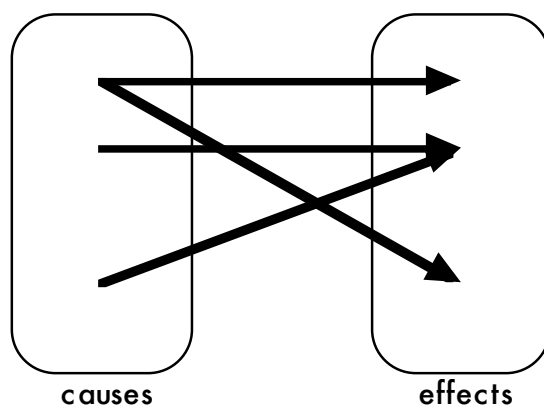


Fig. 3: Incomplete Determinism

Incomplete determinism is not to say that there is no determinism at all or that the clockwork view has to be replaced by a clouds view. It does not mean that anything goes. It only admits 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. Seen this way, strict determinacy is but a special case of causality. It applies if, and only if, the system is deprived of the freedom to choose between several alternatives.

Thus the thesis of incomplete determinism not only opposes the thesis of complete determinism but also leads to a new understanding of determinism which includes completeness as correct under certain conditions only.

Incomplete determinism and the methodology of science

If it is true that it is incomplete determinism which is drawn from research in self-organization, it is advisable to rethink how science not only empirically describes reality but also provides prerequisites for decision-making in societal practice, by producing theories which account for why things happen and how the occurrence of events can be influenced by actions, whether their object is nature or society.

It is argued that the inference formalism, which in natural science is taken for granted as the only logic of explanation and prediction, cannot apply universally and has rather to be confined to the class of completely determined phenomena. Since the bulk of methods of understanding practiced in social science reveal shortcomings, too, in that they do not aim at or fail in overcoming the fragmented picture of society which is split up by approaches that focus at either the actions of individuals or the collective phenomena like rules, regularities and resources at a systemic scale, it is proposed thus the methodology of both natural and social science be founded on dialectical reasoning. Only a dialectic-aided logic may fit the indeterminacy of our world.

The failure of the „naturalistic“ logic of explanation

Speaking in terms of formal logic, an explanation or prediction is the deduction of a

conclusion from premises such that the conclusion describes what is to be explained or predicted, and that the premises are made up of descriptions of what together is expected to do the explaining or predicting. After Hempel and Oppenheim this scheme is called deductive-nomological, if it couples empirical and theoretical knowledge by subsuming facts (empirical) under some law (theoretical) that covers those facts.

Given a universal implication as a first premise, which represents the covering law, and an instantiation of its if-component as second premise, which represents some initial or side condition, the application of the rule of *modus ponens* derives an instantiation of the then-component as a conclusion which represents just that final condition which was or will be observed. The conclusion must be realized when the premises are the case. *Per definitionem* the truth is transferred from the premises to the conclusion. Put ontologically, the existence of what is expressed in the concluding proposition is reduced to the existence of what is expressed in the propositions forming the premises.

Here the affinity of the formal-logical scheme of explanation and prediction to the mechanical ontology becomes obvious. Since the premises may be interpreted as descriptions of the causes and the conclusion as description of the effect, and since the deduction is exclusively stringent, the logic suggests a causal transformation mechanism that is strictly deterministic.

This logic is the folio of the reductionistic program in science as is pointed out in row one of table 1. Reductionism, however, fails to perceive evolution because it tries in vain to deduce the new from the old which, in this perspective, is to present the sufficient condition from which the new simply results. And it is frustrated by the systemic ordering of layers when it likewise proposes to deduce the whole from parts.

This logic is also the background of the simple anti-reductionist monistic view which is a kind of projecting of the new onto the old and of the whole onto the parts. It postulates that from the

a posteriori the antecedents are deducible and from the macro-state the micro-states. It is referred to as holism in row two of table 1.

This restricted logic is unable to cope with emergent phenomena, self-organization and evolutionary systems where explanations do not work to shed light on why in bifurcation situations a specific option out of many options was chosen, nor are predictions (at least for the nearest future) possible, nor is the fact reflected that in complex systems like social ones the slaving principle – or the principle of making a consensus – is not tantamount to fixing individuals on a certain behavior without exceptions to the rule.

	<i>old/parts</i>	<i>new/whole</i>
reductionism	sufficient condition	resulting properties/entities
holism	resulting properties/entities	sufficient condition
duclism	independent properties/entities	independent properties/entities
emergentism	necessary, but not sufficient condition	emerging/ dominating properties/entities

Table 1: Types of methodologies and the logical relations between old and new and parts and whole, respectively, in reflecting evolution and systems

The failure of the „culturalistic“ methodologies of understanding

Hempel and Oppenheim’s positivist scheme is supposed to apply in social science as well, e.g. for the explanation of historical events by individual motivating reasons like beliefs and desires (for a criticism see Bohman, 1991, 16-56) or in rational choice theories after which no order emerges that influences the choices of the rational individuals. Besides this reductionistic application there is a projectionistic one, to which e.g. functionalism

belongs, which cannot cope with the fact that, on the one hand, there is an indefinite number of ways to fulfill a certain societal function and, on the other, any number of functions may be served by a certain means.

However, the naturalistic approach has been strongly opposed by a tradition which emphasizes the different approach sciences would have to choose when dealing with social facts.

There are two scenarios. Contrary to objectivistic notions of a superior order, according to hermeneutics, social facts are the behavior, the actions, the interactions of agents on a micro-level which – because there are no laws in societal life like laws in nature – cannot be explained or predicted but only understood by observers who interpret these agencies. This process of constructing an understanding is seen as circular as long as interpretations have to refer to other interpretations and hence as contextual, that is, limited to a certain perspective and not intersubjectively valid. Ethnomethodology is one example for this line of argument.

Second, contrary to methodological individualism, social facts have to be treated, according to Durkheim, like things that exist outside of the individuals and independently of them, building a macro-level (of whatever reality) which ought to be described in terms of the macro-level exclusively. The German Luhmann school of sociology is the most prominent representative of a social systems theory without actors of like kind.

Both ideas, while altogether representing a chasm between a micro- and a macro-perspective in social science, produce another chasm between natural and social sciences, so-called hard and soft sciences. This is due to the fact that social science has always been occupied with a domain in which indeterminacy is a constituent factor.

Limiting scientific investigation to understanding in terms of actions or to structural considerations assumes a cloud-like world in which dependencies between the micro and the macro-world can only be

imagined, but not looked upon as real. As is shown in row three of table 1, this distorted perception leads to a dualistic way of thinking which cannot provide a sound knowledge of how evolution goes on and systems are structured.

In need of a dialectical logic

Emergentism, instead, regards what can be seen from row four of table 1; first, the old as well as the parts as a condition that is necessary, though not sufficient, for the emergence of the new as well as the whole. That is, because a formal-logical deduction can only make explicit in the conclusion what the premises implicitly already contain, emergent properties or entities like the new and the whole are, in principle, not deductible. In so far as they are not deductible, the narrow deductive-nomological model is not applicable. In so far as there are conditions identifiable which serve as presuppositions describing the basis on which the emergence takes place, there is no need to make use of one of the one-sided dualistic models.

Emergentism, second, holds that the new and the whole, having emerged, have a dominating influence back on the properties or entities from which they arose. This downward causation (in German „Makrodetermination“), however, does not imply the applicability of deduction, because the old and the parts, by virtue of dialectical reasoning, are not fully determined by the macro-level, but retain a certain degree of autonomy. And because it is stated that this autonomy is constrained by the macro-level, no one-sided interpretive understanding or structuralism is needed, again.

That is, incomplete determinism cannot go hand in hand with complete explanations and predictions and cannot go hand in hand with simply any interpretive or structuralist understanding. Incomplete determinism can entail only incomplete explanations or predictions in that the premises are never complete. But it can require complete understanding in that both the micro- and the macro-aspect are covered. Thus, because none

of the arrows in the general scheme of self-organization in figure 1 signifies a complete causal determination none of them can be reflected by logical deductions, but altogether they circumscribe a kind of understanding which comprises all the circle – its constituents in their own right together with their asymmetrical relationship.

This kind of understanding seems to be the general case throughout the disciplines, as is partial indeterminacy throughout reality, and the mechanistic explanation or prediction seems to be a special case which is true under well-defined conditions, as is total determinacy.

A model of self-organization in social systems

Thanks to this methodological turn, the divide between different disciplines with different object domains vanishes. According to that the self-organization cycle working in social systems may be conceived as shown in figure 4.

There are two levels. At the micro-level the elements of the system, namely agents, are located. They carry out actions, and by the interplay of the fluctuating individual actions they produce fairly stable relations among them which, in the form of rules, that is values, ethics and morals, and in the form of regularities which concern allocative and authoritative resources, gain a relative independence from the interactions. Structures like that emerge thus on a macro-level, where they exist in their own right insofar as they, in turn, influence the agents. On the one hand, they constrain the individual agency by setting conditions that limit the scope of possibilities to act and, on the other, just by doing so provide it with the potential for realizing options it would not otherwise have. In so far as the structures do not cause directly, and therefore cannot determine completely whether or not these options will be realized, for the actions are mediated by the individual agents,

dominance cannot control the outcome, either. The structures are inscribed in the individual agents by an endless process of socialization and enculturation, but the engramms which are produced in the individuals serve as cognitive tools for the anticipation and construction of ever new actions which may or may not obey the rules and accept the values and recognize the ethics and follow the morals, and which may or may not fit the regularities and renew the allocative and authoritative resources and thus may or may not reproduce the structures. Either way, interaction reflects upon the conditions of its own emergence and may consciously be directed at the structures in order to maintain or alter them. In this sense only, that is, because in their recursive actions the agents refer to the structures, these structures play the dominant role in this relation of bottom-up and top-down causation. Nevertheless none of the relations in this causal cycle leads to plain results. Each influence has consequences which due to the inherent indeterminacy cannot be foreseen. By this, and only by this, qualitative change is possible.

This reconceptualization of the central issue in social science – the issue of how agency and structure are to be related – in terms of dialectic, emergence and self-organization is able to resort to and integrate important ideas and insights of recent attempts to overcome the dichotomy in social theory which (with the exception of Artigiani, 1991) do not explicitly refer to an evolutionary systems theory of society (e.g. Giddens, 1984; Alexander, 1995; Mouzelis, 1995; Reckwitz, 1997). It promises to bring about a solution to the problem of how to deal with indeterminacy in the object domain of science.

Seen from this angle, and taking into account the many reservations natural scientists manifest when confronted with the philosophical consequences of their own findings in self-organization, one could almost state that it is the natural sciences which may learn from social sciences rather than *vice versa*.

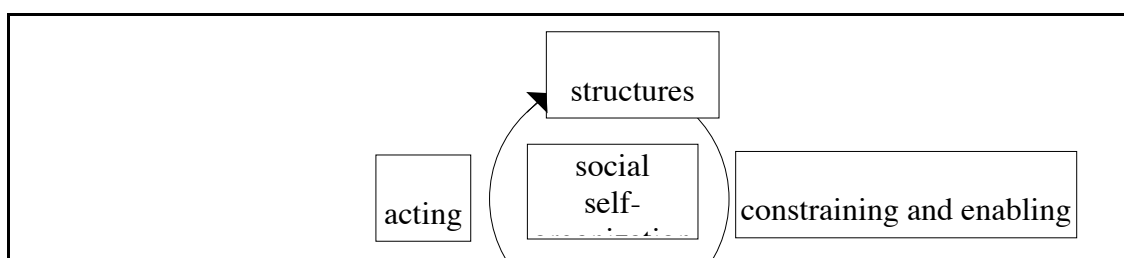


Fig. 4: Self-organization in societies

References

- Alexander, J. C. (1995); *Fin de Siècle Social Theory – Relativism, Reduction, and the Problem of Reason*; London etc.
- Artigiani, R. (1991); *Social Evolution & A Nonequilibrium Systems Model; The New Evolutionary Paradigm* (ed. E. Laszlo), Gordon and Breach
- Bohman, J. (1991); *New Philosophy of Social Science Problems of Indeterminacy*; Polity Press
- Fleissner, P. and Hofkirchner, W. (1997); *Actio non est reactio – An Extension of the Concept of Causality towards Phenomena of Information*; *World Futures*; VOL. 49/50, No. 3–4/1–4 (pp. 409–427)
- Giddens, A. (1984); *The Constitution of Society*; Cambridge
- Heylighen, F. (1990); *Autonomy and Cognition as the Maintenance and Processing of Distinctions; Self-Steering and Cognition in Complex Systems – Toward a New Cybernetics* (ed. F. Heylighen, E. Rosseel and F. Demeyere), Gordon and Breach (pp. 89–106)
- Mouzelis, N. (1995); *Sociological Theory – What went wrong? Diagnosis and Remedies*; London etc.
- Popper, K. (1972); *Of Clouds and Clocks; Objective Knowledge* (ed. K. Popper), Oxford
- Reckwitz, A. (1997); *Struktur – Zur sozialwissenschaftlichen Analyse von Regeln und Regelmäßigkeiten*; Opladen
- Weingartner, P. (1996); *Müssen wir unseren Gesetzesbegriff revidieren?; Gesetz und Vorhersage* (ed. P. Weingartner), Alber