Knowledge Organization due to Theory Formation

Peter Jaenecke

0.1. Resumen

La formación de teorías se entiende como un proceso de organización del conocimiento aplicado a dominios internos. Se analizan las incomprensiones más frecuentes sobre el concepto 'teoría'. Una teoría se define como una representación sistemática de un dominio realizada gracias a tres procesos estrechamente relacionados: el establecimiento de un sistema adecuado de conceptos básicos, la ordenación de la experiencia o de un conjunto dado de resultados experimentales, y la síntesis de hipótesis conflictivas. Desde este punto de vista, la formación de teorías supone un ambicioso proceso de representación del conocimiento. Finalmente, se resumen las consecuencias de este enfoque y se enfatiza su importancia para las Humanidades y las Ciencias Sociales.

Palabras claves: Formación de teoría. Teorías científicas. Representación del conocimiento.

0.2. Abstract

Theory formation is regarded as a process of domain-internal knowledge organization. Misunderstandings about the concept 'theory' are explained. A theory is considered as a systematical representation of a domain realized by three closely related theory-forming actions: establishment of a suitable system of basic concepts, ordering of the experience or given experimental results and synthesizing of conflicting hypotheses. In this view, theory formation means an ambitious kind of knowledge representation. Its consequences are summarized and its importance for the humanities and for society is emphasized.

Keywords: Theory formation. Scientific theories. Knowledge representation.

1. Introduction

Knowledge organization in the broadest sense has to make accessible any wanted knowledge, stored anywhere and in any form. One of its main obstacles comes from the mass of existing material. There are two different approaches to cope with that problem: domain-external and domain-internal knowledge organization, respectively.

Domain-external knowledge organization makes use of technical and scientific possibilities to supply the search for knowledge. It includes among others: compiling dictionaries, classifying and ordering knowledge, storing and retrieving knowledge in knowledge bases, and, more recently, distributing knowledge in world-wide networks. In this field - well-known and rich in tradition - extensive research activities are in progress. Its characteristic feature: It is a descriptive work typically done by librarians, knowledge engineers, information scientists etc., i.e., by *non-specialists with respect to the domain* the knowledge comes from. Although the knowledge is prepared in many different ways by them, the knowledge corpus itself is left unchanged with domain-external activities.

However, all technical progress finally comes up against the limiting human factors. There must be, therefore, also a *domain-internal knowledge organization* devoting itself to activities counteracting the glut of material. The goal pursued by this type of knowledge organization is to order the knowledge of a domain systematically, effecting in that way a reduction. The task requires an expert familiar with both the domain in question and the work of a theorist. This work naturally affects in the knowledge corpus by re-organizing it.

When in the past one was talking about knowledge organization, it was done always in the sense of 'domain-external'; its domain-internal variant was overlooked as yet despite of its long tradition starting with Aristotle's attempt to comprehend all the knowledge of his time. Today domain-internal knowledge organization is cultivated as an integral part of the daily scientific work only in the natural sciences and in mathematics. In centuries of development one knew to capture systematically the whole knowledge in theories making it thus comprehensible. *In the humanities (1), however, extensive knowledge was accumulated*, but a genuine theory formation was not achieved here; rather an anti-theoretical tendency spreads more and more, and, quite often, the opinion is held that in these disciplines theories are out of place at all. Some writers seem to reject theory building on the grounds that it seems largely irrelevant when compared to the practice of researchers over past decades. But that can be also looked at from another point of view: The practice of researchers in the past decades may be irrelevant when reviewed with improved models of the phenomena under study (Snow, 1973). It seems that just in such domains where internal knowledge organization might be a most crucial issue, it is resisted in the most violent way.

The aversion to a theory is apparently caused by a lack of understanding of its nature; we start, therefore, with a clarification. In philosophy of science there are numerous approaches to establish a definition of 'theory'. But all these attempts give no answer to the question important for scientists: How to make a theory? There are only a few authors coming from the sciences themselves which deal with that question (2). Nevertheless, even in sciences familiar with theoretical work like physics, no general construction principles were produced; and one would easily embarrass a theoretical physicist with the question asked above. Obviously the theoretical ability is acquired in studying the science itself, and it must be considered a fortunate circumstance that physical knowledge can be represented in a mathematical language. As a consequence, the example of mathematics reacted upon physics and determined decisively the way of its theory formation, i.e., with the representation tool, the methodology was adopted, too. But in the other empirical sciences the circumstances were less favourable. The mathematical model could not be adopted problem-free, and a separate understanding in theory construction was never developed. The following investigation is directed to fill this gap. It is based on the thesis that theory formation is a process of domain-internal knowledge organization. A theory is characterized as a systematical representation of a domain, and it is explained how to realize such a representation. In the final sections, consequences and benefits of the theoretical work are discussed.

In an earlier investigation (Jaenecke, 1994) the knowledge fundus in the sciences was compared with a lot of shards which have to pieced together to a vessel. The paper resumes this simile identifying the vessel reconstruction with theory building. It may best be characterized as 'applied philosophy of science'. It is directed especially to all those feeling the inadequacy of the work in the sciences today.

2. What is a theory?

Opinions about the nature of a theory differ broadly: In natural language 'theory' is often used in a disparaging sense to characterize an unrealistic and impractical construct. In the humanities one is often satisfied already with a vague idea borrowed from the natural language; as a theory is held already any thought put down on paper. From a mathematical or logical point of view, however, a theory is the more scientific the more it is based on mathematics and/or logic. (Snow, 1973, p. 84) These two frequently uttered extreme opinions are equally irrelevant: The first one because of its vagueness, the second one because of its confusion of exactness and mathematization. The latter needs a clarification.

In an empirical science, mathematics is always a means for representation and is as such never subject of the investigation itself. Consequently, an empirical theory cannot be regarded as exact, merely because of the fact that it contains mathematical and/or logical elements, just as little as a grammatically correct sentence guarantees a senseful meaning. Thus, the formula M(t) = M0 e-ßt describes exactly quantitative facts, but it presupposes that there are quantities M, M0, ß, t having a counterpart in the empirical world. On the other hand, a theory is not inexact alone because of the fact, that it was formulated in a natural language. What we need is a new concept of exactness more appropriate for the empirical sciences.

The confusion originates in mixing the concepts 'description' and 'representation':*To describe a fact merely means recording it in any language form. The representation of a fact is a description which in addition reflects correctly the causal relation.*

A description can be made in an infinite number of ways. Apparently it is not easy for scientists to realize that a regression function, however well it might fit the measurement values, is no more than a description. The understanding is aggravated by the fact that within the error limits a description gives no worse results than the representation would do. A description, therefore, can be exploited technologically using it, e.g., to calculate values which have not been measured as yet. The fundamental difference, however, is that from a description less conclusions can be drawn, and some of them may be incorrect. For instance, there is always an infinite number of functions which pass through a finite number of measurement values. But it is not possible to decide by means of the values alone, which function in fact is the correct one. Each of the functions decribes the measurement result, but at best only one represents it really: It is just that function which represents correctly the causal relationship.

Especially mathematically-oriented scientists used to abstract from all as regards content, often succumbing to the temptation to identify a mathematical relation as a causal one. Thus, formula M(t) = M0 e-ßt from mathematical psychology is concerned not only as a regression function to describe a set of measurement values, but also causally as a law of decay of memory traces (Petzold, 1980). That can be done only if one presupposes the existence of something being subject to a decay process. Consequently, among other things there must be assumed a quantity, M, as the strenght of a long-term memory trace. The value of such a formula is tied indissolubly to the question, whether there will be something like a long-term memory with memory traces in it changing in time; i.e., whether there will be something like a forgetting caused by a decay of information. Only if this would be certain beyond doubt, it would be senseful to think about quantitative interrelations. But instead of striving to understand the underlying processes, all efforts are directed to support the model. Doing so, a model, once circulated, can gain a remarkable momentum: Since it is based on shaky grounds with respect to the content, it gets easily into conflicts with new experimental results; this in turn forces to make modifications. Thus, e.g., Wickelgren

(1972) replaces it in the formula M(t) = M0 e-ßt above by √t*****. But because the modified model is not much better founded than the previous one, it remains sensitive to new results as well. On the other hand, each modification of the formalism will complicate it more and more the resulting in an increasing amount of interpretation. Thus, it is not so simple to give the quantity √t a sense already from a physical point of view, but whatever should it mean in psychology, especially in combination with the exponential function? Wickelgren apparently was only interested in finding a better regression function for his measurement data, i.e., he was only interested in improving the description. This is possibly the reason why it is so seldom that mathematical approaches in the humanities change into a generally accepted theory.

In the tradition just described, the contentless formalism is to the fore; experimental efforts are undertaken to justify it. But this way the theoretical research work turned upside-down: *If an empirical theory should reflect the reality, then, and only then, the selection of the representation tools must follow the subject to be represented.*

The essentials are not the tools, but just what should be expressed with them. When quantitative relations are to be recordered, then, of course, one will fall back upon a mathematical representation; when it is a question of qualitative interrelations, then a representation in a natural language will often be sufficient. However, for the latter there are also formal means like semantic networks which can be used to represent clearly a network of relations of any complexity. It is the task of a theorist to search for a suitable representation tool and to use it to represent the domain in question as accurately as possible. Theoretical work in the empirical sciences, therefore, consists for the most part in tackling the representation problem, closely related to the struggling for the optimum expression in an art.

'As accurately as possible' is our starting point for a new concept of exactness; it is a relative ideal of exactness, called 'representation faithfulness'. In contrast to the mathematical-oriented ideal, representation faithfulness takes the content into account. Representation faithfulness is not a condition like consistency which must be fulfilled by a theoretical construct to be regarded as a theory. Rather, representation faithfulness characterizes the ideal state of a theory to which one has to get as close as possible: *Definition: A representation is called faithful at a given moment, if it accounts for all phenomena known until to this moment.*

That means especially that such a representation must not be in contradiction with any phenomenon. The theoretical work of a scientist can be characterized shortly as follows: From the infinite number of possible descriptions the task is to find out the one which represents the domain in question. The demand to include all known phenomena leads necessarily to this goal since each new incorporated phenomenon will reduce the description space.

There may be many interim solutions on the way to a faithful representation. They are not faithful as there are still phenomenon not incorporated as yet; but the representations were developed according to certain rules; we call them systematical representations. With this, we now reached the answer to the question 'what is a theory?':*Definition: A theory is a systematical representation of a domain.*

From the definitions above follows that a theory is a dynamical creation succumbing a change; it is neither fixed to a special domain nor is it fixed to a special representation tool. Both domain and representation tool are ruled out, therefore, for characterizing a theory. What is left alone as the invariant here is the method; i.e., a theoretical construct is a theory, if it was conctructed according to certain rules. No domain is excluded a priori as theory-unworthy. The unity of the method is so to speak the clamp unifying all sciences; it also makes sure that the way of cognition remains unique.

This conception stands in a glaring contradiction to the view on theories held in the Analytical Philosophy (of science) and others schools where the theory concept is just oriented to a special domain, mainly to classical mechanics, and it is based on a special mathematical tool including predicate calculus, set theory, and, a little bit from analysis (Sneed, 1971; Stegmüller, 1970). But such a reduced view about theories cannot be applied to other domains; and, by the way, it is doubtful whether this view does justice to physics itself. However, to discuss this problem in more detail is beyond the scope of this paper.

3. How to realize a systematical representation?

The above investigation stopped by stating that a theory is a systematical representation of a domain. The question suggesting itself now will be: what are the characteristics, or, more precisely, what must be done to come to such a representation? The answer is as follows:

- Establish a suitable system of fundamental concepts.
- Order the known experiences or the given experimental results.
- Synthesize the conflicting hypotheses.

These theory-forming actions are closely related to each other as detailed in the following sections: It does not matter with what action the work is taken up since as soon as one gets involved in one action, very quickly one has to deal with the other one. Mittelstaedt (Mittelstaedt, 1972, 40 ff.) must have been the first (and possibly the only one till now) who realized the cyclic structure between concepts, measurement and hypotheses with respect to physical theories.

3.1. Establishing a system of fundamental concepts

It is a highly interesting phenomenon in the scientific bustle that one apparently can form meaningful statements with completely unclear concepts. In the psychology of memory, e.g., 'semantical coding' is such a multi-used dubious concept. Its isolated explication would not be possible because of the missing concepts needed for it. An explication must always be applied, therefore, to an ensemble of concepts fundamental for the representation of the domain. Which of the possible concepts should be taken into consideration depends on the understanding gained in ordering the research results. In this way it might reveal that it is senseful in psychology of memory to introduce, e.g. 'strength of memory trace' as a basic concept. Of course, such a choice would require necessarily to introduce other concepts closely related to it. The system of concepts is consistent in so far as the hypotheses will be consistent since the hypotheses fix how concepts are related to each other and whether they are quantitative or qualitative. Thus, 'forgetting' in the sense of 'information decay' would require concepts different from those which are needed to grasp forgetting as a case of missed access to the memory. On the other hand, in restricting the space of possible hypotheses about the domain, an established system of concepts operates by itself like a (meta)hypothesis manifesting the researcher's ideology: *An explication of concepts always involves an ordering of matter. If this is followed up strictly, it will lead to a consistent system of fundamental concepts mutually related to each other. These concepts form the backbone of a systematical representation and influence in a normative way the linguistic usage.*

3.2. Ordering of experimental results

When in physics a law has been found then all research and measurement activities on this subject is stopped. Thus, nobody will measure any longer speed or duration of fall as done by GALILEI because it is known that no measurement table, however extensive it might be, can contain information going beyond the known law of falling bodies. In the humanities hypotheses are produced unceasingly. Unlike the laws in physics these do not restrain but promote the floods of experimental results since the experiments are made mainly to support the underlying hypothesis. They seldom bring to light new insights. Rather, they seem to be highly redundant measurements of already known phenomena. If only at least that redundance could be used to verify the experimental results! But since each experimentator is carefully endeavoured to distinguish himself a little bit in the test conditions from the predecessors, there can hardly be found two experiments performed under the same conditions; as a consequence, the results of the different tests can only seldom be compared with each other. Thus, observation data are accumulated more and more, but nobody knows what should be explored with them. No question, that the conclusions drawn from these results will also be quite doubtful.

In the philosophical literature a theorist is demanded to look for the experimental confirmation of a theory immediatly after its establishment. From this one might gain the impression that a theorist would establish a theory without any experience. But in reality the theorist starts theorizing with the professed aim to explain certain experimental facts. However, as the results in the past show, the theorists failed mainly because they found their work on a too small experimental basis, i.e., they ignored most of the known facts.

It is, therefore, imperative to gather and order all availabe results and, at the same time to scrutinize them critically. To order experiments includes exploring and classifying the test conditions - a hard job because seemingly unimportant details are left very often unmentioned in the description of an experiment. It presupposes a sophisticated system of concepts; above all what matters here are uniquely explored measurement quantities. The close connection between hypotheses and experiment is another point of special importance. The hypotheses influence decisively the design of an experiment, and they are needed to interpret and evaluate the results. For instance, some experiments in psychology of memory attempt to prove the existence of a short-term memory. For this, features of the short-term memory must be postulated like its shift register property in order to design the experiment and to give the results a meaning. On the other hand, experimental results, as facts, cannot be ignored in making hypotheses, reacting in this way upon the theoretical field. *A set of accepted experimental results, covered by a theory, represent the empirical knowledge of a domain; from them a regulating effect originates limiting the liberty in constructing hypotheses.*

3.3. Synthesize hypotheses

In the humanities, the most ignored work is the critical look at given hypotheses. 'All bodies expand in heat' is a known physical experience. If bodies would be found showing the opposite effect, one would correct the above assertion, e.g., in attempting to reduce the deviant behavior to differences in the molecule structure. In this way, the system of hypotheses is enriched continously with new knowledge; there are no contradictory experiences except those which could not yet be clarified. In the humanities, however, a hypothesis is rejoined with an antihypothesis, and soon after that the latter suffers the same fate as its predecessor, etc. It is an interplay with a ritual character obstructing each deeper understanding, responsible for the juxtaposition of numerous hypotheses partly incompati-

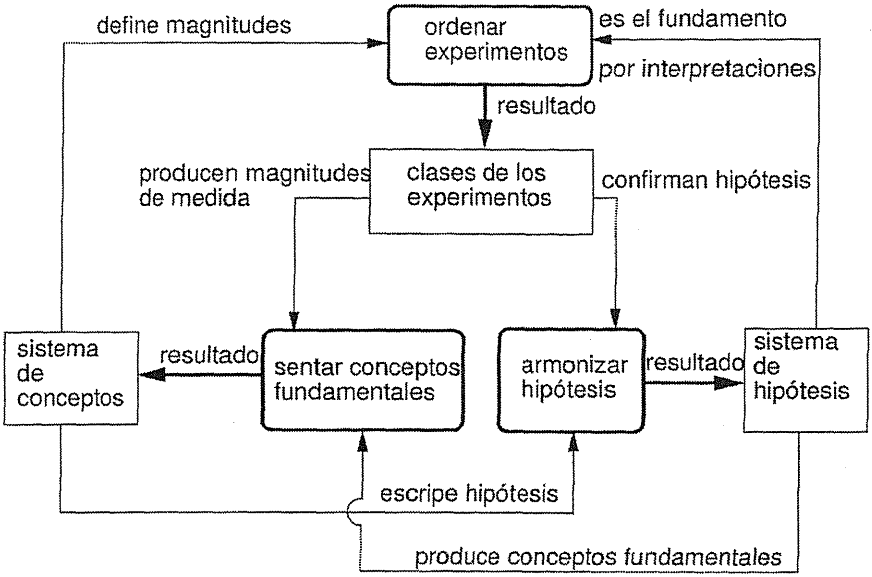

Fig.1. The three theory-forming actions and their interdependencies.

ble with each other. In spite of this confusing variety, one has to assume that each serious hypothesis, as unsatisfactory as it may be, contains a rational core which would be lost if the hypothesis is discarded rashly; and, in fact, many an important insight might be fallen into oblivion in the past this way. The process can be stopped only by a synthesis of the conflicting hypotheses: If there are two hypotheses incompatible with each other then the reason for this must be found. After that, a harmonization must take place. It can be done, e.g., by generalization, or, as in case of heat extension, by a more accurate specification; sometimes problems will also solve by themselves in proving to be a special case of a more general hypothesis. Synthesizing conflicting hypotheses presupposes a suitable system of concepts in order to formulate the hypotheses correctly; however, appropriate experimental results must also be available revealing the regularities asserted in the hypotheses. A set of harmonized hypotheses represents the general knowledge of a domain; it governs the design of experiments as well as the semantics of its technical concepts.

Figure 1. summarizes the mutual dependencies between the three theory-forming tasks; in the appendix an example is given for starting a theory formation (Fig.1).

4. Consequences

Not protected against contradictions in the future, open for new experiences, but constructed according to strict rules which take into account the mutually dependency of the three tasks —that is the idea of a theory we are holding here. This view and the conclusions drawn from it digress markedly from the opinions circulating in the humanities and philosophy of science:

Incomplete knowledge does not make impossible a systematical work, i.e., systematical stringency and incompleteness in things does not mutually exclude themselves. On the other hand, the systematical work cannot guarantee perfect results: the principle of faithful representation, as a liberal demand, does not protect from future contradictions. An empirical theory will be always in a stage of development and will show many a shortcoming especially in its early stage.

Establishing a system of concepts and hypotheses in accordance with experience must be possible for each discipline named as science: As mentioned above, a theory is neither reserved for a special domain, nor must a domain have a certain minimum size: even if a systematical representation would refer itself only to a single, well-formulated hypothesis, it would be a theory in the sense stated above. However, because of the principle of a faithful representation, a permanent development is intended with the theory concept which may increase its size.

Contradictions as well as a juxtaposition of different facts are incompatible with the suggested theory understanding. As soon as contradictions or new facts arise, one must solve those contradictions and build in the new facts into the existing theory. That is why *a theory in development can be neither true nor false*; such characterization makes no sense any longer: The primary criterion for the evaluation of theory is usefulness, not truthfulness (Snow, 1973).

As a consequence, this view is incompatible with the opinion influenced by a logical point of view, a theorist would be occupied with establishing and falsifying theories. The special philosophical school of thought teaching that doctrine overlooks, among others, the fact that in order to falsify a theory one needs a system of concepts and unequivocal empirical results —the system of concepts in order to articulate the hypotheses, and the empirical data in order to perform a certain refutation, i.e., it is taken for granted tacitly just what is necessary to create in an iterative process consisting of an arduous detailed work.

For philosophers of science, theories are objects of investigations like the aircrafts for test pilots. They developed a sophisticated formal apparatus for this, especially, for answering the question of the theory's validity. But they forgot completely another point of view: that of the theory builder. A theorist starts with certain ideas about what the theory should achieve. (S)he works as long as the established goal is reached. Sometimes it may be appropriate to reduce the requirements, sometimes the plan must be given up, i.e., either a theory meets its task at least to a certain extent, or it will not be existent at all. That a theory works is not surprising, because the theorist has constructed it in this very way. Therefore, all philosophical disputes about this subject are unnecessary, just as a discussion would be about why an aircraft can fly.

A given theory does not gain in value by axiomatization since it is a formal procedure which cannot acquire new empirical knowledge just as little as a fair copy of a text and the correction of its grammatical and orthographical mistakes would improve its semantics. But because of its abstract form, an axiomated theory can lose all practical relevance as the axiomatization attempts of physical theories show: they are left completely unnoticed by physicists. If any, axiomatization seems to be meaningful only for "closed" theories, i.e., if there will be no empirical phenomenon not covered by the theory. Since a theory itself does not make assertions about the conditions of its validity, each theory must be concerned as unclosed in principle, except for those theories embedded as special case in a general one like classical mechanics in quantum mechanics. The general theory then provides the limits in which the special one holds. But this is the case for only a few examples so that it must be considered as irresponsible to extol the axiomatic ideal as the highest form of theory in sciences where theoretical work is only in the beginning.

5. To what end a theory?

Building theories and models is not only respectable but extremely useful, perhaps even indispensable (Snow, 1973). With a theory one can keep a general overview; it facilitates orientation. From a theory conclusions can be drawn which exclude certain actions because they are predicted by the theory as unsuccessful. Thus, a theory can save researchers from hopeless investigations like the search for a perpetuum mobile. In scanning the literature one may notice that authors have lost more and more the courage to voice their own opinion; many of them hide themselves behind authorities and/or sail in the fairway of a school of thought. A theory, however, presents an independent basis for argumentation and provides certainty in thinking.

Sciences are based on teamwork. But teamwork can prosper only if all researchers work at the same scientific building, i.e., if they accept a certain stock of knowledge as a basis for their common work. Doing so, they can build on what predecessors had created. A theory is comprehensible and testable for everyone; it can be understood as such a stock, giving the linguistic backbone for understanding and communication, and, at the same time, being the building to which perfection one works. This is reality in natural and formal sciences. In the humanities, however, the tendency dominates to tear down what predecessors had created, or, to begin with a new building with the intention to contrast oneself from predecessors ignoring or denying their results. Because of the limited lifespan they can finish, therefore, only miserable huts compared with those buildings developed in the natural and formal sciences.

A theory opens the outlook to neighbor disciplines where - possibly with different names - the same problems are tackled; it is the prerequisite for each interdisciplinary research. This reveals itself very clearly in the attempt to adopt results from a foreign discipline. To which model of human memory, for instance, should a researcher in artificial intelligence give confidance: to the model from Shiffrin & Attkinson or from Baddeley, or to that from Schank? This example shows that already in such a special domain like the psychology of memory, islands were formed, partly uninhabited now, so that outsiders are helplessly confronted with a contradictory and varied offer. Often they pick out the first model that comes along and, in ignorance of other models, they claim 'as it has been established in psychology ...'

They do this in a manner which makes other outsiders believe that this model would in fact be the only one in that discipline accepted from everyone. A very similar situation arises when an expert system should be developed in a domain. An interdisciplinary-oriented research can be successful only on the background of a generally accepted theory and on the common language going with it.

In the humanities often the stereotype objection is voiced that theory formation would here be impossible. To give a significance to this jugdement, there must be at least a theory by which that objection can be proved, explaining at the same time the special position of the humanities. But if this should be considered impossible, too, then the judgement above reveals itself as merely a dogma, or, possibly more precisely, a lie to cover oneself. Such an attitude has an extreme explosive social force:

When the question arises how to protect man against the forces of nature or how to satisfy material needs, then one has accustomed himself to the belief that the responsible sciences would shortly find a solution. In the past this has often been the case, e.g. with respect to curing, nutrition, energy. But it is a perilous mistake to trust in the humanities that they could cope just as successfully with the pressing international social forces arising from unemployment, climate disaster, international conflicts, consequences of technical development, social brutalization, loss of ethical values, etc. Currently a universal helplessness concerning these problems can be observed endangering seriously the existence of our society. There are congeries of contradictory hypotheses thwarting largely a sound work, and, as in the other sciences, too, the specialization is permanently in progress. Thus, we produce social problems with increasing complexity and attempt to handle them with more and more specialized means: It must be doubted whether the present knowledge is sufficient to solve all problems within the timespan left to us. In this situation, accepted theories might be the tool to exceed the narrow limits of special subject fields and to overcome the knowledge crisis.

Coping today with the mass of scientific literature is another problem. In order to keep an overview and to supply the user with existing knowledge, worldwide research programs are in progress dealing with the use of new hardware techniques, with more intelligent retrieval and a refinement of indexing algorithms, etc. The supreme principle adhered to is: Any material produced must also be kept available; the situation itself is accepted as unalterable. However, the ideal of completeness is justified only in case of intact sciences. In the present situation these methods and objectives threaten to turn out badly to the user because they hardly take into account the limitations of human capacities: When the user physically is no longer able to process the retrieval results because of their sheer volume, any further increase in performance will hinder him in his work rather than help him. But these measures lead domain-external knowledge organization into a dead end, too: The more specialization is advanced, the less orientation gets a domain-external indexer for his work from the sciences themselves. In order to describe each microscopic splinter of thought, as small as it may be, indexing methods must be sophisticated more and more; in a last consequence they are adopted to the overwhelming mass of pseudo-knowledge. Therefore indexing tools proved to be arbitrary to a certain extend, reflecting the originator's conception of the world rather than objective structures.

Here again, the domain-internal knowledge organization arrives on the scene: A theory gives orientation by the ordering strength of its system of fundamental concepts, and in a threefold way it is an important tool in the struggle against the rising mass of material:

- Because of its systematization effect, a theory introduces order into the congeries of facts; fragmentary thoughts are merged into a new knowledge unit, just as individual shards are combined to make a vessel. The number of elements, i.e., the redundancy included in the scientific material, is thus reduced. But no content is lost in this process, on the contrary, even new knowledge is produced, because the complete vessel is more than the sum of its shards.

- From a theory furthermore a disciplining effect arises: thoughtless assertions can easily be discovered as such; a theory prevents from publishing papers containing claims or conclusions incompatible with the theory, or which do not improve it. A theory gives a measure to evaluate material in question. It enables to weed out non-authentic material, for when it is known what form a vessel must have, it is also possible to decide whether a given fragment belongs to it or not, reducing in that way again the wealth of material.
- Problems solved by the theory lose in interest: New solutions are no longer suggested, experimental activities are ceased, and, consequently, the number of publications will go down rapidly. Thus, new publications in classical mechanics are nowadays very seldom.

When one talks of a shortage of resources, one usually thinks of raw materials and energy, but spiritual resources are just as needed for our survival. Just as in other field, we are living here, too, at the expense of the future: we produce, but we do not enrich: Despite overflowing library stacks, ignorance and disorientation steadily increases in all disciplines. We leave to future generations our mental garbage, the access to the old experience is obscured. Something must happen soon; things cannot go on (for long) as they have done so far. Knowledge organization due to theory formation together with the domain-external line could perhaps be a remedy for that.

6. Appendix

6.1.Starting a theory in sociology

The three working fields in theory formation are characterized by C (system of concepts), E (experiences/ experimental results) and H (system of hypotheses). Lets start with

- H1 Knowledge is power.
- C1 'Knowledge' and 'power' appear in this statement as basic concepts. We try first to clarify the concept 'power'. Intuitively one would be inclined to say:
- H2H1 has therefore to be complemented as follows:
  a) The knowledge a person has, gives this person power about other persons.
  b) However, this statement is not clear because all persons have knowledge to their's disposal. To give the above hypothesis a sense, it must be expressed that power results in the knowledge a person has

and, at the same time, other persons have not. We try it again in stating:

c) The knowledge a person has, gives this person power about all those not having this knowledge.

- E1: Now we are at the point to look for an experimental confirmation. We start quite simple with personal experiences. A philosopher may ask himself that he know a lot of things other people do not know, but that nevertheless he has nothing to say, neither in the field of politics, nor possibly in his family. Therefore, the last hypothesis in H2 cannot be true, in general.
- C2: Thus we are automatically led to examine the concept 'knowledge'. Apparently only a special kind of knowledge can give power. But we have no idea how to differentiate the kinds of knowledge.
- E2: We look therefore for examples in which knowledge gave a person power about other persons. It suggests itself to think first to specialists and blackmailers.
- C3: We interupt this thought for a moment to precise the term 'against him/his will' because it occurs to us that a large class of cases can be subsumed under 'against him/his will to pay money'. The effect of power a person has about other persons consists in these cases in demaning successfully money from them. For later, we notice here the need to classify more precisely the kinds of acts a person can be forced to.
- E3: Specialists like physicians or lawyers have to their's disposal a special knowledge on which we have urgently to rely in some situations. The blackmailers' power often rest upon a compromising information.
- C4:We have to interupt again here our investigation becoming aware that we unconciously used with 'knowledge' and 'information' to different words behind of which possibly two different things are hidden. We are demanded in such a situation, either to decide that 'knowledge' and 'information' are synonyms, and if so, we must cancel one of them; or we come to the conclusion that they characterize different concepts; then 'information' appears as a new basic concept and we must clearly distinguish 'information' and 'knowledge' from another. There are strong reasons to follow the second way. One reason is that the knowledge we need from a specialist does not lose its value, whereas the blackmailer's compromising information is of worth only as long as it is not public, and the same holds, e.g., for brokers with respect to the insider information that there exists a takeover offer for a company. We omit here a clear definition of the questionable concepts.

- E4: Using the conceptual distinction made in C4, we are now able to perform a first ordering step by subdividing the experience into knowledge-based and information-based cases of exercising power.
- H3: Similar to E4, the distinction between 'knowledge' and 'information' will normally give reasons to state also the hypotheses more precisely, etc.

We stop here our theory formation; it might be continued in any direction. Thus, e.g., we might steer towards ethics, or we might pursue the phenomenon that in modern societies the influence of the intellectuals is rapidly dwingling. It should be clear from the above example that theory formation is a domain-internal knowledge organization in which a theory is not formed in a straightforward way, rather —with some parallels to PLATO's dialogues— in steps always bound to the actual situation which was produced by all previous steps. The example also reveals that the effect of systematization does not arise from any formalisms, but it arises with an inevitability from the characteristics inherent in the domain under study provided that exactness in reasoning is observed.

7. Notes

(1) 'Humanities' includes all disciplines not belonging to technical, natural or formal sciences.

(2) Mittelstaedt, P. (1972). Die Sprache der Physik [The language of physics]. // Mittelstaedt, P. Die Sprache der Physik. Aufsätze und Vorträge. Bibliographisches Institut Mannheim/Wien/Zürich 1972, 84-115 ; Snow, R.E. Theory construction for research on teaching. There will be surely more attempts hidden in publications from special disciplines.

8. References

Jaenecke, Peter (1994). To what end knowledge organization? // Knowledge Organization. 21 (1994) 3-11.

Mittelstaedt, P. (1972). Die Sprache der Physik : Aufsätze und Vorträge. Mannheim ; Wien ; Zürich : Bibliographisches Institut, 1972.

Mittelstaedt, P. (1972). Verborgene Parameter und beobachtbare Größen in physikalischen Theorien. // Mittelstaedt, P. Die Sprache der Physik. Aufsätze und Vorträge. Mannheim ;Wien; Zürich : Bibliographisches Institut 1972. p. 33-50.

Mittelstaedt, P. (1972). Die Sprache der Physik. // Mittelstaedt, P. Die Sprache der Physik. Aufsätze und Vorträge. Mannheim ; Wien ; Zürich : Bibliographisches Institut 1972. p. 84-115.

Petzold, P. (1980). Mathematische Gedächtnismodelle. // Klix F.; Sydow H. (Hrsg.). Zur Psychologie des Gedächtnisses. Bern ; Stuttgart ;Wien:Verlag Hans Huber, 1980 (2. Aufl.). p. 42-58.

Sneed, J.D. (1971). The logical structure of mathematical physics. Dordrecht, 1971.

Snow, R.E. (1973). Theory construction for research on teaching. // R. Travers (Ed.).

Second handbook of research on teaching. Chicago : Rand McNally Colle Publishing Company, 1973.

Stegmüller, W. (1970). Probleme und Resultate der Wissenschaftstheorie und Analytischen Philosophie : Band II : Theorie und Erfahrung. Berlin ; Heidelberg ; New York : Springer-Verlag, 1970 ff.

Wickelgren, W.A.(1972). Trace resistance and the decay of long-term memory. // J. Math. Psychology. 9 (1972) 418-455.