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Cognitive and Communicative Development in Reality free Representation

1. Introduction: Reality

Reality is the central topos we see behind all activities aiming at adaptation and of all sciences dealing with learning and accumulation of knowledge. The terms adaptation and knowledge themselves require even if only for grammatical reasons a pre-existing object. In the natural sciences envisaging the structures of reality, in mathematics trying to discover their own laws, in the analytical philosophy of language striving for a more precise notion of truth — and, of course, in the realm of life where we see the efforts of species to meet externally defined requirements: the idea that there is something existing independently which is to be recognised or analyzed, and that scientific progress is based essentially on the improvement of the capabilities required by this, prevails everywhere. Adaptation, learning and analysis are notions which have meaning only in the context of realism.

On the other hand, the criticism of reality is as old as the notion itself. That the world is not necessarily as it appears was already expressed in classical antiquity. Since then a variety of realisms have been discussed: "naive" and "critical" ones, "constructive" (Dux, 1982), "hypothetical" (Campbell, 1973), "pragmatic" (Riedl, 1987) and "internal" (Oeser, 1988) realism were introduced. Starting from Plato's realism, the physical reality was complemented by what one could call a notional reality. But all these realisms have one thing in common: there must be an independent authority which alone

decides about the success of our doing and thinking and of the theories based upon it. It is the specificity of this authority which determines which of our theories will "go" and which not. Without this instance which we call reality theories could be as they would like: "anything goes" — the downright unacceptable.

The view that such arbitrariness is the only alternative to the currently ruling realisms is probably the latter's strongest support. However, the fact that our life managing strategies are so successful, particularly when based on the concept of reality, is only a necessary but not a sufficient reason for using this concept. To become a complete reason would require that the relationship can be derived also in the reverse direction, i.e. we must be able to generalise successful experiences into true statements on the structures of reality. This, as we know, is hampered by the unsolved problem of induction.

Here the Constructivist Evolutionary Epistemology, CEE (Diettrich, 1989, 1990, 1991 a&b), tries to go its own way. The view is proposed that the boundary conditions for the formation of theories are not externally defined but given as the requirement that theories have to be consistent with their entire previous (phylogenetic and scientific) history. A similar thing applies to organic evolution. Metabolic mechanisms and higher strategies modify external data according to internal requirements (for example to maintain a certain inner climate) rather than that these requirements (which usually are based on firmly established organic processes) will be modified to respond to exterior circumstances. So development itself would generate the conditions it has to consider further on and which we, as far as the human context is concerned, respect as law making reality, and as far as the organic evolution is concerned, as the given environment to which species have to adapt. Organic as well as cognitive and scientific evolution is a process of conquering the world rather than discovering it (Diettrich, 1992) of acting rather than of study, or of "fantasy" rather than of "calculus" (Schneider, 1992). To justify this CEE approach requires that the syntax of empirical theories can be adjusted to the special conditions of a reality free metatheory without loosing their

functional qualities. How this could be done for the ideas within the context of learning and adaptation or language and communication is the subject of this paper.

2. What does "reality free" adaptation mean?

The reply requires a brief outline of the CEE. Methodologically the CEE refers to the demand of modern physics to formulate the laws of nature exclusively by means of operationalizable terms. This demand results from the insight that classical physics failed vis-à-vis the phenomena of quantum mechanics and special relativity mainly because it got involved with a non verifiable syntax as brought about by the use of terms which were not checked as to their possible definition by means of physical processes. It was taken for granted that all physical quantities can be measured independently from each other which does not always apply in subatomic regions. Also events were expected to be classifiable always in unambiguous linear order of time, which is possible only in cases where the running time of signals can be neglected. To avoid further "undesirable developments" of that kind, it was agreed that theories should accept only operationalizable terms, i.e. that all quantities and properties have to be defined as invariants of transformation- or measurement operators. At least in quantum mechanics this is the only possible approach as some of the special quantities and features used there have no relation to classical terms and cannot be explained outside their constituting measurement process.

This heuristically well proven concept has been picked up by the CEE — extended by the idea that operationalization must be something very general that is the basis not only for successful non-classical theoretical terms but also for classical observational terms and for all logical and mathematical terms as well.

As to the observational terms the CEE realises this by interpreting all regularities perceived directly by human sensory organs and all laws of nature derived from them as invariants of inborn cognitive operators. Even the law of conservation of energy which can be

derived from the homogeneity of time (i.e. from the invariance under the translation of time) therefore depends on the special physiological mechanisms generating the metric of the mental time perception and by this determining what we will call to be homogeneous in time. The law of energy, therefore, is a specificum of human beings. This applies as well for all the other laws of conservation which are based on our phylogenetically established metric of time (linear momentum, angular momentum etc.). It can be shown (Diettrich, 1991b) that even the causal order which we construct on the basis of observations depends on how the mental metric generator is build. Other beings with different mental generators will no longer consider those processes to be equal in time upon which we base our clocks and time measurements, such as the oscillations of a free pendulum or of a harmonic oscillator. They rather would refer to those processes which are physically related to their own metric generator. Accordingly they would come to different conservation laws and different causal orders. This applies for any perception. It are the invariants of perception which construct the syntax of our theories. They form, so to say, what in quantum mechanics is called a representation in Hilbert space. There are many representations and each of them will constitute a special picture of the world but none is generally distinguished by itself. Beings, for example, having a metric generator with a frequency depending on certain elements of the visual perception, would be unable (even in classical approximation) to separate time and space as we do. Such beings would think in terms of entirely different categories ("canonically transformed" categories, so to say). The "representation" (i.e. the "Weltbild") we use has no particular or natural distinction. It is characterised just but by the fact that it is based on the invariants of our phylogenetically established mental operators.

If we extend the domain of the inborn natural perception by means of physical experimental or measurement facilities we can use the results obtained to further develop the theories of classical physics, provided that the experimental and the inborn cognitive operators are commutable (in the sense of the operator algebra). Otherwise the experimental operators will have invariants which are

not comprised in the spectrum of the cognitive operators. The results concerned, then, can no longer be described in classical terms and would require, therefore, either additional ad hoc explanations from outside the theory in question or the formation of non-classical theories such as quantum mechanics. So, only those "laws of nature" which result from observations with the unaided sense organs can be reduced to the structure of our brain and to the mental software applied there. The laws, however, of higher, non-classical physics such as elementary particle physics, would depend on the experimental operators used and their invariants. As the set of possible experiments and, therefore, of possible different invariants is not closed and cannot be predicted, the scientific evolution is as open as the organic. Neither would human knowledge and scientific progress approach a "theory of everything" as many physicists and biologists believe (Feynman, 1965; Hawking, 1979; Wuketits, 1991), nor would organic evolution converge towards a definitive and optimal species — the pride of creation so to say. What we get from research is new solutions to new problems, particularly for those which have been brought about by successful solutions of older problems, and so on. The co-evolution of problem and solution is generally endless (apart from the case that the accumulated side-effects of what otherwise are solutions will extinct human life altogether!)

This approach has two consequences.

The first one is that the difference between observational and theoretical terms can be reduced to a rather minor detail. Observational terms are operationalized by unconscious mental processes, the theoretical terms by conscious and rational procedures. Both of them are "home-made". Observational terms (to which also belong pain, well-being and other feelings insofar as they are caused by specific stimuli such as the perceptions in the proper sense are) remain nevertheless privileged as they are constituent for our world of daily life. We articulate in observational terms not only life situations but also our aims in life . This is why we tray to find out how observations are related to each others and

to our actions and why the empirical sciences are so important for us.

The second consequence is that empirical theories by means of which we generalise perceived regularities, can no longer be evaluated according to their relationship to the structures of an independent reality. Their capability to generalise correctly rather depends on how much they can emulate the mental and experimental operators which produce the regularities in question.

Further to this, reality itself is not operationalizable. To require of reality to have structures which are independent from all human action, i.e. structures which are invariant under all possible operators, would deprive reality just of the specificity which is needed to be a non-trivial notation and which can result only from being invariant under particular operations. In other words: the operator that is to operationalise the notion of reality has to be commutable with any possible operator. Unfortunately, only the trivial unity operator does so. So, what we can operationalize at best is, for example, a kind of current reality which refers to all the operations applied up to now (rather than to all possible operations), i.e. a reality which reflects all the perceptions and experiences man has ever made. This is just what we do when we speak in ontological terms about a reality which — according to our current knowledge — has this or that structure. By this it is evident that what we call reality cannot be brought about by adaptation to an independently existing or ontological reality. It rather suggests that the very purpose of the concept of reality is to immunise as far as possible acquired and proven knowledge as a standardised basis for further development. Cognitive evolution realised this by "telling" us that all knowledge has to be understood as knowledge about reality and that to ignore or to try to change the so called facts of reality would be "unrealistic", the most pejorative attribute for any scientific or common effort. Reality, therefore, is the "cognitive burden" we have to acknowledge with the further development of our life competence, similar to the so called genetic burden (Riedl, 1975) organic evolution has to recognise. In either case the established

structures define the boundary condition for their future advancement.

So, the reduction of reality to the phylogenetically and historically emerged boundary conditions for the cognitive and scientific progress does not mean, as often argued (Wuketits, 1991), that we could ignore the facts of life. Indeed, the way we perceive these facts and what kind of reaction they would require is just the outcome of these conditions. It is evident that we have to take into account the external temperature appropriately, but only because and insofar as this is required by our development as warm-blooded animal; and just as obviously we have to notice of the movements of physical obstacles when moving around. But this, again, is only due to the fact that we, by our physical and chemical constitution, are solid bodies ourselves. If we were beings of the kind Fred Hoyle (1957) invented in his famous science fiction as interstellar "black clouds" which realise their internal functional complexity by means of intermolecular electromagnetic interaction, then we might have to respect certain radio waves but not solid rocks getting in our way. In other words, there is no experience general enough so that any kind of organism has to consider it and which, therefore, could be the basis for a universal law of nature. The reinterpretation of the notion of reality as suggested here concerns only the fact that the laws of nature in their quality as instruments for species specific life management do not fall within the law making competence of an objective reality but within competence of the institution which is responsible for the specificity of the problems to be solved and possibilities to be realised, i.e. within the competence of phylogeny of the species concerned. That the laws of nature as comprised in our classical picture of the world are nothing but the outcome of men's own phylogeny does not mean that they are less obligatory or that we could change them ad libitum. In a certain sense the classical laws of nature we know are part of our cognitive phenotype and, therefore, can be changed as less as our organic phenotype.

This will allow us to see the realist's main argument in another light: the basic experience of all men is that our perception contains regularities we cannot influence. So, they must be objective, the

realist infers, and hence it is legitimate to try to condense them to the laws of an objective world. Here, we concede that we have indeed no means to influence the regularities perceived nor can we alter what we call the (classical) laws of nature -but only so far as the present is concerned. In the past, as we have seen, we intervened well through the phylogenetic decision on the development of the mental operators and by this on the regularities we perceive. The biological development of these operators can indeed well be considered to be finished. What is not finished, however, is the development of possible physical extensions in form of novel experimental facilities with novel invariants forming novel laws. So, law-making is not generally completed. It rather shifted from the genetic to the cultural level.

According to the CEE, not only the regularities we find in sensory perceptions have to be seen as invariants of certain mental operators, and the categories we use to describe them such as space and substance (and which according to Kant are prior to any experience), but also the regularities we find in logical and mathematical thinking. Indeed, the elementary logical structures and procedures which we find and apply respectively in language are phylogenetically based human specifica like the perceptional structures upon which we will apply them in order to generate higher theories. Particularly the laws of logic cannot be explained as universalia in the sense of Leibniz which on grounds of their truthfulness would hold in "any possible world". This view is implicitly held, for example, by Vittorio Hösle (1988) when he writes "the statement S 'there is no synthetic a priori' is obviously itself an a priori statement. So S contradicts itself and its negation, therefore, must be true". There are, of course, categories which, for phylogenetic reasons, are used by all men. Logic as a scientific discipline deals with the structures which can be constructed on this phylogenetically established basis which we later on would furnish with empirical and other theories. Konrad Lorenz speaks of our 'forms of intuition' (Anschaungsformen) which cannot be derived from any individual experience and, therefore, are *ontogenetic a prioris*, but which, however, are the outcome of evolution and so are *phylogenetic a posterioris*. What we call synthetic a priori

reflects nothing but the inborn human specific ways of thinking which outside this framework cannot even be articulated. What is more, no statement at all can be articulated beforehand and outside the framework of human categories if we want to understand them. So it is impossible to find statements which could be accepted by any sufficiently complex intelligence, irrespective of its phylogenetic background and which, therefore, could be called universal. Even the question if a certain statement expressed by an intelligence A would mean the same as what another intelligence B has formulated can be replied only if the categories of thinking of A and B can mapped on each other which is possible only on the ground of a transformation which necessarily is human specific as well. In other words: the notion of universal synthetic a prioris cannot be logically explicated. Statements dealing with the existence of universal synthetic a prioris are neither false nor true. They are empty. This is well in accordance with the views of Kant, insofar as there are forms of intuition prior to any experience — but only prior to any individual experience, not prior to any phylogenetic experience. The phylogenetically accumulated experience, as represented in our picture of the world, and the categories of our thinking and perceiving are the result of an permanent co-evolution. The idea that what is a priori for the individual is a posteriori for the species was articulated already before Lorenz by Spencer (1872) and Haeckel (1902). A summary is given by Oeser (1984).

Let us summarize: we neither can explicate a physical reality in the sense of objective laws of nature nor a 'notional reality' in the sense of universal synthetic a prioris.

The CEE can be regarded as an extension of the nearly classical evolutionary epistemology (Lorenz, 1941; Campbell, 1973; Vollmer, 1975; Riedl, 1980; Wuketits, 1981). The basic idea of the EE is the unity of cognitive and organic evolution. Cognitive and other mental tools, and particularly the categories of our perception and thinking such as space, time and causality, are considered to be functional organs in the wider sense. It is generally understood that they are subject to the same kind of evolution as organic structures and functions. But yet, there is a substantial difference. The EE, in

contrast to the CEE, follows the idea that organic evolution proceeds entirely in adaptation to an ontologically manifest reality. This, then, has to apply also for cognitive evolution. (Campbell: "natural selection epistemology"). Particularly from the category of reality it is said that it could not have been developed but in adaptation to a genuinely existent reality. This argument, however, is not compelling. As we have seen above, there are other possible (for example functional) reasons for the mental category of reality. Further to this, it would mean to legitimize the idea of reality by its own content, provoking by this the reproach of circularity. The opposite conclusion is not compelling either: even if there would be an independent, ontologically manifested reality, it would not mean that men must have reacted by means of creating a quasi depicting category of reality. The main task of mental reality, to immunize proven knowledge, could have been realised also by other mental mechanisms. The same kind of reasoning is used by Lorenz (1983, p. 99) when he describes the functional matching between organic and environmental structures by saying that the hoof of the horse "represents" or "copies" the soil of the steppe-land on which they live. This is based on the allegation that problems would determine the methods by means of which they could be mastered, i.e. that functional adaptation would determine the structures and procedures by means of which adaptation will be achieved which is obviously not true: horses and snakes, though they may have developed in a similar physical environment, have entirely different organs of locomotion which have no structural element in common. Here again, the opposite inference cannot be made either. We cannot derive from a "solution" the kind of problem for which it was made, nor can we see for what a technique or an organ is to be used for — particularly if there is more than one possibility. A bird's bill for example could be suitable for picking corn, cracking nuts, fighting or climbing. The relationship between a problem and the method of its solution as well as the interplay between the various organs or functions cannot be deduced from the structures concerned alone. It can be identified only within the context of their common evolution (co-evolution). In other words: within constructivism there is no relationship between two objects that can be defined as image or picture. The only possible relationship of what ever kind is to

have a common generating root. The similarities of structures are relevant only if they are based on a common generating root.

This suggests looking at the notion of theory under three different aspects:

a. A theory in the structural sense is considered to be a picture, an image or a mapping of a given or created object. This understanding of a theory is mainly found in the natural sciences and in mathematics. Accordingly, theories are considered to be true insofar as they are isomorphic with the structured to be described.

b. Theories in the functional sense are all kinds of instruments for solving given or created problems. This notion as suggested by Lorenz (1971, p. 231-262) and Popper (1973, p. 164) comprises limbs as instruments for locomotion as well as the inborn categories of space and time we use to interpret perceptions and to coordinate mechanical activities. In so far as physical theories in the proper sense help us to master technical problems and to control physical nature they are functional theories too.

c. The notion of a generating theory refers to what a theory will effect. A theory in the proper sense effects, for example, certain statements. According to the CEE, this the only possible and relevant aspect of a theory. Particularly it cannot be said that a theory describes something which exists independently and to which the theory has to adapt in order to be true. Also mental operators are theories in this particular sense. They also produce perceptions which cannot be considered as depicting the causing stimulus because it is entirely a matter of how the operator reacts. In this respect they equal measurement apparatuses which also "decide" for themselves entirely on the basis of their construction how they will respond to the contact with the test object. One could very well consider perceptions as the "reading" of cognitive operators and, reversely, the reading as the "perception" of the

measurement apparatus. Also languages are highly specific theories of this kind generating statements on grounds of the syntax concerned which largely reflects what later will be called the Ur-theory. Schneider (1992, p. 22) said in a comment on Wittgenstein: "If the forms and structures of a language do not depict something which was already there before and independent of the language, then the idea is near that they have been brought about by practising language itself. So it should be possible to understand them as (intended or not-intended) results of actions." (translated by the author). As shown elsewhere (Diettrich, 1992), the genetic code too is only part of a specific reproduction mechanism. It is not a universal biological language, as is sometimes stated, by means of which any arbitrary phenotypic "text" could be expressed. We mentioned already that theories in the wider sense would not only generate their specific objects (statements, perceptions, effects etc.) but also all possible relations and interactions between them, and that this is the only way to explicate the notion of relation. This was what we proposed within the framework of the CEE as solution for the problem of induction or as explanation for what Wigner (1960) called "The unreasonable effectiveness of mathematics in the natural sciences", namely to trace back observations and their mathematical description to their common mental genesis.

From the structural point of view realism implies the equivalence of structure and function: a theory, we say, has functional merits only if it is true. Conversely the application of a true theory would promise functional success. This is the foundation for the program of empirical sciences: to acquire physical competence by means of analyzing the structures of reality. Actually, however, we first of all evaluate a theory according to the success intended. The subsequent explanation of this success in terms of structural theories is not compelling, particularly as it is sometimes not even possible: the most successful concept of organising our life at all, namely inductive inference (and therefore all scientific research), cannot be explained within classical realism. The classical sciences can explain much — but not their own success.

From the functional point of view realism implies the idea that theories and the instances of their evaluation can strictly be separated from each other so that independent evaluation criteria can be found. This view is also the basis for the logicians' notion of truth. In the same way as proximity to reality is seen as the criterion for the success of theories in natural sciences, truth is seen there as the criterion for the success of linguistic behaviour in its contribution to the overall behaviour. Accordingly the aim of natural sciences is seen to identify the (independent) structures of reality, and the aim of semantics to identify universal conditions of truth. Yet this concept cannot be realised. We cannot even identify what we called current reality. The genetically and historically acquired knowledge which constitutes current reality, has no doubt a crucial talk in the evaluation of theories — but not an absolute one, because it may well happen that a theory modifies the existing views and by this also the authorities of its own evaluation. In other words: the genetic, cognitive and historical burden constitute severe constraints, particularly when implemented in phylogenetically older parts. However, the more recently established constraints can sometimes be ignored, at least to a certain degree. A typical example is the revision of the ruling interpretations of experimental facts and data in the light of new experiences and insights. So, even what we called the current reality fails to meet the minimum demand of common language practice on reality i.e. to have a general and independent monopoly in all matters of evaluation in scientific or daily life.

Now we can define what the term reality free is to mean. This attribute does not refer to the content or statements of theories but only to the content of their metatheoretical foundings: A theory shall be called reality free if it substantiates its success through the ability to emulate the genesis of the regularities it describes, rather than through the correct description of externally defined structures. The demand for reality free representation, therefore, does not intervene in the established methods of (problem solving) scientific work but it may well intervene in cases where the aims of research refer explicitly to the structures of an independent reality such as with the

search for the "theory of everything", with the efforts to solve the problem of induction within the context of realism (Chalmers, 1982) or to operationalize the arrow of time, as well as with the attempts to communicate with extraterrestrial intelligences. In chapter 6 we will see that reality free approaches can help us to better understand even Gödel's allegation that mathematics cannot be completely axiomatized.

3. Language and mathematics as theories

In the ordinary notion of language as rooted in realism, there is no reason to see language as a theory. It rather proceeds on the assumption that language is a universal and objective tool for the description of independently existing objects and processes, being able to convey any usual experience. Certainly, natural sciences sometimes require to extend ordinary language into mathematical areas, but this is not seen to conflict with the neutral character of language. Common sense understands that neither language nor mathematics would have any effect or influence on what it may describe. Mathematical methods, as we know, allow to extrapolate physical data and by this to predict new data, but this is not seen as an achievement of mathematics. We rather believe that it is the special physical structure of the world which would permit its inductive analysis. Experimental physical facilities and the results they produce represent another kind of language. They differ from ordinary written texts mainly by the fact that their decoding would require physical competence whereas the analysis of written communications needs language competence. On the other hand we know from physics that there are no absolutely interaction free relations between object and measurement apparatus, i.e. nature and the methods of its decoding cannot be completely separated from each other. So, strictly speaking, it should depend on the methods we apply what kind of statements we have to make on nature. Scientists try to avoid this difficulty by using only statements which they believe to be general enough not to depend any more on the experimental methods, i.e. on the "language" employed — or, in physical parlance: statements on nature should be invariant under the

empirical methods applied. So, the knowledge of what we call the structure of nature is obtained through abstraction from the experimental techniques concerned — like the meaning of a message which could be defined as what is invariant under a change of language. According to naive understanding, language represents a generally unspecific capability independent from whether it is articulated in verbal or mathematical terms or in terms of experimental facilities. Nothing in the specificity of our life experiences is based upon the specificity of our descriptive tools. Language, within the limits of its competence, is seen to be objective and omnipotent. This is what expresses the naivety of the ordinary notion of language: to assume that content can be separated from representation. A similar view on the universality of language (though not necessarily to what is existing, but with respect to what may be intended) is expressed by Searle (1971) in his "principle of expressibility" according to which everything that can be thought, can be said.

First of all, language is a functional theory in the sense explained here. No doubt that language is a proved and important tool for solving technical and social problems.

But language is also a structural theory insofar as it articulates in a rather precise manner essential parts of our world picture. We can read from language that we experience ourselves as individual subjects who see the world as object: most statements of our language deal with subjects which behave grammatically as if they were individuals themselves (in some languages where necessary, even an "it" will be constructed as an impersonal substitute person). The distinction between noun and adjective shows that we subdivide the world into single objects to which we attribute features which in principle can change — except a special one which is by definition unchangeable and which we call identity. (We have seen above that these and other conservation values have no ontological quality and can be seen only as invariants of certain operators. The category of identity, e.g. has developed phylogenetically as invariant of motion (Piaget, 1967) or, as Üxküll said (1921): "An object is what moves together"). Prepositions and the forms of predicates disclose our

belief that we can attribute to any subject a place and to any event a time. Now we know that this is not always possible outside the world of classical physics. Particularly the arrow of time cannot be operationalized independently but only mentally by means of memory contents. (Diettrich, 1989). From two perceived events A and B, A is said to be before B if we can remember A when B happens but not B when A happens. Of course, the past is what we can remember but we cannot remember the future). Conjunctions refer to the causal and logical structures we ascribe to the world, and personal pronouns reflect social categories, (i.e. the view that there are besides ourselves still other beings having principally the same quality of individuality). Many languages transfer nearly all relations into spatial pictures, even causal and modal relations and relations in time. This can best be seen with prepositions which to a high degree derive from local adverbs. We say *in* an hour, *out* of the question, *beneath* contempt, *beyond* all measure, *through* fear, *under* these circumstances, *on the grounds* of, etc. A plausible explanation could be that our three-dimensional world is very much more widely furnished than the merely one-dimensional categories of time or causality, and therefore is a more fertile source for metaphorical loans. Altogether we can say that there is a subtle correspondence between language and the more general experiences men have made in their wider history. Basic experiences which for phylogenetic reasons are common to all men and which, therefore, do not need to be told to anyone, are fixed elements in the grammar of human languages, (the inborn view, for example, that our daily life acts within a 4-dimensional space-time frame is an intrinsic part of our grammar so that in ordinary language other descriptions are even impossible). They form the co-ordinates by means of which the variable and individual parts of our experiences can be notionally localised, i.e. described. Natural languages represent a kind of basic or Ur-theory of the world. In this respect they correspond well to what we would call a theory in the ordinary sense. Those parts of physical knowledge, for example, which we consider to be generally valid we put into the mathematical structure of the theory and in the values of the parameter concerned (i.e. into the "grammar"). The variables of the theory, however, refer to the various possible statements.

Conversely, a language which is not a theory is logically not explicable. The specificity of verbal allegations about the world does not result from the fact that statements describe experiences in a world of given specificity but from the specificity of language itself in its quality as a theory of the world which like any other theory can generate only its own statements. The above mentioned ontological implications of ordinary languages as comprised in our world picture, therefore, are not extensions of an otherwise neutral language which one could eliminate where necessary. Language itself is genuinely a theory. Consequently no general criteria could be established to identify the ontological premises of a theory as proposed by Stegmüller (1969) and other representatives of analytical philosophy, in order to deliberate theories from unrecognized and usually unwanted implications. The critical and very presuppositions of a theory are already embodied in the language applied and its logical structure. What we called the (genetically inherited) Ur-theory is the ontological presupposition of any classical theory. The intention to clear languages or theories of their ontological presuppositions in order to come to a neutral description of nature is based on the idea that the specificity of all description is grounded in the specificity of the objects concerned rather than in the specificity of the describing tools themselves, i.e. it is based on realism. Realism and the idea of ontology free languages or theories are equivalent.

Also mathematics have to be seen as a language we use to describe certain specificities of our perception. In this respect mathematics can be as little neutral as ordinary language. Just as with language, mathematics derives its specificity from the cognitive operators which operationalise mathematical terms. So, mathematics can express only special statements. As the constituting operators are inborn and more or less equal for all men, it seems evident for us that their invariants are universal entities. Here, even more than with the categories of our perceptions, it is difficult to understand that the elementary notions of mathematical and formal thinking are purely human specifica. It is rather a very intuitive view that there is

something such as a notional reality, sometimes called a Platonic reality.

If we start from the suggesting idea that operators constituting the structures of mathematics and of sensory perceptions (for phylogenetic reasons) are related to each other, then the mathematical structures and the sensuously perceived structures themselves must show similarities. This would explain why mathematics does so well in describing the regularities we perceive, or why the world, as Davies asked (1990a), is algorithmically compressible (i.e. why the world despite all its vast complexity can be described by relatively modest mathematical means, or, in other words, why induction is so successful): the physical world — which is the world of our perceptions — is itself, on the ground of its mental genesis, algorithmically structured. Perceived regularities and mathematical structures are phylogenetic homologa. This is the reason why the formulation of (physical) theories in terms of the mathematics we are acquainted with is an essential prerequisite for their capability to emulate the genesis of perception and, therefore, for their truthfulness. From the classical point of view (i.e. within the theory of reality) the algorithmical compressibility of the world or, what is the same, the success of induction cannot be explained.

But what, then, are the specifica which mathematics and the world of our perceptions have in common so that the two areas can consider each other as their successful theories? This is difficult to say as we have to abstract just from these specifica, what is possible only if they themselves do not belong to the most primitive elements of our thinking. The following might be a clue: to the very beginnings of our inborn ways of thinking belongs the fact hat we use the same kind of cut by means of which we separate ourselves from the outside world, we use to separate the outside world itself into single subjects to each of which we attribute an independent identity. This approach is not compulsory. Quantum mechanics shows how the entire (physical) universe can be seen as a unity which can be described by a single wave function. Each division of the universe into subsystems is a matter of the categories applied and therefore is arbitrary as phylogenetically acquired categories are

not determined either. Our inborn category of identity allows us to separate systems into discernible entities. It is therefore constitutive for the notion of plural (and, therefore, for the notion of set) as well as for the notion of cardinal numbers. A second clue which will be considered in chapter 6 concerns the relationship between the metrics of space and numbers.

4. Communication and meaning

If all structures we perceive are only human specific artefacts that can only be defined but as invariants of cognitive operators, then also language structures have no other meaning than what the recipient will generate. This will raise the question about what communication could signify.

According to common understanding communication means that certain structures, for example texts, will be transferred from the sender to the recipient where they will actuate text specific reactions. The text will enable the recipient to draw conclusions insofar as he has understood what we call the meaning of the text. Meaning, then, is something encoded in the text. For the recipient, therefore, meaning is an externally defined structure. A similar view is held by Hofstadter (1979) who believes in the general possibility to decipher context free messages. For him (p. 165) "... meaning is part of an object (or a text) to the extent that it acts upon intelligence in a predictable way." This would mean to concede meaning the status of an objective property in the sense of realism. Further to this, within the framework of the CEE, the notion of analyzing a structure in order to identify the structure's inherent meaning is not explicable. Structures can be generated but not analyzed. What we usually call an analysis refers to other structures which are generated by the same operation and which we, just because of this, perceive as "similar".

Under these circumstances, to perceive a text or any other structure can only mean to reproduce it through the recipient's own generative means. Are these means insufficient, they will have to be

modified accordingly by the recipient himself. This is what we call learning, and the text which has effected this is termed a piece of information. Information is something the recipient did not know before, i.e. what he could not reproduce by own means. To understand a text shall mean that the recipient is not only able to reproduce the text but also to draw the same (or similar) conclusions from it or infer the same texts as the sender. But what does it mean to make inferences and particularly inductive inferences within the context of constructivism? All things which can be derived from each other by extrapolation or by inductive inference, just by this, represent certain relations. Under constructivistic aspects, relations of what ever kind can be defined only through common generative mechanisms (operator, theory etc.).

We can now say: a recipient will understand a text in the sense intended by the sender if he not only reproduces the text but if he reproduces it by the same (or similar) mechanisms as used by the sender. Only then the recipient has, further to the text in question, also all the other texts at his disposal to which the sender could refer, i.e. they can both draw the same 'conclusions'. Strictly speaking this does not require that the generating mechanisms are structurally equal as long as they produce the same. But as they do so more or less with all men it can be assumed that this is due to their common phylogenetic root. In this case they would not only be functional but also structural homologa.

In contrast to the CEE the classical view about communication does not refer to the common procedures of text generation but to the correct interpretation of textual structures as they follow from what is called the meaning of the text. Meaning, then, is the linguistic analogy to the notion of reality when used to analyze observational data. In the same way as we expect from observational data to inform us about the real qualities of the object concerned, we expect from textual elements to inform us about the meaning inherently comprised in the text. The idea that meaning is something stored in the text (rather than in the mechanisms reproducing the text) and that we will find the meaning if we analyze the text carefully enough, corresponds to the idea of realism that objects would decide

exclusively themselves on what they "are" and that we can find this out by means of the empirical sciences. So, like reality, the category of meaning cannot be operationalized. The meaning of meaning, similar to the meaning of reality, has rather to be seen in its function to immunise certain ways of drawing conclusions — just as reality immunises the perceptual interpretation of sensory data.

The question of the compressibility of the world (i.e. why observational data can be successfully extrapolated and, therefore, why induction works) can be transferred into the linguistic area. We can speak of the compressibility of language and we can ask why we can extrapolate texts semantically, i.e. why we can draw correct conclusions from a text. The problem of induction, then (how can we successfully generalise physical data transmitted from nature?), corresponds to the problem of communication (how can we successfully generalise verbal data transmitted from other persons?).

We see here the parallel between sensual and linguistic perception. Both result from mental operators acting upon sensual or linguistic stimuli respectively. The invariants of either operators present themselves as structures. In the sensual case we perceive this structure as regularities which would allow us to complete observations, or, as we would say in most cases, to extrapolate perceived data. In the linguistic case we perceive the structure produced as meaning which would allow us draw the "correct" conclusion from the text given or, as one could say, to extrapolate the text semantically. Regularities and meaning or extrapolation and logical inference respectively are analogues categories in the sensual and linguistic area.

This equally applies for the transfer of simple visual patterns or pictures: the order and the regularities which the sender sees and of which he wants to inform the recipient will be recognised only if they are invariants also of the recipient's own cognitive operators. To communicate with intelligent beings which have an entirely different cognitive constitution with different generative mechanisms, such as extraterrestrial beings, is not possible in principle. Means invested by space research to this end is money thrown down the

terrestrial drain. Here it is usually argued that extraterrestrial beings, wherever they are, are subject to the same universal laws of physics and therefore must have developed through adaptation similar cognitive mechanisms and similar kinds of perception, so that at least a rudimentary communication must be possible. This reasoning proceeds on the assumption that an habitat would determine the methods of its mastering or a problem the methods of its solution. That is not true, as we have seen above. Cats and buzzards approached the same problem, to catch mice, by entirely different and incompatible techniques. So, neither can a cat profit from a buzzard's hunting methods nor can we profit from the aliens' perceptions and knowledge. In the former case physical compatibility is missing, in the latter one cognitive compatibility.

Let us conclude: all relations we state and all regularities we perceive owe their existence to common generative mechanisms for the matters in question related to each other. Generative mechanisms do not only generate their subjects but also all relations between them such as the mathematical representation of a geometrical curve which does not only define what the points of the curve are but also their relative positions:

- the possible relations between words being generated by a mechanism which probably has much to do with Chomsky's generative grammar, we clothe in grammatical rules,

- the possible relations between verbal statements resulting from this we articulate as the laws of logic;

- the possible relations between perceptions as resulting from the mental interpretation of sensual stimuli we attribute to an independent world and call them the laws of nature and

- the possible relations between mathematical objects we couch in mathematical laws we consider to be universally valid.

In all these cases the generative mechanisms would bring about well defined results but it is not possible to deduce backwards from

the results to the way they were produced. From an isolated statement, for example, one cannot derive the generating theory. So we do not know to which other statement it may be related, i.e. nothing can be concluded from an isolated statement. If, nevertheless, we do sometimes very much so, then only on grounds of (tacit) assumptions on the generating theory. The same applies for observations. They do not tell us anything as long as we cannot refer to an explaining theory. From the fact that we might have seen up to now only white swans, nothing can be concluded (particularly nothing on the existence of black swans) as long as there is no plausible explanation at hand. The same applies for languages. The mental mechanisms define the possible relations between words, i.e. the grammar and the above mentioned implicitly comprised statements on our world picture. The grammatical rules identified hitherto, however, do not allow the reconstruction of the constituting operators. So, grammar cannot be extrapolated, i.e. starting from what we know we cannot derive other rules not known so far — as little as one could conclude from one law of nature to another one. New grammatical rules can be found only case by case through empirical methods. Complete linguistic competence is possible only on grounds of the generative mental mechanisms, which we use whenever we speak or think but which we cannot describe explicitly. This is why we cannot provide computers with full verbal abilities. Language is a special theory which none of our computers could emulate.

5. Genetic, individual and social learning

The relationship between communication, meaning and learning can be well studied on the basis of the example of genetic communication:

The classical biological view is that the genotype of an organism determines its phenotype. The genome, so the general saying goes, comprises all information necessary for the construction of the organism. Actually, however, the genome by itself is unable to effect anything. It rather needs a kind of physiological device in order to

be interpreted and expressed, i.e. to be translated into phenotypic structures. This device is called the epigenetic system (Waddington, 1957; Riedl, 1975) and is comprised in the parental reproducing mechanism as a whole. The phenotype depends on both the genome and the epigenetic system. Different species differ not only in the genome but usually also in the epigenetic system, i.e. they speak, so to say, a different epigenetic language. Accordingly the genetic information is written in different languages and can be understood only by the corresponding epigenetic system. This is why different species cannot interbreed.

The reduced monopoly of the genome as a carrier of genetic information will also reduce its role within ontogenesis. The genome is only one of several developmental levels which contribute to the reproduction of the adult organism. Mutations or modifications are generally possible at any level (though they can be realised up to now in a technically reproducible manner only at the DNA level). Whether the result will be lethal or will lead to a modified and viable phenotype usually depends on the conditions of the individual case.

The very importance of the genome lies in its role as a communication medium with sexual procreation. The combination of genomic elements within the framework of sexual reproduction means an exchange of information which will be used for the ontogenesis of the daughter organism. As compared with modifications through genetic mutations, it has a clear advantage due to the fact that the genomic elements to be combined have already been tested within the parental organisms and, therefore, are most likely to lead to a reproducible organism. Autonomous mutations however represent novelties which still have to prove as to whether they will bring about viable or lethal results. This corresponds to our scientific theories when we modify them by means of own ideas, or with new observations when we re-interpret them in the light of new theories or when we decide which of them we will use for the extension of our knowledge. Whether such modifications will be acceptable or "lethal" has to be checked by means of own selection criteria (i.e. mainly by means of our knowledge concerned) before we may present the result in form of

own experiences to other people. If we adopt, however, experiences made and "published" by others we can usually grant them to be well tested and, therefore, to be suitable for our own purposes. The advantage is evident. Experiences and testing must not be made necessarily by each individual. It is sufficient if they are made just once and then "socialised" through communication. Let us call this *social learning* as opposed to *individual learning* based at individual experiences (to "learn" and to "let learn"). A non-lethal genetic mutation, then, coincides with individual learning. Sexual recombination, however, has to be seen as a process of cultural genetic learning.

A consequence of this approach is that no essential differences can be substantiated any longer between organic and cultural evolution of the kind that can be linked to the ideas of Darwin and Lamarck (Diettrich, 1992). All learning comprises the same kind of selection mechanisms. A biological species learns through physical selection, whether a genetic variant will lead to a viable phenotype and therefore will be stored in the gene-pool concerned. Also a scientific theory has to pass the various academic procedures before it will be stored into the archives of accepted human knowledge.

In the cognitive context we stated that information which cannot be anticipated on grounds of existing knowledge, i.e. which cannot be reproduced by means of the given generating mechanisms (novelties), would usually provoke a corresponding modification of the mechanisms concerned. In the organic context there are genetic mutations which will be expressed by the epigenetic system into a novel phenotypic variant without any need for alterations to be met by the epigenetic system. These mutations are reversible, i.e. their effect can be switched on and off just by mutating or re-mutating the genes concerned. A different case is mutations which will effect not only phenotypic but also epigenetic modifications. Such mutations are usually irreversible as the modified epigenetic system will not necessarily understand the re-mutation as an order for its own re-modification and therefore will interpret the initial genome not in the initial way. In the cognitive area this would correspond to a modified

state of knowledge. The same information can be interpreted in a different way in the light of different knowledge and, therefore, will lead to different conclusions. Knowledge, so as to say, is the cultural epigenetic system for the expression of information. It can be shown (Diettrich, 1989) that changes in the epigenetic system can lead to non-identical reproduction. This means that long-term evolutionary processes can develop their own dynamic which does not need to depend on consecutive genomic mutations or environmental changes. (It might be difficult to identify such shifts empirically as they have to be separated from the effects of sexual recombination and mutation). This is described by what was called *non-linear genetics*. A cultural analogy is the development of empirical sciences as described by Kuhn, which is largely a history of developing theories which do not necessarily depend on new experimental stimuli but which rather re-interpret existing experimental material.

As a summing-up we can say: as the phenotypic variance based on purely genomic mutations is rather narrow, evolutionary "progress" as comprised in typogenesis (i.e. in the coming-up of new biological forms) will depend as well on epigenetic changes. Considering the fact that even closely related species cannot interbreed, it is suggestive that the epigenetic evolution will dominate typogenesis. By analogy, the development of knowledge is based not so much on better information but rather on better theories. Scientific progress means better data processing rather than better data acquisition.

There is another equivalence between (a) the position of realism, (b) the idea of the genome as a blueprint and (c) the idea of a universal logic as the concept of true or reasonable arguing. We will call arguing reasonable if the subjects involved will come to (nearly) equal conclusions. Such a social criterion is suggesting as arguing itself is a mainly social process aiming at the integration of views, ideas and theories. Necessary and sufficient for reasonable arguing is that the statements concerned will be interpreted by (nearly) the same mechanisms by means of which they have been generated. The mechanisms themselves do not matter as along as they are

(nearly) equal. ('nearly' is to indicate that the mechanisms can evolve in the course of discussion in the sense explained, i.e. that learning is possible. Otherwise any discussion would be determined and hence without effect). Aside from this coincidence, the ability to communicate neither depends on the structure of the generating mechanisms nor on the special structure of the language used. That we can communicate in different languages without remarkable transmission losses is known. Generally this must apply also for the language in which we speak language, i.e. for the mental mechanisms which constitute the logical and syntactical structures. That we are usually not aware of this additional degree of freedom lies in the phylogenetically determined uniformity of these mechanisms for all men. By this the logic we use is universal for the set of all men. To derive from this that logic must be universal for all thinking intelligences is as unacceptable as the inference from the obvious coincidence of human perception to the existence of a common causing reality of own specificity which would determine also the cognitive strategies of extraterrestrial beings. Similar applies for genetic information which can be considered as a general blueprint for phenotypic structures only within the context of a special epigenetic language, i.e. within the variance of a given species. This limitation is ignored if one speaks of the genome as the carrier of all phenotypically relevant information.

6. Non-classical cognitive extensions in physics, mathematics and language

To recognise a given structure, as we have seen, means to modify the parameter of the generating mental mechanisms in a way that they can reproduce the structure themselves. Anything else that can be generated by the parameter constellation concerned, is understood as being brought about by an extrapolation of the basis or "recognised regularities". This will be the method by means of which we can "read" and reproduce names, numbers, simple patterns and other regularities. The set of what can be mastered hereby is no doubt limited. The spectrum of communication, however, can be extended both quantitatively and qualitatively if

several of the existing mechanisms can be combined into a resulting operator. We will speak of a quantitative extension if the resulting operator is commutable with each of its constituting elements or, using a mathematical metaphor, if the "statements" of the Operator can be axiomatized on the basis of the elements concerned.

What the resulting operator will then bring about (i.e. its invariants) can be described in terms of the invariants of the constituent operators. The scientific methods of logical inference, e.g. are a quantitative extension of certain procedures we apply in daily life. It seems to be self-evident that the cooperation between mathematical and empirical methods is a quantitative extension as well because an appropriate mathematical model does not predict anything which could not be understood within the framework of the constituent ideas. Similar to mechanical machines which help us to surmount the physical weakness of our body, mathematics helps us in all cases where we are hampered by sheer complexity. In neither case will we expect a result which would contradict the theories we have applied. On the other hand, the character of a mathematical model is given not only by its structure but also by the attribution of its parameters to the empirical observables involved — and here are certain ambiguities, mainly due to restricting regulations on the area of definition. In physics, for example, the extension of certain variables to negative or complex values is deliberately excluded because these are "physically not meaningful", as a physicist would say. Nevertheless, sometimes such extensions may well be meaningful. Dirac, for example, by a step which was rather extraordinary for his time, accepted the extension of an electron's energy to negative values as suggested by the mathematical part of a certain theory and, by this, was lead to the discovery of the positron.

We mentioned already that the extension of our sense organs by means of experimental facilities can be qualitative in character as well.This is the case when the experimental facilities used are not commutable with the inborn cognitive operators. This requires the formation of non-classical theories such as quantum mechanics with its uncertainty principle articulated by Heisenberg. It remains,

however, an open question at what point experimental extensions will discontinue to be commutable with our cognitive operators. The construction of physical apparatuses even for subatomic applications is entirely classical. Mechanical, electrical and optical elements are combined according to the rules of classical physics and nevertheless lead to results which can no longer be interpreted in classical terms. The reference to subatomic and similar regions and to the different laws of nature being valid there, as we say, does not help as these laws are a posteriori formulations of results obtained with experimental facilities which are already at the non-classical side. As to the frontier crossing itself they are entirely descriptive, i.e. they cannot say why non-classical theories are as they are. Particularly the non-classical theories we use cannot provide us with any suggestion as to what future experimental innovations could lead to similar upheavals.

For this problem there is an interesting analogy in mathematics. Similar to the operators generating sensual perception which can be extended by physical facilities, the mental operators generating our elementary mathematical conceptions can be extended through higher and more complex mathematical calculuses. This is what mathematics does as science. Insofar as the higher mathematics used is based on appropriate axioms, i.e. (in CEE parlance) on axioms which emulate correctly the cognitive operators concerned, there is no reason from the classical point of view to believe that this will lead to "non-classical" statements, i.e. to statements which can no longer be formulated within the syntax constituted by the axioms concerned. This view substantiated the confidence in Hilbert's program of the complete axiomatization of mathematics — or, in the terms used here, the confidence that mathematics can extend itself only quantitatively. We know, however, from Gödel (see the summary of Ernest Nagel, 1958) that there are mathematical procedures which, though entirely constructed by means of well proven classical methods, will lead to statements representing a truthfulness which can no longer be derived from the axioms concerned. Mathematics (of the kind we know) turned out to be as incomplete as classical physics. In either case nothing but the application of well-tried and sound methods and procedures can

lead to results which cannot be extracted from the foundations of these methods and procedures and, as we must conclude, we cannot be sure that there will be no surprises of a similar kind in the future. The only difference between the physical and the mathematical situation is that we have in physics already two non-classical theories (quantum mechanics and special relativity) and that we can say precisely under what conditions we have to apply them, namely (simply spoken) in subatomic areas and with very high speeds. In mathematics we only know from Gödel that there must be non-classical phenomena, but we do not know what they are and, particularly, we cannot say which operations would expel us from the classical domain. Is it the notion of cardinal or ordinal numbers, or the notion of set or of infinity, or is it the combined application of these notions which comprise the cause of non-classical mathematical phenomena? What may approach us if we continue to formalise logic in order to find solutions for too complex cases? And what will happen if we deal with more and more powerful computers? We do not know — at least not yet!

In contrast to physicists who suggested as an explanation for their respective experiences that they happened to come into domains of nature where other laws would rule, mathematicians hesitated to develop the idea that mathematical research would lead to really new discoveries which by no way could have been expected, even not a posteriori. If mathematics had its own specificity at all as comprised in the notion of Plato's reality, then, this must be something which is included in the very rudiments and which from there would determine all possible consequences. In other words: if there is such a thing like Plato's reality it must reflect itself in the fact that a consistent mathematics can be based only on particular axioms (the analogy to the laws of physical reality, so to say). Once they have been found — so Hilbert's conviction — they would settle once and for ever the "phenotype" of all future mathematics. Mathematics, then, would be nothing but a kind of craft filling up the possibilities defined by the axioms identified — similar to physics which, according to prevailing understanding could do nothing but looking for the applications of the "theory of everything" once it has been found.

We mentioned already that the success of mathematical extrapolation of observed data as a prognostic tool must be due to the phylogenetically based affinity between the mental genesis of perceptional and mathematical patterns. In a special case this can be illustrated by a model (Diettrich, 1991b) which would reduce on the one side the spatial metric to the category of motion (a view first time presented by Piaget (1970) through research into time perception of children) and at the other hand the algebraic metric (as expressed in the transitivity of addition) to the process of counting. It suggests considering moving and counting as analogue notions within the mental genesis of homologue algebraic and geometric structures. This connection may raise hopes of the CEE that a possibly successful study of non-classical mathematical phenomena could be a clue for better understanding non-classical phenomena in physics too — and vice versa. Mathematics, then, would not only help us to extrapolate successfully physical data; it also could contribute to the conception of novel physical theories (as was already the case with Dirac). So, mathematic could outgrow the role of an auxiliary science, in which we have seen it since the beginnings of empirical sciences, into the role of an heuristic partner of equal rights. (Strictly speaking, this already has happen. Of course, that we consider the world to be algorithmically compressible reflects nothing but the suitability of mathematics for prognostic purposes in physics).

The astonishment of mathematicians with respect to Gödel's proof continues, unbroken. Literature is full of respective manifestations. Among others the explanation was proposed that the brain's action cannot be entirely algorithmic (Lucas, 1961; Penrose, 1989). Further to the fact that it is not quite clear what in a neural network such as the brain could be non-algorithmic, this kind of reasoning is not necessary at all. What follows from Gödel's proof is only that what mathematical calculuses can bring about is not necessarily the same as what a certain combination of them could generate. It is as if physicists would believe that physics cannot be entirely natural because apparatuses constructed according to the

laws of classical physics would not necessarily reproduce the laws of classical physics.

The equivalence of language and the theories of physics and mathematics we have discussed will provoke the question as to whether there are quantitative and qualitative extensions also in the context of language. Are there qualitative linguistic tools of development, i.e. tools by means of which the set of what is reasonably expressible can be essentially extended? Schneider (1992) distinguishes here between calculus and fantasy (Kalkül und Phantasie). Calculus denotes those parts of language which can be formalised and axiomatised, as they could result from a generative grammar, whereas fantasy indicates the source of all syntactically non-reducible extensions of linguistic capabilities. However, the question remains open as to what are the possible mechanisms upon the acting of fantasy could be based. A possible clue could be found in an organic analogy: the structures, functions and capabilities of multicellular organisms are based on nothing else than single cells and their structures, functions and capabilities. Nevertheless they exhibit a spectrum of functions and capabilities which exceeds by far that of their monocellular constituents. In the terms used here, multicellular organisms are qualitative extensions of single cells. Similar to the qualitative extensions in physics and mathematics, here as well the qualitative added value does not result from continuous evolution but from the combination of different (or equal) existing elements into new functional units. (In a way, it is the old sentence of the system which is more than the sum of its parts). There is no doubt that the assessable adaptation to given circumstances (e.g. through learning) is an important root of progress. Modular extensions, however, may be well more momentous. This would suggest that also in the field of language the main extensions of verbal expressibility will be based on the combination of different functional elements, i.e. on what could be called metaphorisation. In the section on language as a theory we mentioned the metaphorisation of the notion of space, i.e. the application of spatial terms in a non-spatial context. At about the same phylogenetic times the metaphorisation of the human body (well known to the linguists) should have been developed. In the

physical sciences the analogy to metaphorisation is the combination of experimental and cognitive operators for the further expansion of physical theories. The quantitative and qualitative extensions as discussed here would correspond to what some authors called syntactical and semantical metaphors respectively. Common to all qualitative extension is that their consequences can hardly be assessed. Neither do the structures of cells determine the structures of the organisms they constitute, nor do novel measurement results have any influence on the theories in which they will be embedded. Also semantic metaphors leave open in what context we will integrate them.

7. Learning and adaptation

After having considered learning mainly under the aspect of an activity aiming at the extension of our theories and strategies, we will deal now with its relationship with other terms from the wider context of life accomplishment: adaptation, perception and action.

We have seen that the boundary conditions to which we are subject in organic evolution (adaptation) as well as in cognitive evolution (learning) are the result of their own prehistory. Organic, cognitive and scientific evolution generate step by step the terms of reference they have to observe from then on. We comprise these boundary conditions under the label of reality. But evolution does not only define the subjects of adaptation and learning. It brings about as well the aims to be achieved by adaptation or learning. These aims orientate themselves by the possibilities given, and the development of possibilities in turn would orientate themselves by the aims chosen. Both are in permanent co-evolution. If we proceed on the assumption that learning advances in most cases under the pressure of problems, we have the already mentioned co-evolution between problem creating and problem solving. On the other hand, learning and the development of solution can occur also prophylactically and without acute need, for example stimulated by curiosity or in form of basic research which can be said to produce solutions for problems which do not yet exist. We then have a

similar co-evolution between new possibilities and the applications to be found accordingly which, in turn, will influence the direction of basic research or curiosity. There are reasons to believe that even organic evolution could be initiating in this sense and not only adaptive in the sense of Darwin: under certain circumstances organic structures and functions may well develop over a larger number of generations (as long as they would not distort seriously the existing adaptation) and would find their very importance only in a later habitat yet to be chosen. How the directional stability required for such long term processes could be maintained without the permanent guiding force of external selection as assigned by the synthetic theory, can possibly be derived from the interaction between genetic and epigenetic structures: as the so-called epigenetic system (which transforms the genotype into the phenotype) does not only depend on the genome but also on how the genome is interpreted by the epigenetic system's own predecessor, it constitutes a recursive process which is not necessarily stable. This means that both epigenotype and phenotype will not reproduce themselves necessarily identically and therefore can form long term evolutionary trends which do not depend on successive genetic changes or on environmental influences (non-linear genetic, Diettrich, 1992).

Strategies, abilities and structures (i.e. theories in the wider sense), therefore, can develop in adaptation to immediate requirements but also as problem solutions produced "in stock" the importance of which will depend on the development of problems. Conversely, it is possible that the development of problems will render well established and proven theories in the wider sense counterproductive. Maximising the reproduction rate as strategy for the conservation of species, for example, is optimal only as long as the purely quantitative competition for limited resources would dominate all other kinds of interaction between the organisms concerned. Organic cells which have "decided" in the course of evolution to organise themselves by means of physiological interactions as multicellular organisms have first of all to resign from the strategy of excessive procreation if they do not want to perish as cancer cells. The same applies for man when he lives in socially or

culturally defined societies. The development of those societies proceeds mainly as development of their socio-cultural structures, i.e. as development of the non-genetic interactions between their members. Accordingly marginal became the biological and genetical criteria of procreation. Like somatic cells, men, of course, will continue to propagate biologically, but first of all in order to maintain the basis for socio-cultural interactions and according to criteria related to this rather than to disseminate their genetic information.

If, as we have seen, the question may arise to find for a given problem an appropriate solution, as well as to find an appropriate problem for a solution found before, i.e. if the solution can become the problem, and the problem the solution, then it will become difficult to distinguish accurately between the notion of problem and of solution. Problems and solutions are merely aspects in the context of general evolution.

8. Action and perception

This can be seen with the dichotomy of action and perception. It is not a compelling view that perceptions have to identify problems and that actions have to solve them. First of all, action is something which changes perceptions, and perception is something which will provide plans for actions. Perception in its original meaning is a link in the feedback processes to coordinate actions such as with the phototactic reactions of some protozoa: the light stimulus causes an orientation towards the light source, and this orientation in turn results in an ongoing perception of light. Perception and action are in permanent interaction. Perceptions influence our actions and actions our perception — from the visual control of moving to the visible consequences of our acting upon the environment. Under these circumstances we can also reversely phrase: action is a link in the feedback processes to coordinate perceptions. This symmetry is broken by the category of reality, or more precisely, by the view that action is something falling within the competence of the subject, whereas perception refers to the perception of an independently

existing world — in other words, that action means the influence of the subject on the world, and perception the influence of the world on the subject. The mental theory of reality breaks the direct connection between action and perception and inserts the concept of a real world. In reality free parlance, however, we have to say: perception and action management are two special elements of physical and later also of mental control mechanisms which are in permanent co-evolution.

Let us give an example. We structure our world into objects to which we attribute properties which signalize us what we have to expect when dealing with them. The weight of a stone for example tells us how far we could throw it when necessary. On the other hand we are interested in knowing how properties may change just if and when we deal with the objects concerned. We, then, have to distinguish between properties which usually are invariant under our operations and which, therefore, can be used for the characterisation and identification of objects, and those which change under our operations. This is the distinction between perception and action which, however, is not unequivocal. It depends on what operations we use to constitute or identify and analyze objects or structures (we will call them defining or measuring operations or cognitive operators) and those we use to modify the objects previously defined (we will call them modifying processes or physical operators). In other words: both action and perception refer to operations. Their difference is based on whether we are interested in what the operator will change or in what the operator's invariants are.

On this distinction a categorial or operator hierarchy can be based. As to the elementary perception, this hierarchy starts with the invariants of the most elementary operators which we use to define first units or objects. Further operations may lead to changes of the objects. They as well have invariants which we call properties. Other operations are capable to modify some properties such as the physical shape. To their invariants would belong what one would call material qualities such as density or electrical conductibility. The "strongest" operators we know can transform elementary particles

into each other — and so on to what remains unchanged despite all our physical efforts and what we consider therefore as the structure of nature. The (phylogenetic) decision to take a certain operator as defining or changing is crucial for the constitution of our world picture. The defining operators establish, so to say, the notional system of co-ordinates we use to represent what the changing operators will effect.

The ambiguity of what is elementary and what is derived can be traced back up to organic evolution. If we interpret perception as the process which would enable us to react appropriately to the given circumstances, and action as the process by means of which we can alter these circumstances, we come to the evolutionary dichotomy of action and adaptation: an organism has two possibilities to achieve the vital conformity with the environment. One is the reorganisation of the own constitution according to external circumstances. The other is the modification of the external circumstances according to internal requirements. The higher and the more complex the structure of an organism is, the more difficult will it be to adapt these structures to external conditions and the more evolution will concentrate on the development of those abilities which allow to modify the external rather than the internal world. This goes from the methods of homeostasis maintaining the so called inner milieu, to locomotion to find better living conditions and eventually to the scientific/technological mastering of nature through which men can resign from biological evolution at all. Evolution can be seen as a process of more and more refined adaptation of the own constitution to the environment (as done by Darwinists) as well as a process of more and more refined modifications of the environment in the interest of the respective phylogenetically established own constitution. The cognitive analogy is the fact that men would pursue the improvement of their life strategies not so much through evolution towards sharper sense organs but rather through the development of more intelligent theories using the observations brought about by the sense organs. In the context discussed here the generation of an organism is the defining operator for the spectrum of its possible actions. The actions themselves will generate new observations from which may arise

new possibilities for life management. Realism and Darwinism have in common that they want to derive the knowledge and the capabilities, needed for survival, from the analyzing observation of an independent environment or, respectively, from the adaptation to such an environment. The concept of pre-defined and static reality fails, as we have seen, by the possibility of ever new qualitative cognitive extensions with novel invariants forcing us to rebuild our picture of the world and, by this, to redefine the goals of research again and again —without hope for a definitive end. The concept of Darwinism (in this narrow sense of adaptation/selection) fails by the possibility of qualitative evolutionary modifications, i.e. modifications which will lead to altered requirements and, by this, to redefined goals of adaptation. The conversion of the limbs' function from walking into flying revolutionized the adaptation criteria of the species concerned as drastically as some subatomic experiments mutated the aims of physical research within the framework of the entirely new quantum mechanics.

9. Summary

Metatheories define the criteria for the theories of their responsibility through specifying the set of possible questions and aims, i.e through specifying the paradigm of the field concerned. Theories in the proper sense are responses to questions raised by their metatheory. New metatheories result mainly from qualitative extensions. They usually do not dethrone the theories of their predecessor completely. They rather limit their range of validity, i.e. they specify the areas in which the old questions can be followed further on, and those where new questions have to be raised. (In subatomic small-scale systems, for example, one does no longer ask for the path of particles but rather for the probability of given values for position).In this particular sense the CEE is a metatheoretical offer to all disciplines which depend from the special forms of human thinking and perceiving, such as the empirical and the cognitive sciences, mathematics, logic, linguistics, communication sciences etc. It would be wrong to expect from the CEE directly applicable theoretical approaches. The CEE, at best, can provide

only fecund cultivation areas for new ideas and theories, or can identify not realisable research aims.

From the evidence that the notion of reality cannot be operationalised and therefore has to be avoided in all theories, it follows that it is futile in physics to strive for definitive theories and particularly for a theory of everything. This comprises that we can operationalise experimentally only those terms which have not already been operationalised before mentally, such as the arrow of time (Diettrich, 1991b) On the positive side, mathematics has been identified as a heuristically equal partner of the empirical sciences. Mathematical efforts, therefore, can be attempted also with a view to get clues for novel empirical phenomena. In other words: The CEE legitimizes the generally proved practise to gain inspiration from mathematical procedures for learning, i.e. the setting-up of theories in the empirical sciences. By this the CEE offers an explanation for what Wigner called "The unreasonable effectiveness of mathematics in the natural sciences".

That the vital correspondence of biological organisms with their environment can be reached not only by adaptation in the proper sense but also by modifying the environment concerned accordingly, does not need to be explained by the CEE (though it is surprising how little this symmetry is discussed in biology). However, what has well to be shown is the fact that this will apply also for those kinds of adaptation we usually call learning. Indeed, according to the CEE we can manage our cognitive environment, i.e. the regularities we will find there, by means of analytical efforts and by creating theories we adapt to the data perceived, as well as by changing the regularities themselves by changing the defining operators. Yet, this is rather a matter of phylogeny as the development of these operators is obviously closed. What is not closed is the development of their qualitative extensions by means of the experimental facilities of higher physics. The corrections of our Weltbild that this will induce is what Kuhn called the change of paradigms.

Language as an instrument of social learning (i.e. as conveyer of other peoples' experiences) is developing through qualitative extensions to a far higher degree than the methods of individual learning (such as with physics). Through successive metaphorisation language has left already early in the course of its history the scope of simple description of observations as required for elementary collective life management. As with the organic evolution, language is also permanently re-defining the criteria for its further development according to the current possibilities — from what early abstractions have brought about up to the aesthetic criteria of poetry.

Communication sciences will have to discuss the CEE statement that any, even rudimentary, intercourse with extra-terrestrial intelligences is generally unfeasible.

All developments have in common that their formalisation (and, therefore, their planning and management) is possible only as long as no qualitative extensions are involved. This restricts the possibilities of artificial intelligence considerably to solve given problems. Not restricted, however, is the possibility to experiment in a purpose free manner with the means of AI which may lead to new qualitative extensions. This might not solve even one of the existing problems, but it may open new degrees of freedom and unexpected fields of application. Purpose free experimentation with qualitative extensions is a procedure wich also organic evolution used since its very beginnings in parralel to the strategy of adaptation.

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