Abstract
This paper proposes the working-out of an information concept which is as general as necessary, but as concrete as possible, so that it can encompass the most varied manifestations of information in nature, society and technology without becoming meaningless. This requires a transdisciplinary approach. The authors suggest the outline of a multi-stage model which combines methodologically the preferences of a historical-genetic theory with those of a systematic-structural theory and avoids the pitfalls of reductionism and holism. We attempt to put "information" into the context of recent research in natural and social sciences, which is leading the paradigm shift in the science's world view, under the heading "self-organisation".

1. Introduction
The starting point for the following considerations is the commonly accepted view that a definition of information (in the sense of a general theory of information) cannot be replaced by Shannon and Weaver's telecommunications-related definition if "information" is defined as more than just that which can be measured by Shannon's entropy measurement. The channel model reduces the picture to that information which is transmitted by a sender, and may or may not arrive at a receiver; the origin of information is not considered at all.

The semiotic change in the discussion, above all the question of artificial intelligence, has started to reduce the "sender-receiver" view to the level of a simple syntactical formalism, thus clearing the way for semantic and pragmatic considerations. The semiosis is a cultural process, i.e. one which relates to human
of the semiotic pattern. Can syntactic rules, semantic meanings and pragmatic behaviour in the field of genetics be identified by observers without either anthropomorphising or diluting the communication in the social field down to the level of that between molecules? The range of opinion today extends from the view that spontaneous meaning can be found in inanimate objects (see Haken 1988, the research group around Ebeling (Helbing et al. 1994), Fussy and Grössing (1994) or Atmanspacher in the same volume), to the belief popular amongst social scientists that not even human physiology, but only the human mind can exhibit meaning (see Zoglauer in the same volume). The pragmatic view of information as e.g. everything with an effect either facilitates the undifferentiated application of the term to all possible fields and hinders the exclusion of mere interaction without the character of information; or it requires a subject with expectations when it uses concepts such as novelty, confirmation, comprehensibility, dependence on context, wholeness etc. and thus answers the question in quite the opposite way. The reified picture of "information", as expressed by the behavioural-school-type pragmatic view, which relates the output of a system to its input and treats the whole thing as a black box, will not be opened up by semiotic access alone. The philosophy that information is something brought into a system from outside, which is then taken up and used by the system, evidently has its roots in telecommunications and suggests the existence of something like information independent of the system, whilst the question of information generation can only be made clear by investigating the internal workings of the system.

The divided opinions on the concept of information initially tend to confirm Zemanek's negative prognosis that we will not, in the foreseeable future, have a unified theory of information which covers all disciplines and viewpoints without contradiction and embraces the results of information theory as special cases. Nonetheless, we are optimistic and believe in the possibility of a consistent and practical definition which includes all relevant aspects. Bertalanffy's theory of open systems, Haken's synergetics, Eigen's investigations of dissipative structures, Eigens hypercycle model, Maturana and Varela's autopoiesis teachings and Luhmann's theory of social systems, varied as they are, throw light on the processes of the black box, in the receiver, and thus on the circumstances of the origin of information. We believe that all these teachings contain the seeds of a new paradigm which is about to replace the old mechanistic world view with one into which evolutionary thinking has made its entry (Hofkirchner 1994). We also believe that a new general theory of information must be conceived as part of this paradigm shift. Before going into the implications of such a unified information theory, let us look at the essence of this emerging paradigm.

2. The Paradigm Shift Towards a Theory of Evolutionary Systems

The core of the new paradigm is made up from the philosophical interpretation of combined system-theoretical approaches and evolutionary-theoretical approaches. What is appearing is a theory of evolutionary systems which is both systematic and historic (cf. Ellersdorfer et al. 1994). In this theory, reality is assumed to mean systems which arose from each other, influence each other, and are in a state of constant development. Reality thus has diachronic and synchronic character, it is behaviour and structure, which run into each other and influence each other. The dynamic side is expressed in a dialectic of old and new, the static in a dialectic of whole and part, which together constitute the evolutionary context: the new originates as part of the old whole and continues up to a specific point, at which the dominance of the old over the new changes into the dominance of the new over the old and the parts of the old become dominated by the new whole. The particular element which constitutes the difference between old and new is no longer a part of the old, but rather the essence of the new. Thus reality is ordered.

Such a concept of stages for the universal evolutionary context is simultaneously a phase-theoretical and layer-theoretical concept. As a phase concept it concerns itself longitudinally with the emergence of new qualities in the evolution process; as a layer concept it deals horizontally with the dominance of entities in results of the same evolution process. As a concept of phases it refers to the sequence of states of developing entities in which new states or new entities emerge from old ones. As a concept of layers it is related to the fact that entities of reality are encapsulated in one another, and thus dominate each other. As a stage concept it describes how the development of an entity can give rise to something new, which may eventually gain autonomy and reverse the situation by shaping the old entity. The stage concept combines the phase and layer concepts: what for one is the starting point, is the result for the other, and so on.

It is thus anti-reductionist and anti-holistic.

Reductionism fails to qualify the emergence of the new from the old as such, if it seeks to derive this from the old in its explanation, for the following reasons: either the new is not new, because it was contained in
the old, and only needed to be "unrolled", or the old is not old (as suggested by the reductionist projection of new qualities onto the old). Reductionism fails to recognise the whole as macrodetermination for the parts, because it reduces qualities of a high level down to a low level, or projects the first onto the second, in order to derive the latter from the former.

The anti-reductionism known as "holism" is a philosophical dualism/pluralism in as much as any connection between old and new or whole and part is disputed. It is seen as a question of incommensurable areas of varying qualities.

The multi-stage concept proposed here does not reduce new to old or whole to part, nor does it tear the qualities of different stages and levels of development away from each other. Reductionism is right to see the higher qualities as arising from the lower ones, and holism is right to stress the independent qualities of higher levels. The jump in quality is thus continuous and discontinuous simultaneously. It exists on a particular level only as a potential and not as a certainty. Only when the potential is realised does it become independent.

The actual interactions open up an area of possibility from which one possibility must be realised (determinism!) but which has enough freedom of movement to allow evolution in the most varied directions (indeterminism!).

Evolution means the following: a phase of relatively stable development can be followed by a phase of amplified fluctuations in parameter values, due to internal or external changes in conditions, and so a bifurcation is indicated. The system may organise itself and thus return to a path of stable development on a higher level, but it may also collapse. A jump can be interpreted as the emergence either of a new system state, or of a new system.

3. Implications for a Unified Information Theory

Such a theory of evolutionary systems, which has yet to be developed, must serve as the background theory for a unified information theory, which also still needs to be developed. This information theory proves itself to be a general theory of information-processing evolutionary systems, i.e. it is concerned with generating and processing etc. of information by such systems.

We can come closer to our definition of the information concept by suggesting the following starting point: The appearance of information in modern human society (cognitive and communicative processes in social systems, mediated by the best available technology) is the most highly developed appearance of information which is known to us at present. That is to say, it forms the current end point of a development sequence in which various evolutionary systems, all linked to each other, show stages of differing information-processing.

We also assume that the development of the cosmos is a unique process, in which the various evolutionary branches have their roots. This means that today's state of development in society has predecessors in history from which it arose, that the social development of humanity is a continuation of natural history by different means, and that the ramifications in living and non-living nature reach back to a state of development of our cosmos which is generally known as the "Big Bang".

We can then pose the question: what are the intermediate stages of this highly developed state of information which we know today? What are the forerunners of the advanced information processing typically found in the so-called information society? What are the predecessors of the information processing on pre-societal levels?

The advantage of this approach is obvious. If we are in a position to identify the forerunners of today's cognitive and communicative information in the stages before and below social systems, we can formulate an information concept which shows the real development of information processing by starting from the most abstract factors of information appearance and enriching them with more and more new factors until it arrives at an understanding of information appearance in its most developed form.

To move on from the above-mentioned starting point (the thesis of socio-cultural information appearance as the result of a development process) to the desired goal (the formation of a concept which reflects the development of information appearance) we cannot avoid reconciling two concept patterns with each other, namely that of the background theory and that of the theory of social recognition and communication. A possible approach is to modify the starting points of both self-organisation and cognition/communication theory. The outline of such a research programme is given here.

3.1 Refashioning the Concept of Self-organisation

The results of individual areas of scientific research, like interpretations in the paradigm of "self-organisation" make today's universe with all its subsystems seem to be the product of a chain of
self-organisation cycles, contained one within the other. In this way, self-organisation has developed itself further. At least three major quality jumps, which can themselves be subdivided, make an appearance (see figure 1).

1. **Physical and chemical systems.** All evolving systems are, from a physical and chemical viewpoint, far from chemical and thermodynamic equilibrium. They structure themselves by using the throughflow of energy. We are talking here about **dissipative** systems (after Prigogine). Purely physical or chemical systems which are capable of evolving are simple dissipative systems which collapse if the flow of energy disappears. That is to say, these systems appear spontaneously under the right circumstances, but disappear again as soon as their conditions of existence are no longer present. They come and go in the same way as a reflex.

2. **Biotic systems.** These are also dissipative. Like abiotic systems, they can structure themselves, but have the additional ability to manufacture the components of which they are made, and thus can be called "**autopoietic**" (without having to take on Maturana and Varela's solipsistic consequences). This means that unlike simple dissipative systems they have a special activity: they maintain themselves by adjusting to their environment and changes in this. They obtain the energy they require from their surroundings, and reproduce themselves.

3. **Socio-cultural systems.** Such systems are autopoietic and dissipative, and have a further quality: they not only manufacture their own elements, they actively change the environment in which they live. To a certain extent they thus transcend themselves, and may be seen as "alloplastic" systems. This means that they make other autopoietic systems look passive, because they make external conditions into internal ones, and the environment into internal structure, and because they are **re-creative** (Jantsch in Schmidt 1987).

![Fig. 1 Evolution of Self-organisation](image)

### 3.2 Refashioning the Concept of Cognition/Communication

According to semiotics, information at the level of socio-cultural evolution has a **syntactical, semantic and pragmatic aspect.** It seems advisable to modify the known semiotic pattern so that a nested hierarchy of individual aspects results. This is fully compatible with considerations of recognition theory.

Cognition can thus be imagined as a process of self-organisation cycles, leading one to another (see figure 2). The first, **perceiving,** makes data from signals; the second, **interpreting,** the assignment of meaning, makes knowledge out of data; the third, **decision-making,** makes practical applications from knowledge. In the jump up from one level to the next, a new moment appears. The existence of data is an essential condition for the existence of knowledge, but is not sufficient by itself; similarly, the existence of knowledge
is an essential condition for the existence of practical applications, but is not sufficient by itself. Communication is a process which includes the horizontal dimension.

![Fig. 2 Hierarchy of Cognition/Communication Levels](image)

3.3 Merging the Concepts of Self-organisation and of Cognition/Communication

After such adjustments, the appearance of information may be anchored as follows. Information is every process (and its result) whose result in the system exceeds that of the external influence, and which can be traced back to the system, and which changes the behaviour, state or structure of the system. The type and nature of the generation of information structures would then be varied (see figure 3):

The appearance of information is found in undifferentiated form on the level of self-organising physical and chemical systems. Syntactics, semantics and pragmatics form an undifferentiated unit, as the structural changes are identical with the changes in state and behaviour.

On the level of living systems, whose goal is survival and which must be able to distinguish metabolically-relevant stimuli from others, the recognition of items and the assignment of meaning are essential. In allocating meaning, semantics and pragmatics are grouped together, as long as state and behaviour can also be assigned to a single group. The processing of stimuli as a special form of self-structuring can be proved separately (syntactics) from its functionalisation in connection with the assignment of meaning.

As a result of society's provision of life's essentials, an overview of society's re-shaping of our environment and the awareness of one's individual role in this process appear. This provides the opportunity to choose between different options (pragmatics) which are based on knowledge of the world (semantics); this knowledge became possible once people were freed of the necessity to provide all the essentials of existence.
Fig. 3 Information Processing in Evolutionary Systems

Let us now look at the individual layers. Firstly it must be established that the environment of the system is filled with patterns, signals, physical structures or processes. The environment of the system is filled with patterns, signals, physical structures. They represent differences in space or in time or both which are in principle observable. These patterns lay the foundation for the information process which has to happen inside the system. At this stage of development they just represent differences per se, nothing else.

1. Signals become data: Selection as reduction, filtering and modification.

The system in question is not able to perceive all the signals of its environment and therefore will not be able to use them for itself (something which the "universal observer" could do in principle). It will select some classes of signals out of the more or less infinite manifolds. By this very act it transforms them into data which is "given" to it. Signals "in themselves" become data "for themselves". In this way data is the product of the system, it is the result of a more or less active behaviour of the system.

It will depend on the stage of evolution whether either selection means simply the reduction of classes of signals (in the way that the human ear can perceive acoustic, but not electric waves), or filtering with respect to some spectrum of frequencies of electromagnetic oscillations, e.g. animal or human eyes), or modification (e.g. internally controlled amplification of the signal, possibly linear, possibly nonlinear). On the lower levels of evolution selection can mean susceptibility to certain kinds of energy or certain "windows" of the electromagnetic spectrum which can be completely described in physical and/or chemical terms. On the higher levels one can see more and more active, self-organised selection of signals governed by complex survival goals.

One could call data the carrier of syntactics (where syntactics means the relation between the data elements). Data elements are related to each other by probability patterns for their sequence, e.g. the probability of some characters or the probability of one character showing up after the other in a message. Other patterns can be found in electromagnetic oscillations composed of some frequencies.

On the level of data, Shannon's measure of information can be applied advantageously. He reduces signals to data by allowing only a fixed set of symbols to be transferred. The degree of surprise is measured by the very same mathematical formula by which entropy is expressed in physics. Nevertheless, in Shannon's theory of communication it is applied on a different ontological level. It is related to probabilities of events only. The connection to thermodynamics - where it was developed first - is nearly completely cut. No relationship remains to the microstates of energy, which are of crucial importance in theoretical physics. For information processes, no Second Law of Thermodynamics (leading to Nernst's "heat death") exists. Nevertheless, Shannon's measure of information has the extremal property in common: Entropy, as in physics, reaches its maximum in the case of evenly distributed elements. Shannon's measure can be generalized to measure the complexity of morphological structures in space or in time (Ayres 1994: 225-248), but it becomes more and more a subjective measure the more selection has been applied to signals.

The selected (reduced, filtered, or modified) signals may be used as input for the next steps of the information process. Strictly speaking these data do not represent information, but potential information only. The process of creation of information is located in the next steps of the information process.
2. Data gains meaning: Appropriation.

The crucial process of information creation is located inside the system. Data determines this process in a more or less indirect way, depending on the stage of evolution we are looking at: at the lower levels, mainly in physical or chemical structures, causal links dominate the relations between inputs and outputs in the majority of cases. But some well-known processes exist, which were studied in detail by Prigogine and others. The so called Benard cells (which come up when liquids are heated) are located on the level of physical processes. The Bhelusov-Zhabotinski-reaction is a chemical process. Both show some indetermination in their behaviour. Although the coming into being of cell structures in water, and that of coloured spatial waves in the chemical reaction are quite certain, the very starting point of the phenomena cannot be predicted in a deterministic way. One can say that in both cases the system reacts to changed environmental conditions with a qualitative change of its inner structure or new processes. If one likes to apply the language of semiotics one can call this process a semantic (the relation between a sign and its meaning) one. The system itself reacts by a new inner organisation to some message from outside, thus it links the input data to a self-generated "symbol" representing the meaning of the change in input. It has really created some qualitative new thing per se (although for our universal observer - if he or she has memory - it is already a familiar behaviour). Only when we leave the level of dissipative systems does this symbol have an existence independent of the state or behaviour of the system.

Two more observations can be made: If one compares two experiments on the macro-level, the symbols are the same. But the fine-structure of the symbols will differ in most of the cases. If we like anthropomorphitic terminology, we can say there is the starting point of individuality. A second property has its predecessors here: if you increase the environmental temperature, the internally created structures will remain constant. Thus we can state that the system exhibits some kind of irreversible structural change due to changed external conditions, a kind of memory.

At lower levels of evolution data will have to supply the necessary energy for the creation of new structures. Not only their informational aspect is needed. At higher levels, the energy transport from the outside to the inside is no longer necessary. Internal energy flows, or other mechanisms which are responsible for the acquisition of energy, are available for new structures to be shaped by data. The self-interpretation of data becomes more and more important. The systems react no longer to the signals from outside but more and more in reference to their internal states. Systems are able to react to new phenomena, in accordance with their inner structure, organisation, memory, former experience, learning, "knowledge" etc.

In contrary to Shannon's theory, the "meanings" are not fixed ex-ante, but are constructed as a (qualitative) new reaction to new situations, never experienced before. This production of meaning should not be seen independently from the needs of the system for self reproduction. Depending on the level of evolution, and the need for a highly specialised reaction, the inner symbols will be created and structured (for this reason Eskimos have far more terms to describe the quality of snow than other people have, PC-freaks create their own terminology etc.). On the other hand, these systems will have some advantage if, within the wealth of signals, they have located the essence for survival.

Data is translated into inner symbols, which represent a kind of language of the system, and by this translation they are appropriated. Data for the system is translated into knowledge of the system. This knowledge is the basis of further steps of the information process.

Here we can look for the threshold between mere physical/chemical interaction and information processes. If this kind of data is located on the same qualitative level as their meaning, we suggest interpreting them as physical or chemical processes. Information is there, but only "in statu nascendi". If signals, data and their meaning are of different qualitative levels, we can talk about a "mature" information process. A one-to-one correspondence between signal and meaning will not fulfill our criteria, while systems with symbolic representation, like handwriting, printing, icons, gesture etc., do.


This next step is fully applicable only to highly developed information processes. All physical systems interact with their environment, and an information processing system is no exception. The difference is that in the information process, the interaction is not controlled by the usual laws of nature, but there is a high degree of freedom for the system itself. The meanings of the signals selected, maybe modified by experience, learning and knowledge, are fed into an inner process of clarification. Different options of reaction can be tried, but only inside the system, not being obliged to act in the real world. Models of the world can be created and destroyed, and finally it will be decided how to react to the environment. Thus decisions will control some parts of personal behaviour, they will control the choice of strategies, they will trigger actions to the outside. Once again, as in the step before, the catalog of activities is not fixed in advance. New patterns of behavior could be invented. Nevertheless, a rough division into two categories may be helpful. Decisions partly lead to activities which consist basically of material interactions with the
environment, and partly consist of informative activities only. The first kind leads to direct changes in the
distribution of masses and energy, and thus changes to their flows in the environment, while the latter
starts or stops streams of meaningful symbols recoded into data.
A system should be ready, to a certain extent, to control the way it presents itself to its environment. It
depends on the level of evolution if the system can, in a conscious, reflected way, reduce, filter and modify
streams of data or just creates some disguise by evolutionary mechanisms of selection and mutation. One of
the human rights, the right to control the exposure of one's own data exhibited to the public (Recht auf "Informationelle Selbstbestimmung", a kind of German privacy law) shows the practical importance of this
aspect of the information process in human society. Mimicry, at the other end, shows the possibility of
selection of information without consciousness. If systems are able to act consciously, they have the
opportunity to take into account the status of other information processing systems, and the freedom to
amplify the intended effect by voluntarily telling "the truth" or to deceive. Here we see the basics for
pedagogical strategies, advertising, blackmailing etc.

Decisions can not only trigger informational activities, but material as well. We would not assign the
information process its due value if we overlooked its practical implications. Human societies, but
cooperative animals as well, not only communicate internally; they (re)produce their species, their
environment, their artifacts. A decision could start a certain kind of action. Once again we can state that this
action could be a conventional or an innovative one. But here the decision and action cross the border of the
information system: human practice is in fact the field where information activities have to prove
themselves. If we do not take this broad field into account, many of the informational activities cannot be
explained or motivated. The difficulty at this stage of investigation is that the consequences of any practical
activity cannot be forecasted in a deterministic way. Human practice acts into an open area of outcomes, of
predicted and unpredicted effects, of completely new events as well as of routine results.

In this argument, one should be continuously made aware that there is usually a close link between
informational activity and human practice. Both sides are needed to adequately understand real processes.
Although the singing of birds may have some informational and aesthetic components (and could be
measured in terms of pitch, amplitude, and bits), one should not forget its function for the survival of the
species, for food acquisition, for sexual reproduction etc. On the other hand, it could be expected that a
particular kind of song has produced some evolutionary advantage.

Applied to human society, this view expresses the well-known fact that the often quoted information society
deals not only with communication, but, more than at any time before, with production, distribution and
consumption of material goods and services. A final remark referring to the succession of the above partial processes: if we look at them in more detail, we can see that the determination of the next step is not only caused by the previous one, but other links and even feedbacks are possible: A new theory (created by step 2) can change the sensory perception (step 1) considerably; in the long run human practice will have its effects (via step 3) on all other steps.

A closer examination of the internal information creation processes described above seems to be of
importance for technologies of the future. If we understand such processes in detail, a new type of
technology can be created: the evolutionary machinery. Unlike its mechanical predecessors and unlike
automates, it should be able to execute the process of emergence of new qualities, thus leading us beyond
the proper execution of the orders given by engineers and technicians by technology

4. Conclusion

With the help of a more advanced multi-stage model of information, linked to an evolutionary systems
model of self-organisation of the universe, it seems possible to comprehend society's recognition process
and communications between members of our highly developed information society. The resultant theory
would then be suited to underpinning its own recognition-theory attitude, because the case reflected by the
recognition theory (the case of a relationship between a member of society and an object of his/her
recognition) can be seen as a special one.

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