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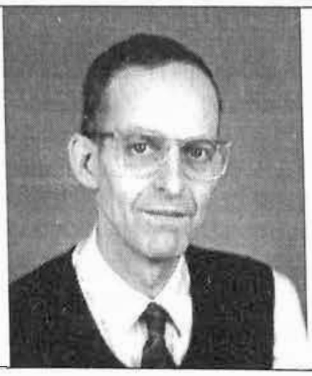
Systems Modeling for Classification: The Quest for Self-organization



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Löckenhoff, H.: **Systems modeling for classification: The quest for self-organization.**
Knowl.Org. 21(1994)No.1, p.12-23, 34 refs.

The necessity and value of models shaped in the human mind in order to support understanding, activities and their control are outlined and mapped with respect to their function in knowledge organization and representation. Advanced understanding of modeling appears as a challenge and chance for the future design of dynamic, learning classification systems, evolving together with the systems they represent, as well as with their environment and theirs users. (KO)

1. Introduction

Our reality is perceived as filtered through models we shape in our minds. Conversely, our reality also shapes us: our ideas, hypotheses, thoughts and, last not least, our actions. Models coin our intentions, the patterns of our value network, the ways to control our actions.

This was known to philosophers of all ages, who in this connection have spoken of visions (religious), of ideas (PLATON), or of patterns and categories (KANT and modern epistemologists). Recently, e.g., MATURANA (Systems Biology), GADAMER (Speech Act) and others may be named. Under conditions of rapid and deep-rooted change and growing complexity, modeling itself becomes subject to sophisticated hypotheses.

Moreover, models decide on our chances to survive and to evolve. As we are learning from imminent ecological problems, models further viability only under the precondition of accordance with our contextual life base. Undistorted communication and learning is paramount for adequate prognoses in order to plan and to control the environment. Models have to be structured and coherent. They are to incorporate the interfaces within the whole network which constitutes reality. A model, therefore, will be understood as the representational system constituting the interface between man and his world. Classification appears as the partial system of intentional knowledge ordering within a model.

Why this fundamental approach? Well known are the phenomena of increasing complexity and dynamics (dynaxity, as RIECKMANN named them). The free space available for system modeling narrows down. So does the chance to preserve system's viability. Still prevailing deterministic/linear models prove inadequate. They are to be complemented by concepts of creative chaos, of self-organization (SO), of fractal geometry and 'fuzzy' systems in general. This recent development seems to establish a constitutive model analogy throughout all disciplines. It proves valid also for a general model of classification.

A few basic aspects of the overall theme will be discussed focusing on representational systems capable of evolving. Advanced understanding of modeling appears as a challenge and a chance for the future design of dynamic, learning classification systems, which will evolve together with the systems they represent, the environment and the user.

2. On Unity, Consistency, Coherence and Recursiveness

The world probably never was what it is said to have been once: in our times very much so. With the insight into the necessary reconsideration of the hitherto prevalent 'Weltsicht' a new hypothesis of the unity of the world: unifying reality, representation, consciousness and models gains strength and corroboration. Throughout science basic structures are now being contemplated: their consistency, their coherence, their recursiveness within constructions, processes and representations is discussed. Though not immediately focusing on that topic this paper is intended to be a contribution to this unifying approach.

3. Classification as a Representation and a Model

To remind the reader of the trivial: Classification is always a means to an end, is always driven by intentions and directed toward or attracted by a goal. Classification is designed from the existing situation and its inherent needs. Otherwise it would serve the user badly; it would prevent optimal problem solving and the furthering of well-planned steps toward goals to be achieved under conditions carefully preset. Moreover, to do this, classification must mirror the specific properties, the structures of the objects classified. Change and dynamics have led to a crisis of modeling. They have produced a need to reconsider hitherto successful linear/deterministic approaches. The necessity to rethink exists also in classification where it applies to basic concepts, knowledge ordering, retrieval systems and operations.

Why is this so, and to what lengths? And, do these mainly static requirements really represent all prerequisites necessary, for example those emerging from the dynamic character of any life act and of change in particular? Classification or, more generally, ordering, is to understand from the life context, or, as V.V. NALIMOV would put it: within the global system of man interacting with his world. Interactions imply the necessity of interfaces, and if there are various levels of interaction, a corresponding system of interfaces. Depending on the degree of differentiation the system will be, as in the case of man, multifold, multileveled and multivalued. It will contain, for example, the material interface as well as the perceptional/informational one; furthermore the rational and the emotional, the formal and the intensional, the individual and the social/cultural ones. As recent research e.g. by D.BICKERTON and, independently, J. ZELGER have substantiated, the representational media, and especially langugage, determine and delimit modeling. K.VELTMAN has shown the probable influence of advanced EDP systems and interchangeable display methods on information retrieval.

For reasonsof economy if not for of transparence and specificity an actual classification will concentrate on the case-specific essentials. But, seen from the dynamic point of view, they all have to be considered in respect to the future possible extensions in order to answer changed requests. Therefore they all will be kept in focus when questioning the core of classification as a representational system for the use of man. System in this context means that all the aspects are closely related to each other, are in dynamic interaction when in operation with respect to a life act. A mere static aggregation, a cluster or even a well-ordered list would not sustain properly a viable system within a life situation. In addition, with respect to the indigenous and intentional character of classification systems (CS) all representational levels must cohere: the basic, the life preserving features of the interacting systems must be compatible with each other and the CS. Otherwise a purposefully intended action would not be possible: there could be no resonance between interacting levels. Recursiveness of structures is necessary within the CS. As V.V. NALIMOV would hypothesize: world has to be perceived, i.e.: represented and classified as a historical and an intentional (causa finalis, ARISTOTELES) unity. Or as systems theory has pointed out: our perception (as probably 'the world') is governed e.g. by the principles of analogy, of coherence and recursiveness.

Within this most general and abstracted context, classification appears as of one of the representational interfaces, mainly between a living system and its world. Classification is a vital part of the representational pattern between system and world. This applies both ways: the representation of the world within the control system (nervous system, brain) and the representation of the viable system through its impacts on the world. In the case of conscious systems, especially of self-conscious man, the reflecting, the self-perceptional representation, e.g. of man to himself is added. The stage thus opened, the essential structures can be hypothetically identified. Comprehensive and general frame of reference is the system of man perceiving and interacting with his world and with himself. Any interrelationship is not direct, but mediated by a representation, e.g between observer and the object observed and, in self-reference, between the observer and himself. Any representational interface is called a model. The order contained in a model as well as the process of ordering is named classification. In short, CS are understood as the order structures of a representational interface. CS then govern our behavior in the widest range: material/energetical, perceptional/informational, rational and emotional, formal and intentional/value oriented: hence in the totality of all aspects important for the preservation of life and for evolution.

This essay on CS is aimed at the actual requirements, that is: the preconditions that all action shaping representational systems must meet if mankind is to survive or, less dramatic, if man is to achieve or maintain an acceptable civilizational/cultural level. We have roughly outlined them in the preceding paragraph. To achieve and to maintain means to induce, to react to and/or to control change, means to cope with the combined dynamics and complexity, which RIECKMANN named 'dynaxity'. It seems feasible, then, to approach representational systems (RS) within the structural aspect of order and shaping order, that is, of models and modeling under the conditions of dynaxity. The precise meaning of the terms will evolve incrementally with the proceding argument. To begin with it will be sufficient to recall the colloquial meaning of model as a representation distinguished by context and intension of man and 'his' world inherent in a modeling subject.

Taking into account dynaxity it seems both advisable and necessary to go 'back to basics'. The change we are experiencing is too fundamental, affecting as it does, personal, social, political and even scientific life, to permit us to remain at the surface and at the level of what has been agreed upon so far. Hence the retreat to general systems and systems modeling in search of the vital aspects for the re-understanding of classification, operation and frame. Or the other way round: systems modeling will provide for the concepts of synergetics, of self-organization, seen here as order principles to be applied to modeling and classification.

4. Modeling in Order to Cope with Dynamics and Complexity

As epistemology and linguistics have elaborated, representations consist usually of many layers, hierarchically ordered and meshed into networks. As for size and quality, models cover the whole range from simple patterns, e.g. to catch a fly to slightly more complex ones as e.g. those to save the world; from actual, concrete ones to most abstract ones. As will be explained later in more detail, modeling is, by powers of verbal language, not bound in principle to any limits of our 'reality' (rather - see above - to those of language). Notwithstanding the various sorts of possible objects of modeling, what would a model of a model look like? That can be directly derived from the initial model of a representational interface. Following the categorial structural elements of a system it is possible to distinguish between the model's internal structure and the contextual environment with its particular properties.

(a) The context of any modeling is the total system of interaction of which the model is a part. It includes the physiological, linguistic and mediating prerequisites for perception, expression and communication. As mentioned before, the model is the connecting, - i.e. the filtering, pre-evaluating, transferring, shaping, controlling, etc. - interface between the observing and the observed system. Of crucial importance for both the emergence of and the coping with dynamics and complexity, here of the environment, are the models for problem-solving and goal-setting, and among them the self-referential models. The self-referent model man has built of himself forms, among other things, his action patterns, his ethics. The models which he has acquired by learning (or inherited, here there are some difficulties), therefore, for decision and task solving methods decide upon his long-term overall success. At this intersection the quests concerning epistemology, cognition, experience, thought and action arise. They will be dealt with in abbreviatied form when we investigate the complementary internal structure.

(b) The internal structure of a model in reference to the 'reality' perceived centers around the always analogical nature of any mental or other representation. A tendentially deterministic view, including of induction and deduction as the chief methods of conclusion-drawing, has been dominant from the Renaissance on. Since, complementarily to deduction and induction, G.BATESON proposed abduction as a further mode of conclusion-drawing, the science of science has started to go back to the underlying analogical forms of conclusion-drawing. (Particularly the quantum approach in physics has shown that determinism might be seen as a special form of analogy.) From various sides and researchers - e.g. STACHOWIAK (philosophy), MATURANA/ VARELA (systems biology, epistemology) or D.BICKERTON (linguistics) it has been shown that there can be no direct experience of reality. We perceive exclusively via internal representations. Transferred to models: there is no original, only a network of models. The actual representations occur internally on different levels and are mediated by different media: sensory, language, sound patterns, visual representation systems such as geometry, or symbols.

(c) Both the contextual and internal properties of a model shape, if not even completely control, our behavior. Stable models are responsible for the contingency of our actions and of our environmental and internal structures. Models are self-referring circles and, when the time factor is introduced, a process symbolized by a spiral, a helix. The appropriateness of models in that dynamic, self-referent respect becomes the decisive base for successful action. Behavior determined by classification, involvement and evaluation of inputs or intensions must result in an interaction, the outcome of which sustains viability and eventually leads to a broader life base. Modeling thus decides on adaption and control. One of the main questions, therefore, refers to the space allowed for individual or species-bound representational flexibility in a given situation. How much latitude is allowed for prognosis and goal-setting, for problem-solving approaches, for the modes of mapping and for choosing the medium to represent by?

Cognitive sciences, epistemology and linguistics have contributed to this general background of modeling. The discourse is still vividly in flux. To my knowledge, STACHOWIAK's standard volume from the sixties, stimulated by the then challenging cybernetic approach, has not been followed up by a similar comprehensive attempt. At the moment research still seems to be busy restating up to now only superficially investigated topics - e.g. problem solving and the basic research of DOERNER - and to prepare the forefields e.g. in epistemology. A discourse or dialogue is not always easy to distinguish, since deep-rooted modes of thinking and conclusion are called into question. A good example is represented by the biased discussion around AI, especially in its stronger hypotheses.

Variatis variandis the above reasoning proves valid also for classification. We classify in order to accomplish tasks, to cope with problems, to achieve goals: in summary to survive and, in the long term, to evolve. This very striving for achievement in general gives impetus to dynamic developments, to change and to evolution. These innate necessities must lead to ever more complex structures. Dynaxity drives itself to ever higher levels. One cannot help remembering the biblical story of the tower of Babel. Is there a way out other than by exhaustion and catastrophe? Historically as well as systematically we have arrived at a critical phase, where dynamics and complexity exponentially drive each other on. It is, by the way, not without consequential irony that modeling and, with it, classification are troubled by the very paradigms they sired themselves, that is linearity and hierarchy and, more often than not, context-free progress. Facing now the quest for a model, for a classifying mode able to cope with dynaxity, our situation resembles much that of the sorcerer's apprentice. When overwhelmed by the ghosts he evoked so busily, nothing else was left for him but to cry for the master. Which is, in parentheses, for classification the necessity to go back to the roots. To comply with this quest effectively the process of modeling the nature of dynaxity needs to be inspected more closely.

Dynaxity cannot be restrained to well-defined areas or to parts or levels of the system concerned. As we know from biological growth, initially small isles of complexity grow into ever larger and more complex systems. What happens some 5000 km from here may have effects on us rather soon, given a high degree of dense connectivity. If for example level F of a nutrition chain is changed this will effect any other level, up and down the hierarchy. This may happen instantly and be directly observable; or the effects may, after a long march through the whole system, show much later and in quite unexpected places far from where they originated. Complexity means that direct, linear reactions are the exception and non-linear impacts on any part of the system rather the rule. Not only the internal structures of the system change, but also the effective scope of the system in toto changes, as do its implications on neighboring systems. This holds true, in addition, for all future interactions. To control dynaxity by means of normal controlling only generates more dynaxity. Ashby's law of requisite variety states that the controlling system should possess at least one order of complexity above that of the system to be controlled. The situation reminds one strongly of the contest between the hare and the porcupine. Dynaxity has always arrived long before.

When condensed into a checklist or drawn in a grapfic figure the foregoing paragraph presents a model of complex and dynamic systems. The properties extracted refer mainly to the need to control dynaxity. This did not happen by chance. Models can, arbitrarily but congruent to the quest for viability, be divided into models of the system in general and models of the control system within this system. Classification is, by its intentional and ordering character, the core part of a control model. Without classification there is no conscious organization nor goal setting, planning or control. Seen functionally: the main function of classification is to serve as ordering structure for control models of systems. The crisis of inadequate institutions we are suffering from right now is a crisis of concepts how to order as well as to control structures. It is not by chance that the problems of description and control of models range on top.

5. Paradigmatic Models of Consequence: Perception, Behavior and Learning/Evolution

'Models of Reality Shaping Thought and Action', the title published in 1984, poses in a nutshell what has to be elaborated as follows. Is there a set of basic models concerning man in his world, and which ones are in what respect crucial? How did they change in history, assuming paradigmatical features for their time? If the latter is true, what paradigmatic forms of key models will dominate the understanding of classification? Though a proper distinction will not always be possible we should keep in mind the subdivision into contextual and internally oriented models and into those of object and control systems.

Exemplarily for both man in his world and his classification of his world, three main models will be discussed: (a) perception, (b) behavior and (c) the central phenomenon of learning. They are punctually and arbitrarily chosen here, rather than as well-defined parts of an ontologic/phylogenetic model of the world in toto and of life and man in general. Discussion will be centered on man. Any questions arising, e.g. if there are preforms of consciousness in animals or even in prelife forms, will have to be discussed elsewhere.

(a) *Perception.* To be is to perceive. Perception expresses fundamentally awareness: of a world through its impact on the sensory apparatus and the perception triggered in the representational system of the brain. Perception is always an indirect representation of what has been filtered through the sensory organs and evaluated by the data-processing circuits of our nervous system, mainly the brain. In a last step the input thus filtered is attached to inner patterns which we become aware of as 'our reality'. There is, to confirm it, no direct connection between reality and perception. MATURANA/VARELA have deduced this convincingly from the systems biology approach, D. BICKERTON from linguistics, to name only the known more recent research.

The consequences of this model reach far into the science of science. If perception is always representational and intentional, is always the result of an evaluation, is always a model born from a representation of the n'th order, then properties like 'objective', 'rational' or 'universal' can be understood in a special, restricted meaning only. A model also must always be seen as a means to an end, i.e. to the survival and the possible evolution of the system which generated the representation. 'Objective' means: appropriate under the aspect of.... A reasoning may be called 'rational', if the set of prerequisites to think and act from is in accordance with a specific view of the world in general and with input-output efficiency in particular. Furthermore, a model is never isolated. To allow for the personality to constitute a coherent unity of all representational systems (NIETZSCHE would perhaps have incorporated this argument into the principium individuationis) each single model is connected with each other model and with the 'gestalt' (see J. ZELGER 'Sprachliche Gestalt'). Gestalt stands for the unity of consciousness, for the coherence of evaluation and the correspondence of operational modes. These are in summa necessary prerequisites of reasonable and, in terms of survival, successful behavior. Again: the principal coherence of perceptional models is the prerogative of individuality, of personality. The same phenomenon indicates the necessary togetherness (not quite in the sense G.PASK uses this term) of each individual with its environment. To be able to survive, that is to evoke predictable reactions, one has to share the essential models with his environmental partners.

These seemingly trivial questions present basic challenges to cognition, to science and to epistemology. The search for universalities is only one of arbitrarily numerous queries. Physics is looking for the 'Weltformel', and classification never quite ceased to strive for a 'universal', comprehensive approach to classification principles. The rules of model building may well present an approach to achieving more transparence concerning the universalities or the general laws governing classification. The layman in classification sciences may be allowed to point to the mutual benefits to be expected if classification is advanced from the modeling side. What appears trivial in a first, superficial attempt will perhaps contribute to refined understanding when explored in depth.

For flexible adaptive or evolving interaction the amount of available latitude that is allowed and/or necessary for representational systems is decisive. Under what conditions must classification be how fuzzy in order to be flexible enough to express shades, nuances and gradual development? Would it not be advantageous if classification could indicate chances and dangers, identify thresholds, support an early warning system? How precise needs classification to be in order to classify referring to an intended accuracy? From which modeling principles can it be decided whether and to what degree a classification must be suitable to build interfaces to neighboring orders of knowledge networking? What principles will provide for the ability to build networks? Which ones will further communication between classifications systems? These questions are seriously to be reconsidered in the age of information explosion and of ever more sophisticated information processing and information compressing. If not for better efficiency, then at least for better transparence, classification should take them into account. Model building already does so.

(b) *Behaviour*. Beginning with K.LORENZ, F.J.J.BUYTENDIJK and many others, ethology has clarified the rules and models which, in our understanding, behavior is governed by. Against the species as the point of reference behavior is shaped and controlled by both innate models and, within the limits of heredity, of models acquired by learning. Simplified here, the nearer these models are to the essentially and basically life-preserving phenomena, the more they seem determined. The more preservation and evolution crave for for flexibility, the more space for learning is allowed. What in the context of perception appeared as flexibility of view, i.e. of evaluation and attachment of sensory inputs, now becomes changeability and flexible behavioral control. Behavioral models are open to adaptation, individually or, for a species, for a given situation or in the course of genetic evolution. They open or close dangers and chances for short or long term development.

Behavior even in its more simple form tends to be highly complex, since it is interaction with the environment. One might reverse the hypothesis of learning by doing (VARELA): Behavior in its not strictly automatic forms is learning, is flexible reacting/interacting, is adaptation to environmental conditions/responses. The models behind it, whether genetic or individually acquired, determine the life chance of the individual and delimit the development of the species.

Examples for applications to classification from daily life are abundant. Models as well as classifications constituting our social security system are notoriously static and inflexible. They classify participants, cases for action, prerequisites for transfer, etc. inflexibly and without too much connection to reality, especially concerning the behavior they impede or encourage. In consequence they have become increasingly complex and inefficient. Scarcely anybody understands them, everybody tries to misuse them in his own favor. - As a teacher I am often stunned to what extent the 'world' of my students is determined and fixed by their socially adopted and professionally acquired views. An engineering student classifies mostly in deterministic terms. He has considerable and lasting problems when introduced to the non-deterministic, rather fuzzy world e.g. of business economics.

Moreover, the models in the background of our classification systems predetermine the potential of cognition and learning itself, of problem-solving and possible goal-finding in the actual order system. How developed is the ability to distinguish, how dense is the possible network of preassigned relationships and, most important, how flexible is the changeability of the models themselves? Faced with those questions it seems but natural that simplified modeling attempts like many of those initially (and still?) employed by AI as e.g. that of the General Problem Solver (GPS) cannot lead very far. This applies to the whole set of fundamentally linear and mechanistic models as e.g. the behavioristic approach of stimulation and response. It remains an open question whether these models can be sufficiently differentiated to overcome this basic deficiency for simple applications. Personally I doubt it. For example, neo-behavioristc methods as Neuro Linguistic Programming (NLP) prove valid only so far as the original linear approach will carry. In the actual case NLP only manipulates the perceptional patterns in order to control opinion building and decision making. As far as I can see all deterministically basic models of behavior will, being only superficially effective, be dangerous. They tend to manipulate; they do not support life preserving communication nor control in favor of free development. Insofar sterile, they will more often than not mislead and destroy.

Excursion: On Ethical Models.

If models are always - if not consciously, then anyway per se - intentional, then any model of behavior is subject to ethical evaluation. The ethical questions opening up cannot be followed here in detail. However, the ethical implications of modeling reach back as far as conscious modeling itself. The discussion between technologically or otherwise inspired views of the world (Weltbilder, Weltanschauungen) is still influential, as e.g. between that of DESCARTES in the French argumentation and more idealistic ones - beware of HEGEL and in particular of some of his followers, too. So are controversies between all kinds of ....isms. Basing e.g. on H.-G. GADAMER, J. HABERMAS more recently hypothesized what can be called a behavioral ethics on the basis of communication. He asks for 'communicative behavior (action)' (Kommunikatives Handeln). The principal argument proposes that any social behavior should be open and directed to communication, that is: to dialogue and discussion. In this way, antagonism, quarreling, and fighting are to be prevented. This in essence old philosophical argument has acquired a new actuality through the dominance of the mass media, through scientifically based methods of advanced manipulation and, in recent years, a general readiness to use force for one's interests.

Strong impulses for ethical rules, for delimitations and positive quests, originate from the various ecological movements. One of their most favorite models is that of Gaya, of the whole world as a living system, and of a corresponding classification of what is important in ecologic action. Variatis variandis the old as well as the newly emerging ethical models should be subject to critical scrutinizing as to the direct and the long term implications on the life-sustaining qualities of social behavior. Well known is the quest for technology assessment, which may serve as a basic example. A model for ethical questioning would, as it is done here, first ask for the transparence of risks and chances inherent in a new technical application. The consequences are then evaluated against the framework of value systems valid in the given case. From these, finally, conclusions are drawn as to the desirability, to the necessary limits, precautions, etc. As e.g. the controversies concerning genetic technologies show, this process, as any ethical evaluation, is not free from bias - e.g. ethics versus economy - and prone to ideology. More generally any ideology may be seen as an ethical model. At least most of them claim ethical origins and ethical goals, mostly in terms of justice and general amelioriation of life conditions, that is progress, social togetherness etc. No wonder one has become or must become very critical when evaluating those models of evaluation. Beware especially of rigid ethical models; they fatally tend to prescribe in detail how to be happy.

Following a ubiquitous tendency to formal scientific approaches - HABERMAS' Communicative Action is but one example - the formal preconditions of ethics and ethical models are investigated. Well known is the concept of 'strategical' ethics. I. KANT's categorical imperative can be ascribed to that class of behavioral models. In main focus is the short, middle or longterm sustainability in respect to life and evolution of behavior. The old Shaman models, the models of witchcraft, of Chinese Strategems etc. are of renewed interest. Lack of basic orientations and/or need for ideological/weltanschauliche complements blend here with escapism and a desire for easy methods of achievement.

A most simple example as to the ethical implements of formal classification rules is the case of duality - either good or bad, no in-between - as opposed to the classification which allows a tertium datur. For example see the philosophical discussion on logic, formal (FREGE) or otherwise. Again, this inquiry into the form-content-value relationship deserves well founded and critical positions, otherwise it will prove treacherous and deceptive. This guaranteed, the approach is worth following. Not only the Khabbhala uses the numbers 1 to 10 and formal graphic/geometrical relationships to build a highly sophisticated system of beliefs and rules on how to live rightly. Algorithmic models are very near to, or easily turned into, mystic models.

To lead back from ethics to dynaxity of behavior: there are some attempts to connect ethics to complex behaviour when explaining the factors reducing behavioral complexity in an institution. Institutional choices, the choice of the structural setup and the appropriate rules and regulations, can be assigned to an ethical quality. A good example is presented by models of leadership and management in business institutions. A tournament of different bargaining strategies has led to an interesting result. It proved that a strategy called TIT FOR TAT was the most effective in the long run, since it accentuated cooperation and mutual benefit. Or: some forms of state constitutions seem to be more effective in securing living space for its members than usually and are therefore also judged to be more ethical. On the basis of such a judgment, and complementing a certain model of social man, a model has been drawn up of what was called 'Strategical Ethics' seen from the point of preservation of life and possible evolution. Naturally, this is a much shortened and simplified account. It might, however, be well expanded into the domains of constitution, justice, etc.

The feature shared by all successful models is, besides the allowance for communication and cooperation, a general tendency to accept or even to further free domains of behavior and development. Or, in negative terms: central rules and regulations and other presriiptions, which reduce freedom of choice and adaptation, are to be kept at the minimum necessary to ensure the identity, autonomy and cont'ı uity of the system. They leave as much latitude as possible for self-organizing behavior. In my opinion, therefore, many an argument speaks for models based on synergetics or, more generally, self-organization as the only ones capable of effectively coping with complexity. Effectiveness here is evaluated in terms of long term efficiency, i.,e. essentially of the system's ability to open up, not to close new domains of action, new chances of evolution. Only those models can cope with dynaxity in a non-reductive mode which open chances creatively and do not lead to dead ends.

The self-referential, self-organizing ability is also the decisive factor to cope with fuzziness or to remain flexible and operable under conditions of rapid change. Among various promising approaches to self-organizing models the afore-mentioned 'synergetics' may paradigmatically be singled out. Developed by H.HAKEN it was originally derived from the behavior of physical, namely laser systems. The model now is most successfully applied to a wide variety of complex dynamic systems. A typical example for the growing tendency to apply it to the social domaiı is 'ı dicated by the title of W. WEIDLICH's recent publication on 'Physics and Social Science' - The Approach of Synergetics'. Other attempts originate from the anthropological sciences (R.FISCH) or philosophy, epistemology (S.J. SCHMIDT) or practical philosophy (see the contribution by J.ZELGER to this conference/in this issue).

Quite an abundance of possible transfers to classification seems obvious. Linear, determined classification schemes are effective when simple and static structures are at stake. Cases lacking dynaxity, however, increasingly become the exception. The touchstone for a classification concept is how effectively it can handle dynaxity. As TH.BALLMER and R.UNGVARY pointed out several years ago already, a 'generic', that is evolvable classification concept is paramount to serve complex and dynamic purposes. These attempts from the early eighties have, to my knowledge, not been continued. The learned classification experts will be able to explain why this was not done and which lines of current research resemble more closely a self-organizing, a synergetic or a similar approach. From a modeler's view the 'generic' classification presents but a first try, since it seems still closely bound to the semiotic properties of language, syntactical and semantical. It must be carefully investigated if this, the language being the very representational system, necessarily ought to be so. At least in parallel an investigation is proposed, if classification does not need a still more general basis, of which semiotic structures are only a part. Behind the postulation stands the opinion that a classification must not be seen as a more or less isolated system, containing objects to classify and systems of aspects, etc. in order to put them retrievably into a goal-oriented order. In addition, it must be seen as the ordering part of a comprising system of information controlled action, enclosing the environment and the user. An inquiry into the latest results of the (quickly progressing) theory of order may prove rewarding.

Any order, any representational ordering system of higher order like classification is sensible insofar and only insofar, as it serves the user well. This is trivial. But, the layman suspects, not all such trivialities have yet been identified and answered by suitable CS. In short, with respect to the requirements for the aforementioned dynaxity models, CS should be synergetic or otherwise self-organizing in design. This feature includes that the user and his/her environment are a constitutive part of any such CS. Which, in turn, calls for equally constitutive communication between user and objects and the classifying ordering system. To venture a paradigmatic analogy from synergetics: The (human, creative) user must be or provide the slaving, the ordering principle for the process of creative information processing. The function of a CS is not to facilitate mere information retrieval and/or information processing. It has, in addition, to provide, by confirming information, the chance to find related new information (or questions leading thereto), seen from the user's point of informational needs. This must be done in such a way that the user may create new pragmatical information, i.e. information oriented to creative application, e.g. to problem-solving and goal-finding. This can be effected only by flexible communication between a CS and its user. Moreover, a CS must be a communication partner not only in respect to a flexible syntactic structure. It needs, in order to enable creative dialogues, to contain semantic information as well: meaning, opinion, purpose. All in all this concept of a comprehensive modeling/classifying system fits neatly into the general model and modeling process proposed initially. (For an elaboration of this topic, see J. ZELGER).

Will EDP programs in the future be powerful enough to support such a dialogue (or even discussion)? What will the basic model of such a representation of meaningful patterns be like? Very probably there have been made, if only partially and perhaps hidden under dominating other aspects, useful attempts to this end. It remains to build a functioning model of a self-organizing, meaningful and communicative classification system: containing objects, user, respective environments and the classifying order system.

(c) *Learning/evolution.* Not unexpectedly fundamental reasoning on representation and modeling leads to the procedural approach and in the end to the core process of life: to learning. If representation is the mode to get an operational picture, that is, one appropriate for life-preserving behavior, then modeling is the mode to decide on the important structures and meanings attached to them within that landscape. Models may be seen as mappings in a secondary representative process. They are the signs, the symbols, the alphabeth of the map drawn from the landscape perceived, the scales for evaluation and priorities to choose and to decide from. Following D. BICKERTON and, in analogy, MATURANA/VARELA, we term the medium of that secondary representation of the primary (perceived) representation: 'language'. The phenomenon of language as such has been purposefully omitted so far. The reason is that the most important function of language, representational learning, is introduced here, that is especially constructional learning. Language, since it makes constructive learning, possible, is the decisive step from a living system, animal or hominid, to self-conscious man. For most practical purposes, to which we must limit ourselves here, the medium which classification of knowledge makes use of is verbal language. (Pictorial language is a language without tongue (langue) and a secondary representational system quite by itself, following an essentially different semiotic. It seems not necessary here to reason about the possible non-verbal forms of thinking and of self-consciousness.) Modeling and classification for all practical means can be defined as ordering following the laws of language.

As K. LORENZ put it succinctly: to live and to evolve is to feed oneself order. Quite correctly the sentence may be transferred into: human learning is modeling in the order of language. Or in reverse: the acquisition of new parts of structures and their incorporation into existing patterns of perception, behavior and, concommitantly, into existing representational systems, mainly language, we call learning. The outcome of a learning process is then: new models to cope with the dynaxities of reality. Or more generally: Learning, constructional learning is the model to evolve creatively new models.

In order to understand better what modeling means, and what queries may follow from that for classification, it appears paramount to inquire into the process and the respective modes by which learning takes place. In order to acquire and to assign information to an existing order and to relate meaning to meaning structures, information theory distinguishes three main classes: confirming, new and pragmatic information. Confirming information contributes to continuity and stability. New information furthers development into new areas of knowledge and stimulates pragmatic information through new experiences thus acquired. Pragmatic information, born from experience, from dialogue and discussion, contains the creative element arising from the experienced response to conclusions and to action. Essential for our line of argumentation is that a pragmatic dialogue will more often than not be a self-stimulating, self-sustaining process, creating by question and response. Working techniques make use of this structure by repetition to confirm, by directed/controlled randomness to acquire, and by pragmatic techniques to create knowledge. Creative techniques test and relate new structures, connected by techniques of relational/analog learning. Aiming at the functions and origins of language BICKERTON, in general accordance with the above classification, more transparently distinguishes experimental, observational and constructional learning. Experimental learning follows immediately the individual experience. Observational learning transfers analogically from an observed situation to a similar, directly experienced one. Constructional learning alone constructs in the absence of an immediate experience solely from information within the representational system. It constructs, hypothesizing and proposing, within the informational domain new models of planning and acting in the mode of inductive, deductive and abductive (analogue, G. BATESON) reasoning.

In constructive learning, which is bound to language since it is made possible through the medium of language only, lies the key to all further steps of learning, e.g. deutero-learning (G.BATESON), meta-learning and hence of every higher development. Once constructive learning is born from representational structures, any level of a higher order may be constructed: meta-representation, meta-language and meta-models of the n'th order with no obvious limits.

Will it be possible to transgress the (representational) Rubicon to the dynamic construction of classification systems in a similar way? The principal limitations are given by the structuring laws of language. Within these, no fundamentally unsurmountable obstacles can be seen. Referring to the holistic system of classification as outlined above: Each dialogue between two persons potentially results in constructional learning. Thus a dialogue between user, CS and environment may, together with and through the user, enable the whole system to learn constructively. The task will be facilitated by more powerful EDP systems, able to cope with even larger masses of data and even more complex relationships. Artificial Intelligence especially contributes examples for the inherent linguistic limitations, e.g. when trying to translate from one language(!) into another language within a contextual language domain. How far will self-organizing programs or concepts of e.g. language computers solve the problem? Probably the partial solutions will raise other still more fundamental difficulties, again in the domain of representation and the setting of orders when modeling. Therefore, it appears recommendable to inquire further into the recent findings in linguistics and in computer sciences, including their scientific subfields such as e.g.the mathemathically based Formal Concept Theory (R.WILLE). A systems expert might perhaps formulate this as follows: the problem and hence the solution lies primarily in the process and only secondarily in the structure and strategy of classifying. For example the processes of synergetics and language in particular and of self-organization in general present good candidates for detailed research into the building-up of dialogically learning CS.

Regard should be paid to the impact of the multi-media technology in connection with advanced EDP systems for representation and dialogue up to cyberspace. K.VELTMAN has brilliantly elaborated the resultant new possibilities and consequences. They reach far into the domains of human thought and man's fundamental modes of perception and comprehension.

6. On Model Building: Pragmatic Conclusions Reconsidering Epistemology

At this point a quasi self-referential feedback to the preconditions of representational systems in the domain of human cognition and emotion is useful. In the attempt to find out what modeling might operationally be approached, and how, in analogy, classification should be approached, virtually every aspect of cognition and emotion, of the representational act, of the processes of learning and evolution, is touched upon. This is scarcely more than was to be expected. The initial approach, the model of the model as the very interface with reality and classification as its intentional and ordering part, leaves no other way open. The result so far has been a rather mosaical picture of the systemic aspects. It remains to transfer them to actual modeling and classifying.

What necessities, what intentions lie behind? What purpose does such a 'back to the roots' pursue? The answer in terms of modeling is deceivingly easy. The material and hence the intentional and the informational relation between man and his world is changing. The causes and symptoms have been discussed in the above. We shall state them in terms of modeling here and will do this in a woodcut fashion. First, ecology designates the general context. For the whole span in man's biological existence from hunter's times to Post-Renaissance and modern times, modeling operated in varying degrees of whether or not, and how far, environment did matter. It is not for longer than 20 years that we in the Western hemisphere have been discussing the impacts of environment as a primary, not only as a secondary factor. Context so far was treated as given and moldable; the latter without too much consequences for the design of the internal structure. There have been early warnings e.g. from agriculture; a certain influence has been also exerted from the biological and social sciences, where context always played a constitutive role. Nevertheless, environment was seen not holistically but as a partial, aspectual context, restrained to the immediate, one-levelled, linearly-structured domain. Such a context was mostly passive and, if active, predictable in its reactions, its interactions with the internal system. Behind this stood the largely unquestioned belief that the world, as mechanical systems do, follows predetermined rules, symbolized in the model of God as a watchmaker. The developing art and science of modeling itself, the learning process within science and science of science concentrated on often simplifying formalization and cause-effect relationships. This has been termed the mathematization of the world, and later, with the growing necessity of visualization - see fractals - observed as geometrization, as e.g. V.V.NALIMOV sensibly pointed out. Not that it had not become obvious already at the turn from the 19th to the 20th century that determinism had only limited explanatory power and that its simple forms provided too crude a model to perceive, evaluate and predict outside the technical sphere. But for the main part of technological research and technical application this was largely neglected, assuming a position 'as if'. The arising anthropology and in particular psychology were treated as an exception unless - see Taylorism and Behaviorism - they used deterministic approaches themselves. As long as there were no directly felt constitutive consequences, there was little reason to change. Ceteris paribus, under given and stable conditions, the accepted base for scientific research and the validity of results was of the same nature.

Both the relatively negligible importance of the context and the determinism of hypothesized rules (laws) led to models of inner structures which could be treated as autonomous and, for practical purposes, as disposable and manageable. The apparent success of such models proved them valid as long as the systems were not too large and not too complex. The practice, however, confronted engineering and control increasingly with complex, fuzzy, multilayered and multiaspectual systems, which could not be handled linearly, if at all. Those systems made apparent not only the economic, social or in general practical limitations of linear modeling. As general systems theory and cybernetics from level I to II ff, and as advanced models from natural sciences revealed, there were fundamental constraints. They showed that such systems can establish only temporary, floating equilibria within a given bandwidth and a process of perpetual change. Moreover, interactions with the environment as well as inner structural changes eventually will lead to so-called phase transitions (synergetics, physics) or to fulguration (biology, ethology), i.e.to the spontaneous emergence of new orders. By those transitions, which may assume the form of a catastrophe (R. THOM), systems with fundamentally new qualities will emerge. Change will adopt the form of a metamorphosis, which cannot be understood by means of linearity.

Nature, modes, extent and, last not least, epistemological properties of transitions are under intensive scrutiny from various scientific disciplines. The interim findings shed light also on the structural side of modeling. For example, hierarchy, symbolized by its dominant form of a tree, is replaced by the concept of multidimensional networks, which includes hierarchy only as a special case. Also, and most importantly, network structures are, likewise multiaspectual and multivalued. Measurement and evaluation, as effected from different aspects viewed from different subsystems, will lead to differing judgments, to intentions, to goals. Different yardsticks are to be applied: from formal effectiveness to ethics, from validity to viability. Structures dissolve into the temporary, aspect and time-dependent state of order adherent to a continuous ordering process.

The dynamic qualities and the singularity of these classes of processes have been comprised under the name of self-organization. The concept signifies the change from an essentially mechanical model in the tradition of DESCARTES to a modeling employing biological and behavioral (not behavioristic) models based on the analogy to consciousness and the brain. The model of mere cause-effect is replaced by representations of analogies related to other analogous concepts in analogue conclusion processes. Seen from definable systems, process governs structure. Order incorporates itself less in static, well-defined and treelike structures, but in algorithms describing processes, phase transitions, bandwidths and thresholds, critical paths/events, long-term development and evolution.

Consequentially, such lines of argumentation culminate in the reconsideration of our basic concepts of time and space. Instead of a more detailed discussion not possible here, the book of NALIMOV (Time, Space and Life. The Probabilistic Pathways Of Evolution, ISI Press (1985)) is recommended. It brilliantly lays open the nodal questions which arise when these basic modes of perception (I.KANT) are reconsidered under the auspices of complexity and dynamics; which means: under the auspices of life, of consciousness, of the human self. When contemplating the consequences concerning cognition and emotion, the man's ways of classifying his reality and particularly himself and his fellow man/woman, basic epistemological questions like that of anthropomorphism or the anthropic principle open up.

This argumentation furthermore confronts us with the modes by which the human mind tries to cope with complexitiy, with dynaxity. On the one side cognition and its paradigma algorithm result in what can be called the rational perception of the world. It is, uno actu, emotionally complemented and evaluated to full perception of the actual situation, i.e. of the one of importance for the perceiving system. Its paradigm is experience (Erleben), which in the extreme case can be mystic. More practically we may speak of reasoning and feeling, both of which approaches are contained, for example, in creative intuition.

This situation is marked by a growing concern as to the basic capacities of human beings to solve reasonably and effectively even highly complex and fuzzy problems. We call attention here to the basic research done by D. DÖRNER and E. DE BONO.

7. On Dialogical Models: Towards an Evolving Classification System

The preceding lines indicate topics which classification science have to consider, even if they are far from exhaustive and, as all modeling necessarily is, subjectively tinted. In order to serve fundamentally changed tasks, classification must strive for creative ordering surpassing that of the presence, and for long-term evolution of knowledge transgressing the current state of ordering. Preliminary answers for the transfer to actual classification practice become exemplarily evident in the following contribution by ZELGER on "GABEK, A Dialogic Networking Approach to Knowledge Order". In an exemplary case the answers to an open question concerning the personal experience following an institutional change are analyzed. To this end the structure/meaning relationships are extracted and mapped with the aid of a PC program. The order emerging inheres the structural order which the laws of language imposed on the opinions of the people who answered the question, and their evaluation of the importance of their concrete experience. It is expressed by the frequency and level of the meaningful relationships which appeared in the texts. Naturally the inherent order systems are multileveled and multivalued. The actual order, therefore, is called forth heuristically by the researcher when dialogically working with the text within the framework of GABEK. The actual analysis of the results will lay bare ordering structures that confirm structures of opinion and opinion-forming rules known from linguistic, physical and biologic approaches, namely synergetic and fractal patterns.

ZELGER's approach appears as an interesting attempt which systematically undertakes to reveal the hidden orders in verbally expressed objects of classification. The system in toto exhibits the features we found necessary for an evolving classification system: Context and contextual structure, texts produced by self-conscious human systems via the representational system of language, classification understood as the ordering structure of the classified system, or, in the case of control, of the control system. Most important for the dynamics of the whole system is the active part played by the user, who operates the whole system as a heuristic instrument. Classification appears as the interface-controlling structure enabling the user to build up and proceed from a superficially unordered representation, i.e. through verbal answers to a question, though arbitrarily specific and specifically ordered representations latently contained in the original texts.

Back to general argumentation: EDP, hardware and software, is progressing, if ever so slowly and with frequent drawbacks, to sophisticated models of self-organization. The process is supported by a better understanding of the processes within the brain, and of the manner these may be linked to the phenomena of human consciousness, especially to the human self, e.g. by neural networks. Are there, then, more general features of the trend which modeling seems to pursue, a direction these models are drifting to? Corroborating the views developed here from basic modeling assumptions, new practices of learning, organizing and structuring knowledge indicate a rough model of modeling and of classification as follows.

(a) The model will be dynamic, i.e. designed for dialogue with the user. The dialogue will take place between the user and the text, that is between the user and the people who originated this text. The people will be represented by the text they originated, namely by the network of the meaningful relationships they expressed. The basic order will be that of language, as shown e.g. by D. BICKERTON, superimposed by the interfering orders of the e.g. professional subjects the texts are dealing with, the directional order of the question itself, the individualities of the persons who answered, etc. Dynamic is also to be understood in various other ways. It has to match the dynamic of the questions to be perceived (observed, controlled), it has to account for the dynamics of the system as a whole and of all its parts: observed objects and observer, process and behavior, materials, patterns and meaning. In principle even the effective extensions of the system and its interfaces may change. In the final consequence time, space and with them measurement scales will be affected.

(b) A classification model furthermore ought to be dialogic, thoroughly and throughout. Any dynamic system is in principle a learning system, thus securing relative continuity, stability and identity. Any system where human consciousness is included is a learning system per se. Dialogic, constructive learning is necessarily comprehensive. Together with the system the prerequisites to maintain its life change, do the corresponding priorities change, factually and intentionally. Human self-consciousness contains and incorporates a modeling, classifying interface of which the crucial function is to learn constructively and which evolves intentionally and self-referentially.

Considered to the end, classification must potentially be capable of representing every order on all representational levels of the system classified. Or the other way around: as far as the change, the evolution goes, classification represents the dynamics of the system. In this sense, e.g. VARELA equates cognition and doing, learning by acting. This does not mean that there is no distinction. The relative equation of each partial system with the system as a whole is necessary - constructive learning on the basis of language is holographic, as change is - when evolution is referred to. Within the process and the network of dialoguing, i.e. of material, informational and intentional interaction, the relative autonomy of each partial system is paramount. Otherwise a dialogue, an interaction, would not be possible.

Concluding the hypothesis it seems sensible to propose that all attempts at building an evolving classification system should be tested and evaluated against the above frame of reference. In most practical cases the test can be narrowed down to the core question in what capacity and to what extent the human observer, user, system/order manager, controller etc. is to fill an active role. Using a transparent example ZELGER shows this necessity convincingly. Furthermore, to mention another crucial application, it should be investigated in respect to EDP and AI applications, in what role and by what substitute, as defined by its functions, the actual human person may be replaced, as is realized e.g. by expert systems. By the way: this problem of partial replacement of human knowledge and self-consciousness appears crucial for all representational systems destined for the support of human learning. This is even more true for decision and control functions.

Referring more closely still to the pragmatics of classification, one may conclude that the frame for actual CS modeling should be even more neatly preset. A CS is always a quid pro quo, it always has to comply with the special needs of the potential user and, not to forget, with standards of economy and efficiency. This includes also all attempts at building up a universal CS. For example, what is the function of the CS within the evolving system? How are the interfaces with related, neighboring CS to be provided for? What developments are to be expected within the contextual system, which ones within the internal structures? What kind of control systems are superimposed? What kind of dialogue, therefore, is to be expected as necessary? What media seem to be appropriate? Perhaps a concept of planned change for the CS can be designed in advance.

In the end, a CS will be chosen on the pretext that it fits the requirements best. Is this utopian? It will help substantially to acquire better understanding of the rules which govern model building in general, in particular the laws of representations through language, whether verbal, written, or coded. The insights gained into the structure of language will very probably be useful, too. The same applies to formal approaches as e.g. Concept Analysis (R.WILLE), to the concept of neural networks or to that of a computer based upon the laws of language. And so on.

There is much to be done. Let the science of the order of the organization of knowledge begin.

Epilogue: Limitations by Language Structures?

Representation is effected through a medium, through a set of meaningful signs structured by semantic and syntactic rules. Man is rightly - even if not sufficiently? - seen as the mammal using language. Does the statement remain valid: what is not in language is not in reality? Or: what one cannot speak of, one should be silent? Even if there are other media than verbal systems: is there a general structure, are there general sets of rules connecting all media which could be hypothesized? How, and to what extent do these ordering principles dominate representation and our models of our worlds? Will this approach lead back to a fresh view on what I.KANT called the basic modes of perception, of space and time and the rules they follow when enfolding, through number and spontaneity, into our reality?

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