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Finnemann, Niels Ole

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Rule-based and Rule-generating Systems

by NIELS OLE FINNEMANN

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EDITED BY
PETER BØGH ANDERSEN
CLAUS EMMECHE
NIELS OLE FINNEMANN
PEDER VOETMANN CHRISTIANSEN

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Rule-based and Rule-generating Systems[1]

NIELS OLE FINNEMANN[2]

l. Introduction

Until the 19th century scientists almost always assumed that the universe as a whole could be described as a uniform, completely rule-based and hence deterministic system. During the 19th century emerged the notion of the universe as a set of such systems, in part a consequence of the breakthrough of dynamic models in physics (eg. statistical theories in thermodynamics (Boltzmann and Gibbs)), biology (eg. Darwin's theory of evolution) and other fields. Nature became dynamic and the natural dynamic included the evolution of new domains and levels. The origin of life was now seen as a first step in the evolution of a biological domain or level, and the later origin of human beings and mental processes were seen as a first step in the evolution of a psychic, symbolic, social and cultural level. The origin and evolution of these phenomena were now assumed to take place in physical nature (i.e. as processes within time and space) and no longer seen as fruits of a divine creational act or big bang at the very beginning of everything. The notion of the universe as a set of rule-based and layered systems has also been maintained in most 20th century theories (eg. various kinds of functionalism and structuralism), eventually accompanied by theoretical reasoning on the relationships between the various systems and levels (eg. psycho-physical parallelism, emergentism). Relationships which still seem to give rise to some highly intriguing questions on the connections and interactions between physical, biological and mental phenomena.

There is a good reason for this. If the universe as a whole is regarded as a single rule-based system, there is not much room for the idea of many distinct

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[1] This article is partly based on a presentation given at the symposium »The emergence of codes and intentions as basis for signprocesses,« Odense University, October 26-28, 1995.

[2] Dept. of Information and Media Science, Aarhus University, Niels Juelsgade 84, DK 8200 Aarhus N, Denmark.

rule-based systems. And if the universe is regarded as a set of such distinct systems, it is not easy to see how there can be only one universe. If the relations between the various systems (whether physical, biological or mental) are rule-based they cannot be distinct and autonomous, and if these relations are not rule-based one may wonder how they relate and how their autonomy can be maintained if they are all existing in the same universe of time and space.

There is a close relation between the notion of levels and the notion of downward causation. On the one hand, there cannot be anything like downward causation if levels are considered to be purely conceptual phenomena, while on the other hand one needs an idea of downward causation if levels are considered to be constituted as distinctive real processes in the world. A higher level process completely separate from and not interacting with lower level processes cannot be a process in the same universe as those lower level processes. Furthermore, without the effects of downward causation as one of the interactions there would be no reason to specify any higher level(s) in the first place. Without downward causation everything could be explained (except the existence of explanations) on the basis of lower level concepts alone.

It has been argued that higher level processes might constrain lower level processes without causing any effects.[3] It is not easy to see how this could be the case. If, for instance, we consider mental processes as higher level processes, it seems difficult to understand how an idea (a mental state) could act as a constraint on the neurophysiological system if the idea did not cause some neurophysiological processes. How this actually works is still completely unknown, but in any case it seems to function very well.

It has also been argued that there will always be an equivalent lower level description of the assumed higher level processes which causes the lower level effects. This would be very nice, since it would allow us to reach a real, unified theory of everything—and not only a unified physical theory. But so far there is no evidence that something like this is within reach of contemporary science. Partly this is due to the fact that even if a lower level manifestation of a higher level process exists, a fixed or invariant relationship between the two does not necessarily exist. I shall return to this theme later in the article.

The idea of downward causation presupposes the existence of separate but coexisting and interacting levels. There has to be an upper and a lower level and a connection which does not undermine the distinction. There can only be an upper level if the existence of processes on this level makes a difference

[3] See for instance Køppe, Emmeche and Stjernfeldt in this volume p xx..

for (i.e. causes an effect on) the processes on the lower level. Upper level phenomena have to be conceived of as autonomous actants able to cause effects on the lower level. Furthermore, the notion presupposes that the origin of the upper level can be explained as a (coincidental or rule-based) result of processes on the lower level.

The implications of these presuppositions (the existence of levels and the generic and interactional relation between them) are controversial in at least two respects:

1) Concerning the assumption of the existence of levels: if we assume the existence of an upper and a lower level (or even more levels), it follows that we do not consider the relationship between the levels as a completely deterministic relationship, since the assumption that the relation is deterministic implies that there is no way to distinguish a separate upper level. The upper level is always completely described by the lower level description. There would be nothing to add.

According to the tradition of modern science there is only one alternative left, namely to assume that the relationship between the levels is randomly variable. If so, there would be no relation to consider at all.

In this paper I will introduce another alternative: the relation is not completely random but variable, because the relations between levels are constrained by various sorts of redundancy functions stabilizing the higher level processes on the lower level scale and allowing interaction between the levels both as individual events and as repetitively occurring patterns.

That a relation between levels is variable indicates the following:

a) that a given lower level process may be accompanied (eventually controlled or caused) by different higher level processes. There can be a number of different higher level causes for the same lower level effects. For instance, a machine (lower level system) may be a functional part in a number of different complex systems (higher level system). Hence, there can be more than one interpretation of such a machine. Take as a simple example the use of a given algorithm for a number of different purposes, or the number of possible codes for the interpretation of the same physical figure, eg. two or more meanings of the same sequence of letters.

b) that a higher level phenomenon may be manifested in different lower level processes. A goal (or a macrostate) may be achieved by means of a number of different procedures, tools or machines (or microstates). Take as a simple example the number of possible physiological variations in the pronunciation of the same sounds or a word (eg.

variations due to gender, age, dialect, sociolect, etc.) or the number of possible molecular microstates corresponding to one macrostate.

2) Concerning the generic relation between the levels (upward causation or emergence) and the assumption that upper level processes may cause effects on the lower level (downward causation): upward causation is controversial, since the notion implies that there is something in the effect which is not in the cause. However, after Darwin it is not easy to see how the idea of upward causation from simpler to more complex systems can be avoided. While there is something like upward causation from simple to complex organisms inherited in Darwinism, there is no idea of downward causation: the notion of natural selection does not refer to the existence of a selector controlling development from above. In Darwinism selection takes place as a result of a blind process and not as the result of intentionally controlled intervention. But since Darwinism implies that the human mind and intentionality is understood as results of evolution, it follows that the process of upwards causation leads to the evolution of phenomena capable of exerting downward causation in so far as the human mind takes part in the further evolutionary process. This may take place in many different ways, one of these being the invention and production of tools, artefacts and symbols.

For those who deny the validity of the notion of downward causation a main question is whether, for instance, symbols, technologies, tools and artefacially produced machines can be described with the same conceptual apparatus as the one used to describe the physical and chemical conditions for the emergence of these phenomena, i.e. without reference to human intentionality or similar notions for mental phenomena.

In this paper it will be argued that there cannot be a physical theory of the universe if there is not the capacity to create symbols in the same universe. The existence of theories presupposes the existence of symbols. It will also be argued that no symbol or mental process can be defined only according to physical criteria, insofar as the notion »physical criteria« denotes the conceptual framework of contemporary physics. Furthermore, it will be argued that the assumptions of there being only one universe and of us being a part of this universe ourselves both because of our bodies (whether conceived of as physical or biological) and because of our minds imply that we need to accept the following notions.

I The notion of distinct levels. If the mind has no independent existence relative to the physical processes there is no room for the existence of *a theory* of physical processes as distinct from the physical processes.

II The notion of coexistence and interrelations between different levels, since without such interrelations there would be more than one universe or there would be no descriptions within the universe.

III The notion of the emergence of and interaction between levels. The need for the notion of emergence follows from the fact that we cannot trace the existence of biological and mental processes as far back in time as the existence of observable physical processes. If biological and mental processes are generated within the physical universe, they are necessarily interrelated parts of this universe.

Now, one may ask how such things as organisms or mental processes might at the same time be regarded as generated from a former purely physical universe and as phenomena which possess certain kinds of autonomy including a capacity to cause effects on the lower, physical level. In the following I shall argue that the question cannot be answered within the conceptual framework of nature as a set of rule-based systems—and that the inclusion of mental processes in the idea of nature presupposes the idea of what will be denoted as rule-generative systems.

There are two basic and interconnected ideas. The first is that redundancy provides the basis for a transition from individual events which happen by chance or by choice into repetitive occurrences which allow a structure or pattern to acquire new functions or meanings and thereby also allow a change of rules or the establishment of a new rule. The second is that redundant patterns which serve as a means to stabilize a system on the lower level may do so while at the same time being utilized for various and changing functions and/or meanings on the higher level.

For these reasons redundancy provides a means of both stabilization and change as well as a means of interrelation and interaction between different levels in a system and between different systems.

The point of departure for this discussion will be taken in two symbol systems based on redundancy. 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) is provided by means of—differently organized—redundancy functions. It will be shown that the use of various kinds of redundancy both allows the maintenance of systems in unstable micro- or macro-states, the suspension of previous rules, under-determination and over-determination as well as the generation/emergence/creation of new rules more or less independent of previous rules.

Since the notion of redundancy is both controversial as such and often avoided, I shall discuss the concept (as defined in Claude Shannon's mathematical theory of information and in the semiotic framework of J. J. Greimas) and give a more general definition in which the redundancy functions are seen as a means to overcome instability due to noisy conditions and even more important and less recognized also as a way to allow new rules to be generated, but at the cost of a rule-based stability, determination and predictability.

Finally, I will discuss some of the possible wider implications for the study of cultural and social systems—in which there will always be various kinds of noise (whether from the underlying levels and/or from the occurrence of individual variations) and address the question of downward causation from psychical (intentional) systems to physical and biological systems.

2. The rules in the computer

Although the computer is often seen as a rule-based machine—and as an paradigmatic model of the notion of rule-based systems—a closer look at the functioning of this machine gives an excellent demonstration of the limitations of this very notion while at the same time demonstrating that the use of redundancy functions is necessary for the physical processing of the symbolic (and hence mental and intentional) content in the machine.

In the case of computers the shortcoming of the notion of a rule-based system is directly related to the fact that the symbolic rules which are to be processed in the machine have to be represented and processed as a string of bits which can be manipulated on the level of the individual bits and hence completely independently of the formal rule itself (cf. Finnemann 1994). This may be difficult to do. Normally another programme is needed to do it, and it may often give absurd consequences, but the important thing is that *is* possible to do, since this means that the previous states in the computer do not determine the later states in any compulsory way.[4] Automatically performed (rule-based) processes in the computer are the result of a deliberately composed sequence of steps which we choose to run automatically for the sake of our own convenience. The rules which control the data processing can only do so as a result of a process in which they are themselves manifested and processed in exactly the same way as any other kind of data.

[4] As originally shown by Turing, there will not always be a rule for the next step in a universal computing machine. He therefore described the machine as both an automatic calculating machine and a choice machine. There is no difference between these machines; there is a difference between situations in which the instruction for the next step is already defined and situations in which the next step is chosen deliberately. Since the instructions never is a part of the definition of the machine they can always be deliberately chosen.

Consequently, it is always possible to intervene in and change/modify the system of rules from the lower level of the bits. Since this can be done deliberately and bit by bit, there are no invariant restrictions on the character of such modifications. Rules can be suspended or varied, or their functions can be changed independently of the content of the rule and on a level beneath that of the rule itself. It is not only possible to change or modify any previous rule, it is also possible to feed completely new rules into the system if only they are manifested in the binary alphabet.

In this way the computer illustrates how a completely deterministic process on the higher level (of symbolic formalism) is processed in a system in which there are only random and optional relations between single and discrete states on the lower (physical) level, which is the level of the actual operations.

One of the main points here is that the level of »physical operation« and execution is always the level of binary digits allowing us to go from an interface directly to this level and manipulate any formal procedure according to our intentions.

It should be obvious from this—albeit brief—description that the formal rules used to perform the organization of the binary sequences do not guarantee the stability of the system, since they can be modified, varied, suspended or ascribed new functions, and so forth. Of course, we have all seen that the violation of formal procedures may cause the machine to go into a closed loop or freeze. We do need rules to stabilize our operations, but we do not always need the very same rules. And even if the machines freeze, we are able to restart and continue.

What we have here is a system in which the rules are processed in the same time, space and physical form as the phenomena (data, substance ..) being ruled. The rules are manifested as an integrated part of the ruled phenomena, on a par with them, implying that there are systems in which the rules can be changed, modified, suspended or ascribed new functions during the processes, whether influenced by any component part of the system or from lower level phenomena (noisy physical substance) or according to new intended or unintended external inputs. The computer is a machine in which physical and mechanical determination is restricted to a single move from one state to another on the level of the bits.

As a consequence of this it seems necessary to introduce a concept of what I will label rule-generative systems, which are different from rule-based systems.

Rule-based systems can be defined as systems in which the processes are governed by a set of previously given rules (given from the outside of the system and inaccessible from within the ruled system). The rules govern the system and guarantee the stability and existence of the system.

In contrast, rule-generative systems can be defined as systems in which the rules are the result of processes within the system and hence open to influence both from other processes in the same systems as well from higher or lower levels and the surroundings. Such systems are to some extent, but not completely, governed by the rules, which are themselves open to modification, change and suspension.

In such systems the rules are neither able to provide the stability nor to explain the interactional relations between the levels. Hence we need to explain how stability and interaction across levels can exist in these systems.

3. Redundancy as a means to stabilize noisy systems

To my knowledge the question of redundancy as a means to stabilize noisy systems was first addressed by Shannon (Shannon 1949), who tried to find a mathematical method to determine whether a received bit—let's say an /I/—was actually an intended part of the message sent or whether it was changed from an /0/ as a result of the influence of noise during the transmission. Shannon's answer to the question was that it would be possible to solve the problem by adding a control code to the message sent. By means of this additional coding it would be possible to correct the received message, eliminating the noise resulting from the transmission. The additional code should be a distinct part of message, but it should have no impact upon the meaning of the message. For this reason he described the method as »combatting noise« by increasing the redundancy in the message.

Shannon uses the notion of redundancy in a rather vague and loosely defined way about any recurring patterns of no importance to the meaning or structure of the symbolic expression, and he is not very concerned with the various different forms of redundancy. However, such different forms can be identified, even in his own original paper, in which we can find several types of redundant 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:

1 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 symbol system 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.

2 Redundancy defined as possible but unused patterns/forms allowed by the symbol system. In this case it is not the manifested parts determined by the symbol system, which are seen as redundant, but the set of possible alternative, 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.

3 Redundancy defined as the statistically determined repetitively occurring patterns 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.

If the classification is structured according to the relation to meaning we get the following definitions:

TYPE I: *Redundancy defined as opposed to meaning.*

(a) Repetitive patterns without any meaning/function. Meaning is seen as related to the whole message, including rules necessary for the interpretation.

(b) Patterns belonging to the system (invariants/constants). Meaning is seen as the new information and defined as the part of the message which is distinct from the (rule-governed) parts belonging to the rule structure of the symbol system.

(c) The amount of possible alternatives to a specific message in a given language. Meaning is seen as the actually selected new information as in b).

TYPE II: *Redundancy defined as independent of meaning.*

Recurrent patterns (statistically defined) in the whole message, whether representing the system or the specific information/meaning.

TYPE III: *Redundancy defined as formally defined meaning*—added for the purpose of »combatting noise«

In this case redundancy is defined as calculated information added to a message to verify the legitimacy of each symbol—contrary to the possible, unintended occurrence of the same physical form as noise. Meaning (= the calculated, redundant information), is calculated by interpreting a given sequence of notation units as a formal expression (i.e., ascribing a formally defined semantic content according to which the legitimacy of the individual units can be verified by comparing with the ascribed »values« of other units). Redundancy of this type is only redundant at the semantic level of the original message, since it is a specific sequence which has to be added to the message transmitted (instead of being eliminated) and is necessary for the verification. It forms a distinct or specific part of the transmitted message. In this respect it equals information.

Rather than going into further detail and explaining why Shannon needed all of these different notions, I shall concentrate on why he needed a notion of redundancy at all. The basic reason for this can be found by considering the character of noise as it reveals itself in the identification of notational units.

There are three aspects of noise involved. First we need to be able to identify notational units as distinct to the background. Notational units are always manifested in one substance or another. Second we need to be able to identify notational units as distinct compared to other units (in the same or related notational systems) and third as the most complicated aspect: we also need to be able to identify a notational unit as a legitimate (intended) unit compared to the possible but unintended occurrence of the 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 as a symbolic unit from an physically identical form which is not intended as such) has 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 can also exist/occur without being symbolic units—whether the forms are provided by nature without any human intervention or by means of that. While the first and second aspects can always be solved by specifying certain physical criteria for the physical form of the individual units, there is no way to solve the third aspect by means of such physical criteria. This is why there cannot be a mechanical theory of symbol systems and of meaning.

Since Shannon's main purpose was to find methods to increase the capacity of the transmission channels, he was primarily concerned with methods to eliminate the redundant parts of the messages and hence reduce the amount of signals used to transfer the messages. What he found was that it was actually possible to reduce the amount of redundancy in the original message by means of various—primarily statistical—methods, but since these reductions made the transmission more vulnerable to noise (especially of type III), he also found that he could only eliminate one kind of redundancy (statistically defined) by introducing another (however more economical) kind, namely the formally defined control codes.

As one of the most interesting implications of his work we can state, first, that redundancy in one form or another seems to be necessary to maintain the stability of the symbol system on the basic level of physical manifestation, and, second, that redundancy on one level can to some extent be substituted for redundancy on another level. For instance, eliminating redundancy type II is only possible by adding redundancy type III, i.e. by substituting semantically defined redundancy for statistically defined redundancy—the latter being defined at the level of notation units.

Since redundancy type III is defined in a formal semantics, it can be defined independent of the semantic content of the message. In other words, it can be added before and eliminated after the transmission, without influencing the content of the message at all. In this case the formal procedure is neither part of the syntax of the message nor of the semantics, but of the computational syntax used to stablize the message during transmission. Since any message can be stabilized by means of a number of different redundancy structures, it follows that a given message can have many physically different manifestations. There is no passage from the physical manifestation to the meaning which does not involve knowledge of codes to distinguish physical patterns which are noisy from redundant patterns in which meaning is always incorporated.

Conclusions concerning Shannon.

(1) Some kinds of redundancy are always needed to communicate messages—even in the case of physically precise (unambiguous) expressions. The basic necessity stems from the fact that any physical form which can be used as a symbol/notation unit (as information) can always exist as a mere physical form (as noise).

(2) It is possible to substitute formally defined redundancy on the semantic level for (statistically) defined redundancy on the notational/physical level. 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—on different levels. Since a substitution of this kind is always possible, it follows that a given level can be modified both with and without effects on other levels. A new pattern may be generated without any impact (on the meaning or function of the system) at the time of formation, but it may be ascribed a function at a later time or a previous function may be

changed into another or fade away. Changes may take place with as well as without impact on the content/function.

Although Shannon demonstrates some of the complexities involved in the notion of redundancy, he is mainly concerned with the opposition between repetitive structures on the hand and singular occurrences on the other. Consequently, he sometimes considers 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.

It is probably no coincidence that this is quite contrary to the definition of redundancy by Greimas and Courtes (Greimas and Courtes 1979/1982), who are concerned with the function of redundancy in ordinary languages, since it is well known that repetitive patterns are often used as a means to express meaning in linguistic messages. As a result, Greimas and Courtes' definition of redundancy is opposite that of Shannon's in that they define redundancy (or recursive patterns) as patterns of some—not yet theoretically defined—importance to the internal organization of meaning.

The opposition between these two concepts of redundancy brings us directly to the core of the difference between rule-based systems and rule-generating systems based on redundancy functions. If as 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. In one of the cases (that of Shannon), any kind of repetitively occurring pattern can be redundant, regardless of whether the repetition is completely superfluous or follows from the rules of the symbol system. If this is so, there is no way to explain how the use of repetitive patterns may take part in the expression of the content. In the other case (that of Greimas & Courtes) it is possible to specify the meaning of repetitive structures, while it is not possible to take into account the occurrences of individual events since the meaning is related to the repetitively occurring patterns. Yet at the same time the two concepts taken together show that meaning can both be manifested as repetitive patterns and as unique manifestations.

What we need is a concept of systems in which there are no *invariant* borders between individual occurrences, repetitive patterns without meaning, repetitive patterns which may have meaning and repetitive patterns necessary for the organization and structure of the expression.

It is no coincidence that both Shannon and Greimas/Courtes are actually in agreement when it comes to the question of how we can distinguish between regularly manifested occurrences which are redundant (and hence assumed superfluous) and those which are parts of the syntactical rules of the symbolic system (and hence assumed necessary). The only difference between these manifestations is the difference between patterns which have a regulative function and patterns which do not have any such function. What they both need, however, is to establish the possible connections between the individual events and the repetition of such events as redundant or eventually as part of the meaning and/or as functional rules. However, this is only possible to do if it is acknowledged that there are systems in which the function of a pattern may be variable.

4. Individual events, redundancy and the generation of new rules in language

I shall now demonstrate the existence of such relations by means of a linguistic example which will show how new codes or rules can be generated in systems independently of preexisting rules by utilizing individual occurrences and redundancy functions.

The example is taken from a recent innovation in everyday Danish concerning a group of compounds which for some years ago were changed—rather suddenly—to a new form as listed below:

New form			
Børneren	for	Børne-haven	(kindergarten, nursery school)
Døgneren	for	Døgn-kiosken	(24-hour service kiosk)
Fritteren	for	Fritids-institutionen	(youth recreation centre)
Trykkeren	for	Fjern-betjeningen	(remote-control unit)

There is a rule of reduction in this, and we can describe it by saying that a weak ending is substituted for the second part of some compounds. This is not a general rule in ordinary Danish and it is only applied to a limited group of compounds, namely compounds referring to central—new—institutions in daily family life in Denmark from the 1970s onwards.

Hence the conditions and restrictions for the use of the rule are extra-linguistic and not rule-based but based on the familiarity of the compounds in daily life (which is a case of redundancy). But the rule is not only based on—social—redundancy (familiarity), the content of the rule is also related to linguistic redundancy since it is a rule that reduces superfluous parts of the manifested expression.

Maybe one should also take into account that the compounds, except that of »børnehaven«, refer to quite new—and previously not yet culturally internalized—institutions, making the language usage in the area less stabilized.

We do not know the empirical details of this development, but we do know that there is an origin—a first case. Somebody said one of the new words (presumably the word »børneren«—maybe coined by a five- or six-year-old girl or boy) for the first time on a certain occasion. Since it was an innovation, a new way to speak of something well known, we can furthermore assume that the articulation of familiarity was actually a part of the message (new meaning) contained in the new form in the first manifestation (hidden message: listen, I don't need to say »børnehaven«. You know what I mean when I say »børneren«). If so, the first manifestation of the new form is part of a specific meaning, as is often the case in ordinary language. The following steps are more unusual, since most linguistic innovations of this kind normally fade away very quickly. In this case, however, not only does the new form spread among a limited group—it spreads all over the country. The new form is repeated again and again and becomes familiar and commonly used as ordinary language while the specific meaning in the first case (that the institution has now become so familiar that we don't need the whole word) fades away, which at the same time opens up for the use of the new form as a paradigmatic—regulative—form which can be used as a rule for similar innovations.

Familiarity—redundancy—is both a condition for the first use and for the acceptance and spread into larger groups as well as for the application of the same pattern onto other words. It is the general precondition for the change as well as for the selection of the range of application.

The example can be regarded as a general paradigm, which may be called the mechanism or the principle for generating rules in redundant systems.

The mechanism is a process developing through 3 steps:

(l) The first manifestation of a new form or pattern, or introducing a new way to speak of something which at the time has become familiar: for example, as an expression of the new information that it has become familiar (i.e. the new form represents a new meaning). There are also cases in which existing forms are used in new constellations (such as syllables, for instance, are used to form new words).

(2) The acceptance of the new expression, i.e. repetitive use of the first manifestation, changing it from being new information to being an established custom—implying acceptance of the familiarity. This will normally take place in a smaller group and then—in some cases—it will spread. The most interesting cases being those which actually spread

throughout the whole linguistic culture, that is, forms which can be used in public.

(3) The spread of the use of the pattern as established custom and the use of the custom as a rule applied to—a set of—other compounds, in this case compounds representing central institutions in a newly changed way of daily life (Danish welfare society anno 1970 and onward).

Redundancy as a mechanism for variation in language is in use on all levels: 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 is often manifested in different syntactical expressions. The scheme of linguistic clauses allows a number of 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 will not (they may be chosen deliberately without impact on the meaning). The possible variations on the level of syntax is 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 axis in the overall linguistic system.

This is one of the reasons why I see ordinary language as based on redundancy,[5] 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 under-determination, interferences between rules and the lack of rules for regulating relationships between overlapping rules and so forth—phenomena often described as marginal—expressed for instance in the phrase: no rule

[5] Concerning the concept of redundancy, it is always a phenomenon presupposing an observing and interpreting mind for which 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 actually have an organizing function.

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, e.g.: 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.

In my view this is an obvious demonstration of the basic mechanism in redundancy-based symbol systems, such as linguistic and computational ones (while formal symbol systems are rule-based). I don't think it proves that language as such is not a rule-based system but is based on redundancy structures of this type. However, that the latter is the case is strongly supported by the fact that it provides a reasonable way to understand the development of language since it allows a development from first manifestations by way of 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 arguing for the priority and pre-existence of 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 describing language (and other symbol systems) as based on redundancy implies that the establishment of rules is seen as part of the usage, including its acceptance, i.e. that the formation of rules is an integrated part of the use—contrary to describing 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 has to be based on redundancy is inherited in the role of language as a mediator between senders and receivers who are not—and cannot be—fully synchronized with each other. One could also ask: why communicate at all if they were synchronized beforehand? Redundancy provides a means to coordinate 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 is often overlooked if not totally excluded (as is the case, for instance, in Shannon's use of the concept).

Redundancy ordinarily denotes the repetitive occurrence of patterns which have no function or meaning, and hence patterns which could be just as well left out: that is, passive, more or less irrational phenomenon. In contrast, 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. The basic reason for this 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 basically consists in four axes of variation, as specified in the following points:

Redundant systems: four axes of variation:

l) An axis constituted around the establishment of forms in a substance. 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. In some cases new forms can be established by legitimating former—noisy—varieties as independent forms. The ultimate limit for establishing new forms is given in the physical substance used, and/or in a set of more or less well-defined physical and/or constitutional criteria for legitimate forms in a given system, one of the main points being that new forms can be legitimated as such, with or without a specific content or function.

2) An axis constituted around the establishment of compositions of elementary forms. 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) An axis constituted around variations in the strength of an articulation. The first axis of variation on the level of semantic content: The level of weakness-strength of a given content expressed. This »more or less strong« type of variation 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).[6] Such variations are not expressed (but presupposed) in written manifestations, whereas only discrete variation (according to selection on a scale) is possible in computers. However, discrete variations can be approximated to nearby continuous variations, at least to the human sense organs.

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

4) An axis constituted around variations in semantic functions. The second axis of variation on the level of semantic content:

- a change in the content or modality of a given form (different from a change in the semantic strength);
- the transition from a first manifestation as a legitimate form with a new meaning, to the repetitive use of the new form—either with a change of meaning or in regulative function.
- a change in the content of the form from new meaning to conventional rule (eg: syntactically stored content).

The basic principle is that variation on one axis in some but not all cases implies variations on other axes and that rules are not necessary for the regulation of the relations between levels. The stability of the system are 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. Consequently, there can be many free variations in the forms on the lower level (as is the case on the notational level in written language, which allows us to use a great number of different physical manifestations of the »same« letter while other physical variations represent the letter changing into another letter or the dissolution of the letter) as well as on the higher levels and in the interrelationships between levels.

5. Downward causation in rule-based systems?

If adhering to the notion of downward causation as suggested by Kim (Kim 1992:120) implies »that you are apparently committed to the consequence that these "higher-level" mental events and processes cause lower-level physical laws to be violated« defending this position seems difficult. To my knowledge at least, the notion of physical laws (contrary for instance to juridical and many other social and cultural laws) has always and only been used as a notion of the relations and structures in the world which cannot be violated by any human being.

Thus, there are very strong logical reasons not to adhere to ideas which violate physical laws. The only question is, which laws? Those of Newton? Of modern thermodynamics? of relativity? of quantum mechanics? Or in other words: how can we reconcile ourselves with the notion of physical laws if these laws have no element whatsoever capable of explaining the origin and development of biological and mental domains in nature? Wouldn't it be reasonable to say that a theory of nature should take into account all the known natural phenomena—including for instance the existence of physicists who make theories on this very nature—as argued by Fink (Fink 1990: 20 ff)? In my view, it would be a reasonable demand. Therefore I have some difficulty concerning the possible character of the basic physical laws assumed to determine the lower level physical processes.

Since I am not a physicist, I am not concerned with describing physical processes, but since I accept the idea that mental processes take place in the same universe as physical ones, I strongly need a physical theory which actually leaves room for or at least allows the origin and development of biological and mental processes in this universe. Unfortunately, it seems that no such theory is available for the time being. One may ask whether this is only a question of some missing links within the existing conceptual framework or whether a change of theoretical assumptions is needed, since the various physical theories seem to share the idea that biological and mental phenomena can either be derived in a mechanical way or do not have any place in the natural world at all.

The interesting thing here is not that a physicist may subscribe to any of these alternatives, but that it is of no importance to the physical theory whether he sticks to the former or the latter. This is apparently due to physicists' inclination to believe in the idea of a causally closed physical universe, which means that a physical theory cannot include any aspect which refers to the existence of nonphysical phenomena such as biological and mental ones. If such phenomena are accepted it is as peripheral phenomena which cannot be allowed any impact on—the understanding of—the physical universe.

We know the roots of this concept of nature very well. It was created as the foundational basis for modern physics in the 15th and 16th century. We also know that it formed the basis for the modern secular world view, according to which physical nature could be described according to a set of universal, mechanical principles. By means of these principles it was possible to overcome two main obstacles. First, that the natural laws on earth were the same as those of the whole universe. Second, that phenomena should not be explained as results of magical forces intervening in natural processes. Together these principles formed the basis for the idea that a secular description of nature were possible. But in spite of these great achievements there was also a price to be paid, since the whole model implied the exclusion of the human mind and language from this very nature. This of course became a main obstacle—and a question that remains unsolved—in later philosophy, in that mind and language (of course, I am inclined to say) need to be integrated into the very idea of a secular nature. The nature in which we actually live as constellations of molecules, chemical and biological processes with minds and languages.

Although language and mind were left outside there was also, as in Paradise, a snake *in* the modern secular concept of nature. While nature was conceived of as consisting of physical matter organized by invariant natural laws, the laws themselves were seen as immaterial and as given from the outside of the system—as created by God in the very beginning—and created as invariant laws acting upon nature, but themselves existing beyond time and space.

While the idea of nature as a system governed by a set of universal laws has played a major role in the modern process of secularisation, it is itself rooted in religion. It is no coincidence that the religious basis was clearly articulated in the works of the founders of modern physics as well as in the works of later physicists and philosophers, at least until the first decades of this century. However, since the notion of God was identified with the notion of universal laws and with the notion of truth (as was the case in deism), there was no need to refer directly to the former when describing and defining the laws, except to explain how the actual world-machine was selected among the infinitely many possible machines—as Newton does in a letter »to the reverend Dr. Richard Bentley, at the Bishop of Worcester's House on Parkstreet, Westminster«:

> The same Power, whether natural or supernatural, ... placed the Sun in the Center of the fix primary Planets, ... and therefore had this Cause been a blind one, without Contrivance or Design, the Sun would have been a Body of the same kind with Saturn and Jupiter, and the Earth, that is, without Light and Heat. Why there is one Body in our System qualified to give Light and Heat to all the rest, I know no Reason, but because the Author of the System thought it convenient; and why there is but one Body of this Kind I know no Reason, but because one was sufficient to warm and enlighten all the Rest.
>
> (Letters from Newton to Bentley, Newton: *Opera Omnia*: IV: 430. The letter is dated dec. 10, 1692, first printed 1756).

Given the idea that nature is a mechanical machine, it is impossible to explain the function of this particular machine purely on the basis of mechanical causation, since mechanical principles are not only blind, but also allow an infinite number of possible machines to exist.

The Newtonian reference to the idea of a divine Author demonstrates that he is actually presupposing a very strong kind of downward causation, but one that is restricted to take place once and forever as a great creational act in the very beginning—at a time when only the word existed according to the Bible. In this way modern physics evolved on the basis of the idea of downward causation initiated by a divine creator and explicated in the idea of natural laws which constituted the describable world as a causally closed physical universe. Nature was given top down. Given such laws, man could study Nature buttom up.

If, on the other hand, the selection of the specific machine is seen as a pure coincidence (and not as the result of the action of an Author/design), there is no way to maintain that the result of such first coincidences should be a rule-based machine at all. We may stick to the idea, but we have no obvious reason to claim that it is axiomatically true or to deny that the laws may also have evolved as regularities in the same time and space as the phenomena ruled.

There are some strong arguments which may explain why the notion of transcendentally given rules has not only survived in physics, but has spread into many other disciplines as well. The most important might be that we are almost always interested in knowledge which can be used in more than one case, implying that we are interested in recurring or recursive processes, even if nature as a whole develops irreversibly and hence never repeats its own former states—as is described in modern physics.

The idea of nature as one overall rule-based system is based on a monotheistic idea, but what about the notion of the universe as a set of such distinct systems? Should it be conceived of as a kind of polytheism? Or is it only a momentary idea waiting for someone to find the rules for regulating the relation between such systems?

Few, if any, seem to believe that modern science should have shifted from a monotheistic to a polytheistic foundation. The second option seems to be more widely accepted, mainly because of the philosophical principle of continuity. The idea of the existence of distinct, separate and autonomous systems seems to violate the idea that there is only one universe—and hence the basic principles of science.

It is possible to accept the basic idea of continuity, that there is only one universe, without accepting the existence of only one option: that the continuity can only be guaranteed by the existence of a set of universal rules or laws established from the very beginning as the result of a divine creational act. On the contrary, this option is based on a questionable identification of truth and law. Another option is that continuity in time and space could also be seen as a continuity of substance allowing a variety of changing relationships between substance and form as well as individual events to take place. Individual events and phenomena are found in many areas, in quantum mechanics, in biology and in human affairs—why not then in our theories about these phenomena?

I admit that many phenomena which at first sight seem to be individual or unique events later prove to be instances of rule-based processes. I don't think we should rule out this experience, nor is there any reason to rule out the existence of some unique and unrepeatable phenomena in the world—individual life for instance, or various cultural phenomena. Maybe even physics, as some physicists have speculated, is a case of individual events which in some cases form the basis for a kind of »habit formation« which eventually evolves into stronger »natural laws« as a late (even if only measured in nanoseconds or less) and strongly stabilizing result.

Among the reasons to accept the notion of downward causation one might count the difficulty in describing or explaining the effects of human activity on nature without this notion. If we are not prepared to accept that in some cases mental processes may be necessary causal forces in nature, there is no reason to care about what we can do, what we actually do, and what we cannot or should not do. How, for instance, would it be possible to describe such artefacts as mechanical machines without any reference to the human motives manifested in the selection and organization of the physical matter and energy used? One might wonder whether anyone can imagine that these machines would be around if there were no causation from the human mind to the physical surroundings. Pure mechanical causation won't suffice, regardless of whether it is tried on the level of atoms and molecules or on a higher or lower level of physical organization.[7]

However, the notion of downward causation is often rejected because of its troubling implications. The notion is in conflict both with the Cartesian separation between mind and matter, and later with materialism, because it is assumed that it violates the notion of a causally closed physical universe:

> Downward causation prima facie implies the failure of causal closure at the lower level, and the in-principle impossibility of a complete theory of the lower level phenomena in their own terms. Can we seriously think that biological theories must include references to mental phenomena as causal agents?
>
> (Jaegwon Kim, 1995: 193-194)

Maybe not, but nonetheless I will try to be serious in my claim that biological theories must include references to mental phenomena as causal agents. The first part of the argument is simple. Since human beings are biological there is no way to eliminate our own mental processes and capacities from biology.

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[7] Any artefact can always be described both as artefact and as pure physical phenomenon (for instance as a constellation of molecules or electrons, etc.). While the former description will need to include an intentional aspect (as for instance function), the latter will not since it can only refer to mechanical relationships. Take, for example, a roof. While the artefactual description will refer to its function (to give shelter), which defines the roof as roof, the physical description will refer to the physical matter (a constellation of molecules of various kinds), the location of this constellation relative to the surroundings and so on, but never to its function as a shelter for a living organism. On the other hand, one may ask how it is possible to identify some molecules as belonging to a roof on a purely physical basis.

Accordingly, references to mental activities as causal agents are implied in evolutionary theories describing how we influence natural selection in various ways. We are able to decide to kill each other and other biological entities and execute such decisions—as well as to alter a huge number of species. Nowadays it seems that we have broadened the range for such effects to a new and unforeseeable scope, as we are now able to manipulate nature on the genetic level, while the lower limit—the bottom line—of such manipulations fades away since even in this area the basic components seem to be constituted as complex processes performed in time and space.

Much of this may be explained away, as if we always act in the same (predetermined) way regardless of whether we are aware of it or as if intentionality can only work on the basis of causality. In such cases we might say that this is only downward causation in a very limited and restricted way, meaning that this kind of action does not change the basic components and laws of the phenomena. This may be true. The only question is how we can detect the lower limits of mentally caused intervention. As we know from modern science, the basic units of Newtonian physics were not, as assumed, indivisible units. Nowadays we are able to split the atoms, but not to describe a new invariant lower level. On the contrary, inside the atoms the distinction between matter and energy seem to fade away as a distinction between clearly separable phenomena. But there is still some substance, and it remains to be shown that this substance can always and only be defined by a specific quantifiable form—as has been assumed since the rise of modern science.

In the 20th century the notion that substance is defined by quantifiable form has been abandoned in various points of view and replaced by the notion of amorphous substances and autonomous forms and structures—possibly self-regulating structures able to produce innovations on the basis of pre-existing rules. However, it seems to be worth considering whether this is only one of the first steps towards overcoming the untenable identification of substance with—quantifiable—form which formed the axiomatic basis of Newtonian physics. But a first step only, since it leaves us plenty of forms and structures but no continuity in nature. The various theories of autonomous or self-dependent forms do not explain how the forms themselves (and new levels) come into existence and how they relate to the substances they form and in which they are forms. The next step might be to acknowledge that the relations between substances and forms may not always be invariant relations. If so, we might describe one of the conceptual lines in the history of modern science as the development from the notion of universal rules ruling the whole universe as if it were a static universe via the notion of dynamic rules of evolution and change and on to the notion of a world in which the rules themselves might be changeable. From laws of a static universe via laws of possible change and on to the possible change of laws processed in the secular world.

We can find such changes of laws many places: in societies, cultures and biology and even in Einstein's theories, as he claims that light, for instance, is emitted as particles according to the laws of collision but spreads as waves according to the quite different set of laws for interference. Similarly, we may ask whether the transition between the laws of energy and of matter in the famous equation $e=mc^2$ could take place if it does not take time.

The only thing lacking is the recognition that even such changes of laws need to be understood as processes which themselves take place in time and space—whether accessible to human intervention or not. In such cases continuity is detectable in time and space, albeit only on the level of substances.

Once it is recognized that the notion of universal, transcendentally given natural laws in modern science is a specific instance of the notion of downward causation, it becomes possible to discuss whether it should now be removed from physical theory, but even so the question remains whether it can be removed from biological, psychological and cultural theories and whether it has any importance for the understanding of rule-generative systems.

6. Downward causation in rule-generating systems?

A definite answer to this question may not yet be in sight, which means that at present we are only able to reflect on the proper framing of this question. To this end I will take my point of departure in the relation between the notion of physical and mental states. In contemporary functionalist terms there is only a minor difference between these notions, and the difference is treated as a matter of the area of application—in different but otherwise amorphous substances. Models of physical states are transferred and used as models of mental states and vice versa. The domains are considered parallel coexisting levels.

However, this cannot be true since mental states—such as those caused by perceptual experiences, for instance—need to be stable in time independent of their surroundings. In other words, a mental state can only exist as an invariant unity over time, implying that a mental state is necessarily related to at least two different physical states. Instantaneous perception at a certain moment cannot take place at all. Since we know that perceptual inputs only come in a continuously flowing physical process, the question is how stable perceptual impressions—and in a broader framework, how mental states—can exist.

While to my knowledge we have no idea of how to explain the very origin of perceptual capacities and the human capacity to create symbols, we are able to state that these phenomena presuppose a capacity to »store« signals coming in time as if the sequentially processed signals represented a simultaneously manifested state. And although we have only a rough picture of how perceptual impressions and mental content are incorporated in the neurophysiological system, we are forced to say that the mental states are manifested in the underlying neurophysiological processes in a way which implies that some processes in time on the lower level are utilized as (or cause) perceptual and symbolic content which does not vary according to the same time-scale. If it did there would only be chaotic impressions disappearing as soon as they appear.

The existence of mental phenomena presupposes that the underlying neurophysiological processes are organized and utilized according to a temporal dimension which is not implied in the description of these processes as purely neurophysiological/chemical and electrical processes. Therefore, we cannot exclude the possibility that a kind of downward causation may actually be involved. Mental processes may not change the neurophysiological system, but they certainly have impact on the actual processes performed in this system and may actually influence the functioning of the brain and the entire neurophysiological system.

We can demonstrate another aspect of the symbolic/representational capacity of the mind by comparing the mind to one of the most sublime of all known mechanical devices, the computer. While it seems impossible to deny that human beings possess the capacity to create various kinds of symbols and symbol systems including various kinds of notational systems, we know for sure that the computer cannot create its own notational system. While the human mind possesses the capacity to create a number of notation systems, the computer has no such property. The notational system has to be built into it by its human creators.

A comparison between the human brain and the computer is of course only possible because of their basic differences. There may also be differeneces concerning the depth of downward causation in the two systems. In the case of the computer we can say that the hardware of the computer is not changed or open for changes from the level of the software processed. In this case we know this is because the machine is built in a way which allows it to receive a specific kind of input manifested in a physically well-defined notational system. There is a bottom level for changes within the system. If the message is sent in another—stronger—voltage, this all changes. The limits to lower level changes are given as threshold values which cannot be transgressed without the system breaking down.

Concerning the mind, we know that we can create various representational systems even if we do not know how they are incorporated. The variety of legitimate input signals also seems to be much greater than in the case of computers, in which there are only two legitimate and discrete signals. While the computer is always digital, the mind might also be able to utilize analogic brain processes and hence to exploit a wider range of processes. Furthermore, we can say that if the neurophysiological system is a kind of an informational system—and that biological phenomena are defined by their genetic code—then there is no hardware involved in the definition at all. If there are only codes in some substance, there is also a way to disturb—and eventually change—the codes.

It seems worthwhile to pursue the idea that the neurophysiological system and the mind interrelate as different axes in a redundancy-based system, and that we cannot rule out the possible existence of downward causation in biological and mental systems. Meanwhile, it may finally be possible to dismiss the specific form of downward causation—the notion of eternally invariant and transcendentally given natural laws—which has previously been in use in the history of modern science.

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