Abstract

On the Notions of Rulegenerating & Anticipatory Systems.

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Abstract.
Until late 19th century scientist almost always assumed that the world could be described as a rule-based and hence deterministic system or as a set of such systems. The assumption is maintained in many 20th century theories although it has also been doubted because of the breakthrough of statistical theories in thermodynamics (Boltzmann and Gibbs) and other fields, unsolved questions in quantum mechanics as well as several theories forwarded within the social sciences. Until recently it has furthermore been assumed that a rule-based and deterministic system was also predictable if only the rules were known, but this assumption has now been undermined by modern chaos-theory describing rule-based and deterministic, but unpredictable systems, while catastrophe-theory delivers a set of types describing various kinds of instability and conditions for the stability of a given system.

Hence a main trait in the theoretical development in the 20th century science can be described as a basic modification and limitation of some of the fundamental and strong assumptions forwarded in the previous epochs of modern science. Ironically, the very same process has been a process in which the human capacity to intervene in nature has expanded dramatically and mainly by the help of the very same theories, and not least because they allow nature to be described and made manipulable on a lower level and a more fine-grained scale.

While the overall theoretical consistency between the various theories has gone, the reach of human intervention in nature has increased based on quite new dimensions whether in the area of physics (e.g.: energy technologies, chemical technologies, nanotechnologies etc.) of biology (genetic manipulation) or in the area of psychology, sociology and culture (artificial simulations of mental processes, new means of communication, implying changes in the social infrastructure and cultural behaviour etc.).

While some of these changes and new conditions can be reflected from within the conceptual framework of rule-based systems, albeit more complex than formerly recognised, others seems to give rise to the question whether there are »systems« and relations between different systems in the world which are not rule-based?

For instance, it seems to be obvious that the notion of instability represents a major conceptual break with former theories of rule-based systems, as the stability of the latter is an axiomatically given property implied in the very notion of rule-based systems, while instability can only be the result of external influence which should be explained as the result of another rule-based system. While there are no difficulties implied concerning the stability of rule-based systems, the notion of unstable states of a system raises the question how there can be a system at all if there is no invariant stabilising principles?

This is the first question which I will address. And I shall do so by taking two examples of such systems as my point of departure. The first example will be the computer and the second will be ordinary language. In both cases I will argue that the stability of these systems (which are both defined by the existence/presence of human intentions) are provided by the help of - differently organised - redundancy functions which both allows the maintenance of systems in unstable macro-states, suspension of previous rules, underdetermination and overdetermination and generation/emergence/creation of new rules more or less independent of previous rules by the help of optional recursions to the permanently accessible underlying levels as for instance the level of binary representation in computers.

Since the notion of redundancy is both controversial as such and often avoided, the concept is discussed (as defined in Claude Shannon's mathematical theory of information and in the semiotic framework of J. J. Greimas) and leading to a more general definition in which the redundancy functions serve to overcome noisy conditions, but at the cost of rule-based stability, determination, and predictability.

A second question will be how the notion of rule-generating systems relates to the notion of anticipatory systems and it will be argued that rule-generating systems shares some features with anticipatory systems and that the former from a certain viewpoint can be seen as a subclass of the latter, although anticipative features are not necessarily a part of the definition of rule-generating systems. On the other hand, it will be discussed whether anticipatory systems which are not rule-generating systems can exist and it will be argued that the capacity to anticipate is strongly limited if it is not part of a rule-generating system. Therefore, it is concluded that the most powerful anticipatory systems need to be rule-generating systems.
Keywords: Rule Generating Systems, Anticipatory systems, Redundancy and Noise, Computers, Language.

1. Introduction.

The notion of rule-generating systems presented in this paper has been developed to describe certain features which seems to characterise a wide range of social and cultural phenomena and processes and it is as such defined as an alternative to the notion of rule-based systems. Both notions will be introduced, defined, and explained in section 2 and it will be argued that the relation is not only that of an opposition, but also one of inclusion, since the existence of rule-based systems within the domains of the humanities are seen as manifestations of a specific subclass of systems, i.e.: systems in which a set of previously generated rules are maintained and kept invariant for a period.

Since the notion of rule-generating systems is seen as the inclusive - and most general - notion within the domains of the humanities one also need to ask how these systems relates to biological and physical systems in which they are always included themselves. This question will be discussed in section 3 while the relation between the notions of rule-generating and anticipatory systems will be discussed in section 4.

A few preliminary remarks concerning the basic approach might be useful for readers who are not themselves scholars within the humanities as well as those in the humanities who are sceptical to the use of the notion of systems within these domains.

The position taken in the following can briefly be described as the result of an attempt to include the occurrence of individual - and eventually unique - events as a significant phenomenon in the analysis of cultural processes. While the occurrence of individual events is a generally accepted phenomenon within the humanities the understanding of the significance is at the same time one of the most controversial questions and the different answers to this question forms one the most important dividing lines between different paradigms such as structuralist theories (in which individual events are seen as instantiations of the overall structure or as a specific state in a system or as an insignificant exception) or hermeneutics (in which individual events are seen as a transitory, changing mental step in the hermeneutic circle or spiral) or post-modern deconstructionism (in which individual events can only be connected randomly in a purely voluntary and arbitrary way, eventually forced).

While each of these paradigms can be - and has been - critiqued from within the specific domains to which they are applied they can also be critiqued on a par with each other as they are all based on the common assumption that the phenomena's described in the theories exist in a kind of a vacuum as if the cultural and social phenomena could be described as purely autonomous and internally defined phenomena which are not at the same time biologically and physically manifested.

However, the attempt to relate cultural processes to the biological and physical world raises a series of complicated questions as contemporary physical and biological theories do not provide an indisputable or unified understanding of physical and biological processes. The two main obstacles seems to be l) that physical and biological theories do not provide a firm basis for the understanding of human activities which involve conscious, goal-oriented, normative and aesthetic choices - or in short how to solve the dualism between the material world and human mind and 2) that physical and biological theories almost exclusively are based on the analysis of repetitively occurring phenomena's (patterns, structures, relations, laws etc.) leaving the occurrence of individual events in the margin as peripheral or noisy disturbances. A third obstacle is that physical theories presupposes that the basic physical phenomena (matter and energy) and laws are universally given, while basic biological and human phenomena only come into existence (and fade away) within the physically defined universe - implying that there is an empirical question of origin (of life, of mental processes, of symbolic representation) within the physical universe.

What is needed when seen from within the humanities is theories of biological and physical processes which do not rule out, but at least allow if not explain the occurrence of mental processes and individual events as potentially significant events in nature.

A proper framework for this should be found in the well-established philosophical principle of continuity which are also often referred to in modern science. However, to avoid the dualism between matter and mind it is necessary to include the mind and human activities in the notion of nature as such. Hence the distinction between physical, biological, and mental processes is not seen as a distinction between three separate domains - but as a conceptual distinction which does not refer to the existence of some distinct, »materialised« or otherwise completely distinct »levels« which exist independently in nature. Mental processes are at the same time also always biological and physical processes. But if physical processes are not always biological and if biological processes are not always mental there are still some differences to be taken into account. Consequently, the notion of physical, biological and mental processes will be used to designate three types of processes of which the two latter are characterised by a certain degree of relative autonomy. Or otherwise framed, that the description of biological and mental processes will need to include concepts which are not implied in a description of physical processes. Concepts such as noise, memory, representation, and codes are contemporary examples. While the main question from a physicist's point of view will be to explain how biological processes can arise, the main question from a biologist point of view will be how biological processes can be stabilised as relatively independent of the underlying physical transactions and how mental processes can arise. From the point of view of the humanities the main question will be how mental processes and human activity can be stabilised as relatively distinct within the biological and physical universe. Since I am neither a physicist nor a biologist I shall concentrate on the latter.

2. Rule-based and Rule-generating Systems.

Although the notion of rule-based systems might be unusual, most scientists will probably be familiar with the idea of a system in which the processes are governed/determined/caused by a set of general rules, which are assumed to be independent of the specific system and inaccessible for change from within the ruled system. The notion of rule-based system refers to such systems whether the rules are seen as causal physical laws, as pure formal rules (as in mathematics and logics) or as biological and even social »laws« or invariant structures. The basic idea is that the stability of the system is guaranteed by a set of invariant rules whether the invariance is seen as permanent (e.g., as in the idea of eternal laws or as in invariant mathematical relations) or only as given within the »lifetime« of the system. Change of laws may occur, but only if they can be assumed to be the result of another set of rule-based processes within or from the outside of the system.

The notion could also be defined as a general notion of one of the common and most basic assumptions of modern science since the 16th and 17th century and it is often defended by the claim that it would be impossible to do science at all without this notion since it forms the basis for the idea that nature can be described in a scientific way. If we cannot assume the existence of repetitively occurring (i.e. rule based) processes we cannot make precise scientific predictions.

Hence there are strong reasons to maintain the idea of rule-based systems and any attempt to question the validity may seem rather hazardous.

However, modern science does not rely only on the notion of rule-based systems, it does also rely on the notion of truth, and we are thereby allowed and even forced to ask whether it is true that any phenomenon or process in nature belongs to a rule-based system? Nowadays, we do have some scientific indications that this is not necessarily the case. Some physicists for instance assume that there were yet no fixed rules in the very first few nano seconds after the so-called Big Bang.

Even if this and other assumptions concerning various sorts of indeterminate states and situations later may be shown to be wrong, they cannot any more be ruled out without any specific proof. The answer to the question whether phenomena and processes belongs to rule-based systems cannot any more be taken for granted as an axiomatically given assumption but must be treated as a matter of - and on a par with other - provable facts. The rules are on the same agenda - as processes at the same time and space - as the substance/form of the ruled.

One of the important reasons for the maintenance of axiomatic status of the notion of rule-based systems can probably be found in the weak and unpromising alternatives offered for instance by vitalism in various forms or by the subjectivist, relativist or postmodern dissolution of the world in unrelated instances and coincidences. At least, references to the poorness of these alternatives within scientific literature seems to play a more important role in science than the vitalist theories themselves.

However, if vitalism is wrong because of the reference to indescribable eventually mystical qualities, and particularism is wrong because of the lack of continuity (implying that there is not one universe but an indefinite number of unconnected fragments and parts) it does not imply that there can only be continuity and stability because of the existence of universal and rule-based systems. The principle of continuity and stability of various domains in this universe could - at least theoretically - be maintained by other means.

What is lacking however is an explanation of how this might be the case and a solid demonstration that there actually do exist systems in which the stability is not provided by a set of rules, but on the contrary that systems exist in which the rules are generated and stabilized by other means during the lifetime of the system.

I denote such systems as rule-generating systems, and I will try to demonstrate that the stability of such systems is provided by the help of various kinds of redundancy functions which among other things allow the generation of new rules more or less independently of existing rules.

Contrary to the notion of rule-based systems rule-generating systems can be defined as systems in which the rules are among the results of processes within the system, implying that the system as well as the rules are open for influence both from other processes in the same system and from higher and lower levels and from the surroundings. There may be constraints for this openness, but the character of these constraints must be analysed in each case. Rule-generating systems possesses a set of features allowing changes of the rules in ways which are not possible in rule-based systems. Since the stability of rule-generating systems is not completely guaranteed by the rules, we need first to explain how stability - and hence the demarcation of the system as such - can exist.

The computer is a good case to consider for this purpose both because it seems to be a well delimited and well defined system and because we at the same time are confronted with a central question, namely how to analyse the relation between the material, physical and symbolic levels of the processes performed in this system and finally because the symbolic rules used to govern the computational process only can do so if they themselves are manifested and processed in exactly the same physical and symbolic format as any kind of data - ie: as a series of strings composed of binary notational units. The function of the rules as rules for the manipulation of data is in this case only the late result of the very same kind of process as the processing of the data ruled.

The basic reason for this very strange arrangement can be found in the principles of the universal computing machine as described by the English mathematician Alan Turing in 1936. The argument runs as follows: If we want to create a universal computing machine in which we can process any possible finite formal procedure, we need to build a machine which itself is not restricted by any specific finite formal procedure, because any such restriction would deprive the machine of its universality. It follows directly that there cannot exist any specific algorithm or formal procedure which is a necessary part neither of every computational process nor of an universal computer.

As we now know the solution of this problem is to build a mechanical machine in which the physical determination is restricted to one operation, one step, while the combination of steps into sequences is performed by an optional composition of sequences of bits. Since the composition is optional - and permanently editable - it follows that the previous steps and processes does not determine later steps and processes in any nonoptional way. The system allows any formal rule to be modified, suspended, substituted for another, or ascribed a new function.

Any process, any rule and any kind of data performed in an computer has to be manifested and physically processed as such sequences of bits and since these sequences are compositions of such bits they can always be manipulated on this level - bit for bit - quite independent of the previous content - whether it is data or rules.

The relation between steps is in principle a random and optional relation.

The processes in the computer and the stability of the system are basically defined not on the level of the formal rules, procedures, or algorithms, but on the level of mechanically effective notational units.

The relation between the binary units and their symbolic functions and content is even more strange since there can only be a restricted, finite set of units available while it is always possible to introduce new - semantically defined - notions in formal systems. In computer the number of units must be defined at the time the machine is build, while the formal procedures and the symbolic content processed can be defined and provided at any later time. The programmes or rules which we use to govern and control the processes in the machine is not part of the machine, but of the material processed by the machine.

This may seem trivial, but it is not since we are not able to define a finite set of legitimate units to be used in formal expressions.

In this respect the main result of Turing's analysis was the proof that it was possible to transform or translate any finite formal procedure into a format which could be executed in a machine with only a limited, finite set of units available. I shall not go into details with his proof since the main point here has nothing to do with mathematics but with the fact, that the finite number of units (in practice the two binary units) implies that the symbolic content and the formal rules can only be ascribed to sequences of the very same finite set of (two) bits. Since there are only two bits necessary it follows that these bits take part both in the representation of rules and of data. They have no content of their own and there are no definable restrictions to the possible content they may be ascribed over time. The binary units constitute an alphabet consisting of a finite set of legitimate, but semantically empty letters.

While the notations in formal expressions are defined as semantic units either as referring to a rule (e.g. a +) or as data-values, the computational notation system is defined as a finite set of legitimate physical values which shall function as mechanically effective units and they are necessarily defined independent of the possible semantic content.

What Turing showed was that formal expressions could be transformed to a computational (binary or informational) notation format, but he did not describe the differences between these two kinds of representation and the wider implications of these differences.

We have stated the difference but not yet explained that it is a difference which cannot be described within the general framework of rule-based systems. For instance, one might argue that there is only a transition from one set of symbolic, logical, or formal rules to another set of mechanical rules.

But this is not so, and the reason is that the transition from a formal to an informational representation is a transition from a symbol system which is stabilised on the level of semantics (the rule system and semantic entities used in the formal expression) to a symbol system which is stabilized on the level of physically defined notational units.

A formal procedure can only be processed in a computer if the semantic content (whether a rule or data value) of each formal unit of expression is distributed into a sequence of binary units. The semantic content is processed on a lower level which on the one hand makes the processing vulnerable to disturbances (noise) from beneath and on the other hand allows optional changes on the lower level scale independently of the previously intended semantic content of formal rules and data values on the higher level. The conversion from formal to informational notation implies that the same content can be manipulated according to quite different principles because the informational notation units does not have any semantic content of their own. They are only defined as legitimate physical units which shall take part in the processing of both rules and data values.

However, the physical and mechanical criteria involved in the stabilisation of the binary sequences do not suffice because they cannot be used to decide whether a binary signal e.g. an /O/ is changed to an /I/ or vice versa because of noisy influences during the processing.

Since computers normally do function, we know that there are practical solutions to this problem around. The basic principles of these solutions were described by Claude Shannon in his paper »Mathematical Theory of Communication« (1949) in which he showed various ways to stabilise the expressions transmitted or as he said »to combat noise« by the help of various kinds of redundancy functions. I have treated his analysis elsewhere and shall now only summarize the basic problem and the principles used in the possible solutions.

First one should be aware that there are three kinds of noise involved. The first kind relates to the fact, that we need to be able to identify a notational unit as distinct towards the physical background/substance in which it is manifested. The second kind relates to the fact, that we need to be able to identify any single unit as distinct compared to other legitimate units, and the third - and theoretically seen most interesting - kind, which relates to the fact that we need to be able to identify a notational unit as a legitimate (intended) unit compared to the possible but non-intended occurrence of the very same physical form.

Although Shannon was only concerned with physical noise in mechanical transmission systems the basic question (how it is possible to distinguish between a physical unit/form which is intended part of a message from a physically identical form which is not intended) need to be solved in one way or another in any symbol system.

The reason for this is that we can only use physical forms as symbolic units if these forms are physically possible and hence might occur without being intended.

Since this is the case, it follows there is no way to overcome the third kind of noise by the help of physical and mechanical criteria alone.

This is of course a very important result - implied by but not made explicit in Shannon's analysis - since it forces us to introduce a distinction between on the one hand physical and mechanical criteria and on the other hand intentional criteria for the stabilization of symbolic expressions even in the case of a physically well-defined and mechanically effective alphabet such as the binary alphabet.

As it is probably known Shannon solved the problem by adding a set of control codes (which can be described as a formal and rule-based solution) to the messages send, one might wonder why he - and I - need to refer to the notion of redundancy? The reason for this is that even if it is possible to describe many specific solutions as formal and rule-based solutions, it is not possible to describe the relations between various solutions in the same way. There is no set of rules for choosing among various solutions and what is even more important: the need for rule-based control procedures may vary according to the signal structure of the message. This is very well illustrated in Shannon's paper in which the problem is presented as a result of the effort to increase the transmission/processing capacity by reducing the statistically defined redundant parts of the messages. The notion of statistically defined redundancy reflects the existence of repetitively occurring patterns (on the level of the notational units) which cannot be described in a complete formal representation. These patterns are neither completely determined by any set of rules, nor a part of any specific meaning. They seemed to be completely superfluous, but they were not. If they were eliminated in the transmission the message would be distorted because of the noise in the channel.

The main effort was to eliminate redundancy but what he found was that it was only possible to reduce the (statistically) defined redundant parts of the message by introducing and adding another kind of redundancy, that is the formal and rule-based control codes which should be added to the message to ensure the legitimacy of the received signals, but without having any impact on the content - and hence redundant in this respect, while at the same it is a distinct part of the transmitted message.

The main conclusion of this is simply that redundancy in one form or another is always necessary for the maintenance of the stability of a symbol system on the basic level of physical manifestation.

The basic necessity stems from the fact that any physical form which can be used as a symbol/notation unit (of type information) can always exist as a mere physical form (of type noise). Physics does not deliver concepts to establish this distinction.

A second conclusion is that one kind of redundancy level (determined on one level for instance formally defined redundancy on the level of syntactical sequences) to some extent may be substituted for another kind of redundancy (eventually on another level for instance statistically defined redundancy on the level of (the frequences of) the various notational units).

The (economical and effective) point is that the former can be shorter than the latter. The theoretical point is that the stability of the whole system can be obtained in different ways - and on different levels.

Although each level eventually might function as completely rule-based it would not make the whole system rule-based unless there were also rules for the switching between levels. There are no such rules. It will always be possible to increase various kinds of redundancy on more than one level. There is no upper limit, there is only a lower limit, if redundancy at the bottom level is reduced to a minimum it must be increased on another, higher level. As an implication of this we can state that the computer represents a system in which the stability can be provided by a variety of means on various levels and that each level can be modified and changed while the stability is provided on another level which in turn itself might be modified while stability is then provided either on lower or higher level.

In computational expressions there is no invariant level whatsoever - except of course that of the physical invariant machine. But since the machine operates on the level of the binary notations, this limitation is not of theoretical significance, it is only a question of deliberately accepted practical limitations which can be overcome according to the principles of the universal computing machine.

Neither the sequences of bits, nor the chosen set of algorithms, neither the function of a given algorithm, nor the semantic interpretation can be taken as invariable. They can be declared to be invariant and kept so for a shorter or longer period but only according to a deliberately chosen, human intention. The rules and other means of stabilization are only able to perform this function as part of the processes. They - and the stability itself - exist as the result of optional step to step processes on a lower level and within time and space.

Because of this we can also conclude that each new step - each individual event - in principle allows a choice both on the level of the bits, of the syntactical level of formal procedures and of their functions as well as of level of the specific and overall semantic content. The individual event is not the function of a pre-existing set of rules - if we don’t want it to be so.

If we would maintain that there still are only rule-based systems in the world, we could only do so by including a description of the rules of human intentions and the capacity to create symbolic expression systems as part of the description of each step-to-step process in a computer. We would have to say that there really is no choice.

The evidence needed would include the demonstration of the existence of a rule behind seemingly individual events such as the choice of a given algorithm instead of another to a given purpose, or the change of the function of an algorithm (for instance as a means for another purpose) or a rule which could take into account the existence of different sets of definitions of the ascii-codes just to mention a few cases close to the computer.

The basic obstacle is that the idea of nature as a rule-based system or a set of such systems implies that there are both rules for each system and for the relation between systems, but if the latter is the case there is only one system including the mental capacities, and if only the former is the case, there are also individual events possible in the relations.

Simply to accept the idea of the existence of significant individual events in nature on the other hand is also a risky business since it would lead into a complete dissolution of the concept of nature. There would be no way to connect each individual event with any other equally individual event.

This is exactly why it is of relevance to consider the relation between redundancy and individual events more closely.

The concept of redundancy was introduced by Shannon to describe the existence of repetitively occurring patterns, units or in general: phenomena's which have no function or meaning in the system in which they occur. Shannon uses the notion of redundancy in a rather vague and loosely defined way about any repetitively recurring patterns which has no importance for the meaning or structure of the symbolic expression, and he is not much concerned with the various forms of redundancy. However, such different forms can be found and identified, even in his own original paper, in which we can find several types of redundancy structures which are distinct in respect to structure and/or function.

To the vague and general definition of redundancy as repetitively occurring, superfluous structures/patterns which are of no importance for the content of the message, we can add the following 4 definitions used - although not explicitly defined - in Shannon's paper:

l. Redundancy defined as repetitively manifested patterns/forms which occurs determined by the symbol system used. The idea is that certain parts of a message are determined by the rules of the language structure in which the message is manifested, while other (and distinct) parts are deliberately chosen to represent the distinct meaning of the individual message. In this case redundancy is defined as the parts determined by the general system and opposed to the patterns/ units which represents the distinct parts - which is assumed to represent the content - of the individual message. In this case redundancy is defined in exactly the same way as the rules of the system.

2. Redundancy defined as possible, but unused forms allowed by the language structure. In this case it is not the manifested parts determined by the language structure, which are seen as redundant, but the set of possible alternatives, unused choices allowed by a given symbol system. Redundancy is still defined in contrast to the individual message, but this is now contrasted to other possible messages (or to other possible, but not used rules).

3. Redundancy defined as the statistically determined repetitive patterns in the occurrence of the various notation units, that is: defined without regard both to the content and the rules of the symbol system itself. In this case redundancy is defined completely independent of the symbol system and the meaning.

4. Finally redundancy is defined as formal control codes which are added to the message during transmission and removed when the control procedures are performed.

Although these different definitions demonstrate some of the complexities involved in the notion of redundancy, Shannon is mainly concerned with the opposition between repetitive structures on the hand and singular occurrences on the other. As a consequence he sometimes consider repetitive patterns as redundant and sometimes as part of the rule-structure of the symbol-system, but always opposed to the singular occurrences which he considers as the distinct part representing the distinct meaning of the expression. In short, if there is a repeatable pattern there is a kind of redundancy and if there is an individual event there is meaning.

If the meaning is only in the individual events and the repetitively occurring patterns is only manifestations of the rules of the system, one may wonder why there is a rule-system at all and it is probably no coincidence that linguists such as J.J. Greimas and J. Courtes (1979/1982) quite contrary to Shannon defines linguistic redundancy as patterns which actually do have some - yet not theoretically analysed - importance for the internal organisation of meaning.

The opposition between these two ideas of meaning is particularly interesting because both theories introduce the concept of redundancy although they are built on the idea of rule-based systems. But if - as it is assumed both by Shannon and Greimas and Courtes - we are always dealing with rule-based systems we are forced to define redundancy in one of these mutually inconsistent ways. While Shannon is unable to explain how the use of redundancy may take part in the expression of meaning, (and leaves the meaning as a completely isolated, individual event) Greimas and Courtes are unable (or unwilling) to take individual events into their account since meaning is related to the repetitively occurring patterns. In both theories redundancy is introduced as notion of repetitive structures which differs from rule-determined structures - which are repetitively occurring too - in that the former are supposed to have no regulative function. While Shannon maintain the idea that redundant patterns are superfluous, he actually demonstrates that the redundancy is necessary »around« the individual events and hence do have a function for the maintenance of the stability, Greimas and Courtes maintain the idea that redundancy - although repetitive just as are rule-determined structures - is part of the manifestation of meaning.

The only way to bridge these approaches would be to acknowledge that meaning may be manifested both as repetitive patterns and as individual events occurring as variations in each pattern and that redundant patterns may serve both as means of stabilisation - quite similar to the function of rules - and as a means of the manifestation of meaning - quite similar to individual manifestations of meaning.

While the notion of patterns which neither have the function of a rule nor of a specific meaning may seem strange for many scientists, it is a quite usual phenomenon for instance in ordinary language. The letters of the alphabet represent a selection of such patterns as does the repertoire of legitimate syllables. While the former of these sets is - nearby - closed the latter is open, new members may come into existence. If a new member is introduced, we are allowed to speak of this as an individual event. There must be a first case. Only the repetition however makes the new form to a member of legitimate syllables, but if the repletion only takes place as a repetition in a specific constellation (for instance in an imported foreign word) it has not become stabilized as a member of the set of legitimate syllables. This would be the case only if the new syllable were also used as a compositional unit to form other words. In such cases we have a development from an individual first case, in which a new form is introduced, to the repetition of the new form by which it becomes a legitimate member of the existing repertoire of forms which may be used in various ways in the future. The set of stabilized, legitimate syllables represents a repertoire of redundant forms which may be utilized in several and different ways in future states of the system. In some cases, a syllable is used as a semantical unit ascribed a specific meaning, in other cases it is used without any semantic content as part of a word consisting of more than one syllable and in some cases, it is used as the manifestation of a grammatical or syntactical form. Syllables serve both to the manifestation of meaning, of individual events and of rules and they can do so because they are not themselves loaded with a specific meaning or a specific function.

They may serve more than one these aims at the same time, or they may change function during time.

The use of semantically empty set of letters and syllables in language are traditionally seen to provide a limited set expressional forms which can easily be remembered without limitations of the repertoire meanings which can be manifested. If it was possible to derive the semantic content from a set of rule-based means of expression, there would be nothing to say. The semantic content cannot be completely stored in the syntactical structure. But the semantic content could neither be manifested if it was to be manifested as pure isolated, individual events with no relation whatsoever to the system. The purpose of redundancy in language is to provide the forms which connects the individual event into the system without reducing it to a manifestation of a single state in a completely rule-based sequence. Contrary to rule-based systems, systems based on redundancy allows the occurrence of deviations and modifications of both the meaning and the rules and they do so because they at the same provide the stability necessary for the maintenance of the stability. Redundancy based systems possesses a set of features of change which are different from those of rule-based systems as the redundant patterns and structures may serve to stabilize the system while their own functions/and or meanings at the same time are changeable.

The general relation between individual events, repetitive occurrences, and the formation of rules in redundancy-based systems can be described as follows:

1: The establishing of a new expression form, a new pattern.
  In some cases new forms can be established by legitimation of formerly - noisy - varieties as independent forms. The ultimate limit for establishing of new forms is given in the physical substance used, and/or in a set of well-defined physical and/or constitutional criteria for legitimate forms in a given system. A main point being that new forms can be legitimated as such, with or without a specific content or function.
2: The repetition of the form - changing it from new form to a familiar or conventional form or redundant information).
3: The use of the form as a rule, ie: connecting the form with a regulative function.

Redundancy in language is in use on all levels as a mechanism for variation: notational, syllabic, syntactic, semantic including stylistic variance. Syntactical structure for instance can be described as a redundancy structure. In ordinary Danish a rich variety of meanings are expressed in the same syntactical scheme as most main clauses are manifested in the very same syntactical structure (while subordinate clauses are expressed in a slightly different scheme). This is quite contrary to the relation between syntax and semantics in formal systems in which semantical differences are often manifested in different syntactical expressions. The scheme of linguistic clauses allows several variations on the syntactical level. Some of these variations are optional in some cases, but not in others. Some variations may change the meaning, (ie: they are chosen to manifest a specific meaning) some may not (they may be chosen deliberately without impact on the meaning). The possible variations on the level of syntax are both dependent of the overall scheme and the allowed variations of the scheme and of semantical choices. According to the circumstances - familiarity for instance - some parts of the scheme can even be left out. The syntactical scheme provides an important means of stabilization of meaning by the help of range of possible utilizations and variations, or otherwise framed: it is one of the variable axes in the overall linguistic system.

This is one of the reasons why I see ordinary language as based on redundancy,[1] and redundancy as a precondition or resource for generating meanings as well as new rules.

Another - but connected - reason would be the existence of over- and underdetermination, interferences between rules and the lack of rules for regulating relationships between overlapping rules and so forth - phenomenas often described as marginal - expressed for instance in the phrase: no rule without an exception. Itself a »rule« which can be applied to a very high degree in linguistic matters.

Redundant patterns on a given level can be used in different ways:

I: As a means to stabilize a level relative to another level, eg: syllables to stabilize the use of letters, or syntactical forms to stabilize meaning on the semantic level etc.
II: As a repertoire of forms from which new varieties can be created (pattern deviation)
III: As a repertoire of forms which can be taken into use - to express a new meaning or new aspects of meaning, or to ascribe a new regulative function.

That language as such is not a rule-based system (although it contains many rules) but based on redundancy structures of this type is also strongly supported by the fact that it allows a reasonable way to understand the development of language since it allows a development from first manifestations over repetitive manifestations to the generation of rules. How could language have developed in any other way? We still have a problem concerning the explanation of the natural origin of the human capacity to create symbols. But this is the only mystery left, while those who argues for the priority and pre-existence of the linguistic rules also owe us a reasonable explanation of the origin of these rules.

However, it should be stressed that redundant systems do allow the formation of rules as a means of stabilization. But the point is that the description of language (and other symbol-systems) as based on redundancy implies that the establishing of rules is seen as a part of the usage, including the acceptance, ie: that the formation of rules are an integrated part of the use - contrary to a description of language as a ruled-based system, in which the rules are supposed to be given as invariants, somehow given from the outside.

In a broader perspective we could say that one of the main reasons that language must be based on redundancy is inherited in the functioning of language as mediator between senders and receivers who are not - and cannot be - fully synchronized to each other. One could also ask: why communicate at all if they were synchronized on beforehand? Redundancy provides a means to coordinate between or adjust unsynchronized systems.

Instead of going further into this I shall now give a general definition of the concept of redundant systems - stressing the generative potential which are often overlooked if not totally excluded (as it is the case for instance in Shannon's use of the concept).
In common use redundancy denotes the repetitive occurrence of patterns which have no function or meaning - and hence patterns which could be left out just as well. That is: as a passive irrational phenomenon.

Contrary to this, it can be shown that redundant structures have important functions and are used to many ends not only in ordinary language, but also in computers and in any other known use of physical patterns as carriers of symbolic content.

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[1] Concerning the concept of redundancy, one might add that it is always a phenomenon presupposing an observing and interpreting mind to whom something can be redundant, implying that redundancy is also always relative to something more distinctive. That is: as a difference which in some respect is minor to another. Hence one might conclude that if there is distinct meaning there is also redundancy of some kind. It should also be noted that the only difference between a redundant pattern and a »structure« is the function of the recurrent pattern: if redundant it might have no function at all, except that of the potential functions in the past or in the future, while »structures« means patterns which have an organizing function.

The basic reason, it seems, is that systems based on the use of redundancy possess a set of mechanisms for semantic variation which cannot be found in strictly rule based systems. This set of mechanisms consists basically in four axes of variation, as specified in the following points:

Redundant systems: The four axes of variation:

l) The axis of variation of physical form as legitimate physical form - relative to the substance (new forms, variation of existing forms) for instance: The level of basic notation (in symbol-systems using notations) whether alphabetical, binary notation or other forms. On this axis substance does matter in some way or another.
2) The axis of variation of structural relations between legitimate forms or patterns. The levels of constellations in syllables and syntax in language, the level of the ascii-codes and algorithms in computers.
3) The 1. axis of variation on the level of semantic content: The level of weakness-strength of a given content expressed. This type of variation »more or less strong« is well known from the various speech acts (assertive, directive etc.) Variation on this axis can be both continuous and discrete in ordinary language (oral).[2] Such variations are not expressed (but presupposed) in written manifestations, while only discrete variation (according to selection on a scale) is possible in computers. However discrete variations can be approximated to nearby continuous at least to the human sense organs.
4) The 2. axis of variation on the level of semantic content:
- as change of content of a given form (different from change of the semantic strength)
- as the transition from a first manifestation as legitimate form with a new meaning, to the repetitive use of the new form - either as a change of meaning or in a regulative function.
- changing the content of the form from new meaning to conventional rule (e.g.: syntactically stored content).

The basic principle is that variation on one axis in some but not all cases imply variations on other axes and that rules are not necessary for the regulation of the relations between levels. The stability of the system is in some cases based on the stability on one level while there are variations on another, in other cases the stability is established in the mutual relationship between coexisting levels. As a consequence, there can be lots of free variations of the forms both on the lower level (as it is the case on the notational level in written language which allow us to use a huge amount of different physical manifestations of the »same« letter while other physical variations represents a change of the letter to another or to the dissolution of the letter) as well as on the higher levels and in the interrelationships between levels.

3. Cultural, Biological and Physical Systems.

So far, I have been concerned with some of the reasons to doubt the universal validity of the notion of rule-based systems within the domain of the humanities. I shall now give a more general reason namely that the notion of rule-based systems seems to be inadequate for any attempt to describe the existence of mental and conscious processes and their relation to biological and physical processes. The main argument for this is that mental and biological processes relates to a limited and relatively independent time scale and - as I will argue later - such processes can only exist if the mental and biological systems possess a set of capacities which cannot be derived from any existing theory of the physical nature.

[2] Some linguists tend to define this axis as purely oppositional (binary oppositions) as the difference between marked and unmarked articulations. But I see no reason to exclude a continuous scale of variation.

One of these capacities - mentioned in the preceding section - is the capacity to distinguish between a physical form which is a legitimate member of a symbol-system from a physically identical form which is not. While two such physical entities are identical in respect to physical properties and effects, they are not so in respect to symbolic properties and effects. The difference cannot be done away by considering the difference as an effect of another physical system (for instance the brain) because the same difference applies to the relation between the neurophysiological and the mental processes. The neurophysiological system has to react to a distinction which does not exist in neurophysiological terms, namely whether the occurrence of an entity (e.g., a perceptual impression) is part of a symbolic representation or not. The argument applies to any domain involving notions such as noise, information, and codes and maybe it also applies to any domain involving reference to some sort of organized substance. It may not apply to mathematics, but only to the application of mathematical principles in the description of other natural processes. Plato might be nearby right in distinguishing between the eternal world of pure forms and the real, low and noisy world (if he would only allow both things in the same universe of time and space) and modern 16th and 17th century science wrong in the definition of substance as (extensional) form - and 20th century science wrong in the general dismissal of the notion of substance implied in the idea of abstract, self-dependent forms, structures and relations. The question is reopened - one of the reasons being just a little bit.

The great and wide-ranging effects of small things such as the bit follows basically from the necessity to integrate both physical and mental criteria in the explanation of this phenomenon. There would be no computers if there were not symbolic processes and minds but there wouldn't be computers neither if there were not mechanical nor physically performing machines. In the case of computers, the connection is established only by the help of the bits. While there cannot be noise on the pure physical level, there is no way to eliminate noise completely on the symbolic level, it can only be combatted, reduced, and controlled. This again is only possible because the timescale of the symbolic processes is not a direct function of the timescale on the physical level. The physical signals are processed sequentially, but the control function can only be performed as a process in which later signals effects former signals. The physical timescale is not broken, the universal physical process proceeds continuously, but the effects on the symbolic processes are suspended for a period. Without this there wouldn't be such things as storage, memory or - as it will be discussed in section 4, anticipation which is an even more intriguing phenomenon since we are only able to observe the past and not future events.

Although contemporary physical theory does not deliver a uniform and universal idea of time, we are in general almost always referring to a notion of time as a (mental or »real«) continuously passing phenomenon, which can be measured according to a discrete scale implying the existence of distinct states. There is no great difficulty in this if we are only concerned with either a physical process or a biological process or a mental process, but if we are taking the relationship between these processes - which we need to do according to the coexistence of mental, biological and physical processes in the same nature - we are confronted with a very intriguing problem, namely that a mental state can only exist as a relation between at least two - but probably a huge amount of - physical states which operates on a lower timescale. One may wonder why this is the case and the answer is that a mental process (for instance a perception or an imagination of something) takes time - the stable biological and mental entities (if there are such at all) can only occur as the result of a process, - and the time taken to produce the stable biological and mental entities will always correspond to a change between a number of different states on the physical level.

One might assume that this is only a question of aggregation or sampling of a certain a-mount of physical states into fixed sequences or containers/carriers which at the same time as they are complex physical processes acts as the basic and undividable units on the biological and mental scales. The intriguing point in this is that there is no equivalence between the extension of the physical, the biological and the mental processes. Take for instance spoken language, which is a specific utilization of breathing, speech organs and ear functions while the breathing at the same time is part of several different interacting processes - providing oxygen to the organism for instance. While the kind of molecules in the air does not matter much for the capacity to speak - they only need to be there in a certain density - it is vital for the breathing process. And while the breathing primarily is a process for each individual, speech is primarily a process which presupposes more than one individual. Although we don't breathe in the same rhythm, breathing serves the same purpose for all of us, the individual variations may count for each individual, but has no importance for the general function. They are of minor importance in biology, while they at the same time are of major importance for speech. We can only speak in so far, we breathe, but we couldn't speak if breathing were a purely physical-mechanical process which couldn't be individually varied. Speech is only possible because it is possible to code some individual variations in the breathing.

The function of breathing is inherited in the continuous repetitions, while the function of speech seems to be to coordinate and adjust the relations between different individuals - which furthermore presupposes that they are not coordinated and synchronized on beforehand neither in the breathing nor in the mind.

In so far, we are describing the organism in physical terms we would end up in a third kind of system and relations. Given notions such as molecules, energy and force it would be im-possible to delimit a neurophysiological system or the speech organs and to explain why the movements of molecules should cause a sound effect in the ears but not in the eyes or lungs - or fingers or why in some cases they cause an impression of noise, in other cases an impression of music and in other cases again of speech. It would be impossible to delimit the biological system as well as the mental system since there would be no criteria for the delimitation of these systems. On the level of the atoms, molecules, energy, and force there is only such things as gravity, position, density, velocity, and chemical reactions - and they are all over and acts in a completely uniform - and synchronised way. Phenomena such as the neurophysiological system - assumingly a precondition for the mind - can only be pointed out and delimitated as a specific system by the help of the concept of the mind. We wouldn't know which molecules and processes we should select as the neurophysiological system if we didn't have the notion of the mind as something different than these processes. So, the very special kind of reductionism which seeks to reduce mental processes to physiological pro-cesses tries to do so by ignoring the fact that they can only identify the neurophysiological system by the help of properties they attempt to deny.

This kind of reductionism is right in assuming that there is only one universe, but it is wrong in assuming that it can be described within the framework of a rule-based system and because it denies the existence of the very same phenomena, which are used to identify the phenomena to be described. That physical, biological, and mental systems are not describable within the same set of concepts is strongly supported by the empirical fact that new concepts are always introduced even within reductionist theories when moving from one level to another. If modern science is right in assuming that the universe originally consisted only of concentrated energy, we need to assume that the later development includes the origin of biological processes, eventually implying coding procedures as well as symbolic processes, intentions, goals etc in some - maybe very fragmentary segments of this universe. The processes of breathing and speech are interrelated and connected, but only partly. The two systems differ in their extensions as well as in their functions - and in their historical relations: the phenomenon of speech is much younger than that of breathing, but speech has become a condition for the survival of human beings. There are some hard first cases and evolution of new types of rules and regularities and variations to be explained.

4. Rule-generating and Anticipatory Systems.

The notion of anticipatory systems (seems to imply or) is only of relevance if choices are possible. Given a system in a certain state there need to be at least two options for the next step. However, a choice is not identical with chance. There is only a choice if the next step is taken because of one or another influence (e.g., a conscious consideration, an optional reaction to external stimuli). While a selection of the next step in a random process can take place immediately, a choice takes time. The notion of choice implies the existence of a system which can maintain itself as stable during the time needed for the selection of the next steps. A choice implies a suspension of the physical timescale. Since any system is always also physically manifested and processed it follows that the stable state is stabilized in an underlying physical process - the stable state needed to perform a choice may be seen as an aggregation of several physical states, but it is not definable on the level of physical states since a description of physical states does not provide the criteria for delimitation of a stable system with the capacity to choose. The process of choosing is a process in which the system spends time in which a series physical states is aggregated so that a diachronic physical process functions as a synchronized unit on a higher level, while the lower-level physical processes proceed continuously. The movements of the molecules do not stop according to the higher level entities/states.

Physical theory (such as thermodynamics) provides models for relations between random processes on a lower level and ordered states on a higher physical level, implying that a physical system may have more than one scale of time as there is no direct correlation between processes on the timescale on the microlevel and macrolevel - some processes on the lower level may cause a change on the higher level while some others do not and the criteria for this distinction can only be identified and measured on the macrolevel. But even so it does not provide any criteria for a distinction between chance and choice in so far as it does not provide any criteria for the identification and measurement of the time needed (and processes performed) for a choice to be made.

The distinction between chance and choice cannot exist within the framework of any existing mechanical and/or physical theory. The notion of choice implies the existence of systems, processes and states for which there is no room in physical theory which only allows chance, but not choice. The basic obstacle is that a choice implies that the system is capable to be stabile - acting as a unity - across a series of different physical states. The next step is neither the result of a deterministic mechanical process, nor of an instantaneously and random process. While theories allowing chance also allows random variations and hence certain kinds of innovations, they cannot explain how stability and innovation interacts as interdependent processes allowing changes of the system to take place.

While modern physical theory introduces chance and modern biology choice - both allowing a wider range of possible changes in nature, there is still a need to introduce a notion for the possible changes of rules (or laws) due to the facts that many rules only exists as resultants of processes within time and space and that many known rules or laws was neither given from the beginning nor can they be derived as a consequence of previous existing laws alone.

It would not be unreasonable to expect that the concept of anticipatory systems - defined as a system which may contain predictive models of itself and/or of its environment, which it can utilize to modify its own present activities (Rosen, 1985: 195) - would be a candidate as a notion for such systems, although it is not clear whether the possible modifications allowed includes the modification of the constituents of the system and the system itself?

Considering the computer for instance, we can say that the physical machine is not a system possessing any capacity to modify itself, while we ourselves are capable to do that. However, if we consider the computer on the level of binary notation, we are considering a system in which any string of bits can be changed into any other string by the help of a third string, while the two bits themselves are the only invariants. There are no limits for the possible changes of the system on this level, which means that restrictions can only be imposed from higher levels - which - as described earlier in this paper - means that these higher-level constraints remain optional - they are deliberately chosen for a given purpose and kept invariant during a period. If Turing is right in his description of the principles of the universal computing machine we can take it for granted that any finite procedure can be converted into this system in which the rules are manifested and processed in a format which allows both the complete suspension or dissolution of the rules as well as an unlimited number of possible modifications and changes between different rules. Although rather inconvenient it could in principle be done bit for bit. If anticipatory systems belong to the class of Turing-compatible procedures, they would be open for these types of changes too - in so far, they are converted into and represented in the binary alphabet. But this operation would imply that the anticipatory system as such could only be considered as a selected higher-level representation in another system which would have another description, for instance the one previously given.

Now, computers are not intrinsically rule-generating systems, they are only vehicles for such systems, namely human beings which are capable to build and use such machines whether to mathematical purposes or to a variety of other purposes. Since there is no evidence that the brain operates with a notational system as does the computer, we cannot transfer the properties related to this system to the brain. Maybe rule-generating systems possesses only a much more limited set of possible ways for the change of rules? This may well be true but even so there is still an open question concerning the character of these constraints since they must function as constraints on the level of codes and representation, while at the same time they can only be constraints if they are physically manifested and processed in time and space. The same would apply to anticipatory systems.

If as argued representational systems necessarily are based of redundancy functions at the bottom level - that of the physical manifestation of the representational units (whether in the brain alone or supplemented by an externalised representational system) anticipatory systems are also based on redundancy functions as are rule-generating systems. The major difference so far seems to be that the notion of anticipatory systems does not include any account of how individual events (whether produced in the system as noise or as the result of external disturbances) may be the point of departure for the formation of a repetitive pattern which eventually again may be utilized for the generation of new rules and change or suspension of former rules.

There are yet - to my knowledge - no answers known to the question how redundancy based systems comes into existence and eventually gives rise to rule-generating systems, it can only be stated that if there is a redundancy based system there is a potential for rule-generative procedures to take place, and if as argued anticipatory systems are based on redundancy they could also be rule-generative, while rule-generative systems are not necessarily also anticipatory systems. Anticipatory systems are of a more specific type than are rule-generating systems since there may be rule-generating systems which does have any predictive model of themselves nor of their environment.

In so far, an anticipatory system would always be able to provide itself with the right model of itself as well of as the environment it would be much more stable system than a rule-generating system without predictive models. The predictive models would be a strong instrument to control noise and redundancy on the lower levels. But since predictive models are only models of something else there are no way to guarantee that the model is completely correct. And since anticipation of future events can only be stipulations based on experiences of the past - the future is not observable - there is always a risk that the predictive model is not able to react adequately to later events/observations. It may need a correction of the model itself. This is what has often happened in the history of science and in many if not all other areas of human affairs. For this reason, it seems that anticipatory systems which are also rule-generating systems are preferable because they are more powerful than anticipatory systems which are not rule-generating systems.

While 19th and 20th century theories have been much concerned with laws of change they have not been much concerned with questions concerning change of laws. In this respect the notion of redundancy seems to be necessary as it provides a possible chain between chance, choice and change even of laws in so far they are processed in time and space.

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