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ABSTRACT

Two kinds of perspectives governing the provision and preservation of knowledge, a universal and an ecological perspective, are discussed in this paper. In the first case, scientific observations are represented through a semantic interpretation of facts. This is illustrated with a series of experiments on semantic feature perception in the recall of pictures described by descriptor terms. In the second case, scientific observations are conceived as part of a constitutive context. Consequently, the researcher's development toward structurization and his use of precise concepts and well-defined conceptual relations requires an orientation toward the cooperative dimension of the context. This is illustrated by an ecologically oriented study of an information system that measures intentionality and orientation by means of an Agent-action-Objective (AaO) formula. Within the AaO formula a dependency between the cooperatively operating and interacting components creates the absolute terms (i.e., the invariants); these, in turn, serve as a point of departure for information synthesis. It is demonstrated that scientific reporting has the intermediary function between context and knowledge representation. Intentionality and orientation are fundamental in the development of concepts and conceptual relations. (21 references) (Author/DB)

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Abstract

Two kinds of perspectives governing the provision and preservation of knowledge, a universal and an ecological, are discussed in the present article. In the first case, scientific observations are represented through a semantic interpretation of facts. This is illustrated with a series of experiments on semantic feature perception in the recall of pictures that were described by descriptor terms. In the second case, scientific observations are conceived as part of a constitutive context. Consequently, the researcher's (knower's) development toward structurization and his use of precise concepts and well-defined conceptual relations requires an orientation toward the cooperative dimension of the context. This is illustrated by an ecologically oriented study of an experimentally designed information system. Within this system the intentionality and orientation of the single researcher has been measured by means of the AaO formula, derived from the Agent-action-Objective paradigm. Within the AaO formula a strict dependency between the cooperatively operating and interacting components creates the absolute terms, i.e. the invariants. These invariants serve as point of departure for information synthesis, i.e. the establishment of knowledge. It is demonstrated that scientific reporting has the intermediary function between context and knowledge representation. Intentionality and orientation as reflected in the course of a document-event involvement is fundamental in the development of concepts and conceptual relations.

The descriptive and theoretical formulation of the cognitive mechanism advanced in previous articles (Bierschenk, 1984a, 1984b, 1986, 1990a, 1990b) demonstrate that stage plays a critical role in the architectural configuration of cooperative action. In the present context, the ecological orientation in the analysis of knowledge management is of particular import, because it comprises some fascinating intertwined logics. One is related to structure and the other to form. The mechanism operates at its fifth stage with structure and form as the independent variables of experimentation. The change from dependent to independent variables constitutes a discontinuity with the following result.

The complementary role of form and structure may be imagined as a complementary arrangement in a three-dimensional space. For that reason, an action component (a) has to be introduced. By assigning values (-, +) to the a-component it is possible to manipulate the independent variables. Consequently five basic activities can be carried out in the created action space:

1. fixating the component to which the value (-) is bound,
2. binding the value (-) right adjusted,
3. mobilizing the component to which the value (+) is bound,
4. binding the value (+) right adjusted,
5. supplementing for place holders by transference of letters or letter combinations from one stage of development to the next ensuring the preservation of continuity. Though transformational change from one stage to another constitutes a discontinuity.

It is suggested that all pairings possible will highlight problems that have obstructed a clear resolution of both the study of (1) relations versus orientation (features, attributes) and (2) intention versus invariance (conservation, identity).

Fixating (--) of both structure and form, namely, means zero processing, while their mobilization (++) implies maximal information synthesis. In this respect the value combination (--) signals the presence of relations as carriers of information pertaining to structure and/or form. Thus, fixating both structure and form implies the zero hypothesis for a study of the conceptual apparatus that underlies scientific change.

The four sections of the action space are complementary in the sense that the value combinations (--, ++) and (-+, +-) express a double asymmetry. Each pair exercises a certain control over the development of every other. They constitute the mechanism for developmental control over the differentiation and integration of knowledge. The differentiation process, resting on the (-+) combination, can be studied by measuring variation in orientation. The (+-) combination implies that the differentiation process is concerned with variation in intention. Integration is represented by the (--) and (++) combinations and thus only indirectly accessible for the empirical study of knowledge.

The Problem of Knowledge Representation

Scientists working within the fields of Artificial Intelligence and Cognitive Science have repeatedly pointed out that they have constructed models for knowledge representation of significance to psychology. Their goal is to build so called expert systems based on the fundamental assumption underlying all classical reasoning in philosophy and formal science, namely, that knowledge is the product of associative relations holding between pure elements (i.e. primitives) within a universe, that is relations detached from structure and form and consequently from any real meaning. The nature of the knowledge representation of the proponents of connectionism in Cognitive Science lack a constituent structure, despite the appearance of knowledge trees with labelled nodes in the diagrams of the underlying models.

Contrary to empirical evidence, the so called "knowledge worker", e.g., Newell (1981) believes that computers being "symbol handling systems" with the basic functions of "reading", "writing" and "storing"; "copying", "comparing" and "erasing"; "branching", "looping" and "controlling" make it possible to represent knowledge as axiomatizable classes of sentences in a formally clarified language and a standard context as substitute for a universe.

From this it follows that knowledge has to be characterized on the basis of formal logical relations with the aim at generating a formal inductive logic as the model of rational epistemic acceptance. This tendency to "frame" nearly every scientific issue solely in formal logical terms has resulted in conceiving knowledge within the framework of logical mechanics and thus closely linked to computer technology. However, knowledge is nothing that can be reduced to a question of memory capacity (in the computer or human being) and retrieval by computers or humans. By confusing retrieval with recognition the problem of establishing knowledge is ignored. Instead knowledge is conceived as something that somehow emerges out of the hardware of the machine.

Relations in the Organization of Information.

Of fundamental importance for an information process to take place is the presence of information carriers. Bibliographic data on a document, a reference, an abstract, or entire documents may be defined as carriers or objects of description. They are characterized by physical existence in the sense that they can be sorted and classified. However, carriers must allow different kinds of processing or transformation of the information they carry. Transformation means that information is restructured. For example, indexing is a process of transforming through classification of a document, which also effects the recognition of the information classified.

For the purpose of collecting and maintaining knowledge, the UDC (Universal Decimal Classification) was developed for the organization of

book stocks on shelves. The starting point was Dewey's Decimal Classification (DC). The decimals are retained within the UDC and the literature is organized in ten main classes, designated by number (0-9). The UDC differs from the DC by using recurring decimals. The task of the classification system is to define the relationship between single elements. The characteristics of a UDC hierarchy is its resemblance of a tree with strict super and subordination. By means of the ten main classes subjects are grouped together, even though a strict ranking order in the subclasses is maintained. Consequently, reorganization is only possible through addition and expansion along the outer edges of the tree. Thus, the representation of the knowledge of a particular discipline, depends on the successful indexing of its documents. The assignment of descriptor terms specifies the place of a particular document in the classification system. The terminology of representing concepts and their relations has been organized in thesauri. One widely used thesaurus for computer-based information search within the Humanities and Social Sciences is the Thesaurus of ERIC Descriptors (ERIC = Educational Resources Information Center), which in principle builds on hierarchic trees.

Three types of relations are used in the organization of the vocabulary. These types are basically USE ("See or Use") and UF ("Used For"); BT ("Broader Terms") and NT ("Narrower Terms"); RT ("Related Terms"). The terms in the first group have a control function. By USE is indicated which term is the more correct one (used by professionals), whereas UF indicates which term has been used earlier designating the same particular field. Thus, the UF function admits retrospection, that is, contact with the historical development is maintained.

The descriptors are organized by means of the hierarchical relations BT and NT. The importance of these links is that the information searcher can let the built-in hierarchy guide his search. The possibility of relating different hierarchies is provided by the RT function. There is also a possibility of updating in the sense that additional descriptors may be assigned to the system, depicting the progress of the subject field.

A complex subject field may also be decomposed into as many aspects as possible. One of the oldest philosophical classification systems based on facets is Ranganathan's "tree of knowledge". Five universal facets "Space", "Matter", "Economy", "Time", and "Personality" describe the knowledge of the world. Different disciplines show different facet organizations. Moreover, one and the same discipline may be differently facetted, depending on the classifier's world view. To illustrate the facet principle, it could be elucidative to use the EUDISED'S Multilingual Thesaurus, which has a fully realized albeit crude, facet classification. The examples chosen are the facets "Thesaurus" and "Vocabulary".

Example of Facets: Thesaurus and Vocabulary

Thesaurus	Vocabulary
BT: Reference Material	
RT: Dictionary	RT: Lexicology
Lexicology	Terminology
Semantics	Thesaurus
Terminology	Word
Vocabulary	Word Frequency
	Word List

The EUDISED thesaurus is divided into 20 main facets. One of them is called "Documentation" and consists of two subfacets: "Information, Service" and "Index, Bibliography". Under the second one, eight facets are organized. The second one of these eight facets has 10 subordinated facets of which "Thesaurus" is one. "Thesaurus" is, among other things related to "Vocabulary" as indicated by the alphabetically listed RT terms in the example. The close correspondence between the two facets is obvious although "Thesaurus" is more closely related to "Dictionary" and "Semantics" while "Vocabulary" shows greater relational closure to a "Word" facet. This exemplifies the greater richness of relating terms horizontally compared to vertical relations expressed by hierarchies. To be hierarchically organized, the example given would have to contain NT relations. In spite of the obvious difficulties with an efficient organization of universal classification system, the search for such systems does not seem to cease.

Variability in Intention and Orientation

To analyze the knowledge of the world the concepts of "intention" and "orientation" have to be accounted for. The dividing line to be drawn between the world surrounding a person and the universe of philosophers, mathematicians and computer scientists may be defined as contrast between structure, utilized by an active inquiring agent, and computational complexities, defined and established on the basis of pure logical terms. This observation implies that the expression of intention and orientation inherent in a graphical display or verbal expression has to depict crucial structural qualities of thought in such a way that the active inquiring agent can capture its intention and orientation by extracting invariants, i.e. higher order functions. These are assumed to be shapeless and formless. By making explicit reference to the process of perceiving or conceiving structure as constituent of world knowledge, it is referred neither to pictorial or image-like thought nor to thought that is verbal or symbolic. Instead, the Kantian schema is assumed to be the common basis for object and events to become knowable (Bierschenk, 1984a), because this schema captures their crucial qualities of structure and form.

The concept of structure is used to distinguish generalized patterns from actual but extracted or abstracted relations in which objects and

events are embedded. This use of the concept is essential to a psychological or any other empirical study of expression. Especially in the study of knowledge, expressed through language, it is very easy to find the concept of structure confused with the concepts of form and organization. The same applies to computer science, where purely combinatorial or syntactic approaches blur a clear understanding of what issue is under study. A set of interrelated features may constitute a pattern, a domain or a class or composite, but it does not constitute a structure. Therefore, a set of primitives, logical terms or graphical elements may be sufficient for generating complexity, but definitely insufficient for providing information. Information cannot be defined in pure logical terms as both Shannon and Weaver as well as von Neumann so well knew. In accordance with this view, psychological processes that pick up information are considered distinctly different from mechanical processes implying a composition of a copy, which can be stored, accessed and retrieved from the computer or any other memory. Thus an ecological approach to a psychological study of knowledge management examines its degree of structure through discontinuities and broken symmetries.

Perception and Recall of Semantic Features

The focus is on the instrumental aspect of cognitive structure as expressed by the organization of features. Above all, two problems have to be accentuated. The first one concentrates on the organization of features as expression of knowledge representation, while the second concerns the construction of information systems. Organization, in both cases, presupposes a possible way of formalizing knowledge. The attribute "cognitive" is in the formal sciences very frequently used to label aspects which are not easily expressed by formal definitions. With this in mind, the discussion centers on the central importance of semantic descriptors, a kind of feature analysis and recall.

In a series of four experiments on semantic features as descriptors for pictorial recal, Broadbent, Cooper, and Broadbent (1978) have tried to provide an answer to the question of what kind of organization would be most effective, hierarchies or facets. They constructed a semantically founded test material that were (1) organized in hierarchies, (2) organized in facets, and (3) non-organized in pseudo-matrices. The question to be answered was whether semantic descriptor terms can be fitted into one or the other organization even though they may be less suitable. Here, it is assumed that a descriptor term can be fitted into an existing organization. But this would require considerable processing time at the same time as such an effort would lead to "retrieval" error. The experimental results showed that words that have been incorporated into a certain organization in which they were given the function of being cue words do not provide any advantage to retrieval compared to words whose semantic content is not judged to fit into the given organization. The reason is that semantic content does not positively effect the retrieval process. Instead, it is

effected by the goodness of fit of the organization. Semantic feature effects are assumed to differentiate with respect to what organizing principle is being tested. For example, hierarchically organized terms are overdetermined (16 classes in the experiment result in 30 terms, whereas a facet organization requires only 8 terms). The principle result of the experimental outcome is that no significant difference between hierarchy and facet can be demonstrated. This may be due to the fact that the exemplifications used are processed as sets and not as single terms. The main result is, that neither principle is of any advantage compared to the other. This implies that organized knowledge can be better retrieved than non-organized.

The experimental system for information storage and retrieval was used by Broadbent and Broadbent (1978) with the aim to study semantic descriptors for picture recall. The experimental design, consisting of four recall experiments, were based on 100 pictured Christmas presents projected by a slide projector. A number of subjects drawn from Broadbent's Oxford pool were asked to produce a list of descriptors which they found to be most appropriate to the respective picture.

An attempt was made to develop a procedural specification by means of a simulated context. Through the task of indexing presents suitable only for women of a certain age, facts could be described semantically within the standardized framework. Thus, person descriptions were constructed and presented to the experimental subjects. Thereafter, their task was to recall the descriptors by means of which they would be able to retrieve a certain kind of Christmas present. To be sure, storage and retrieval have been associated with the management of facts. However, recognition and recall have been linked to the context dimension intended to impose meaning on the facts.

On the average three descriptors were used in describing a picture, i.e. a fact. Furthermore, when the subjects were told to use a descriptor term list produced by others, more than three terms from this list were used. Moreover, changing the artificially produced context would also result in the use of a larger number of terms, but each single term occurred less often. Unfortunately, operations like recall transform experience to symbolic representations and thus, blur a clear cut experimental result on the orientation and consequently on the import and use of descriptor terms. The reason is that the classical scientific approach of semantic feature analysis and the assumption of associations of the universals of logic within a universe or standard context will not shed any light on the problem of knowledge.

The operationalization of the system concept by Broadbent and Broadbent (1978) has been made dependent on the composite of a number of associatively related experiments. The dimensional domain incorporated into the design of the experiments is an insufficient measure for satisfying systems condition. Therefore, "system" will be used further on in the sense of an structured arrangement whose constituent parts are

not regarded as separate and associatively linked elements but as defined through a coordinative function. It does not matter whether or not demonstrable links exist between single components. A higher order function is the necessary and sufficient condition. Broadbent's definition, however common it may be, cannot be considered sufficient for a scientific study of a person's cognitive orientation toward facts. The concept of a system can be comprehended only as the cooperative interaction of a unity with its environment.

This systems thinking has govern the experimental design of an ecological study on the co-variability of intention and orientation in search for scientific information and development of knowledge. The study will be presented next. Its task has not been to find direct relations but to construct a system based on the hypotheses:

(1) that information structures should be reflected in sequences of events, and
(2) that it is the structure in the events that links information and information searcher.

An Ecological Approach to Scientific Discourse

The ecological approach to studies of human information processing and behaviour is a trend in both cognitive and natural sciences. It stresses the indisputable fact that human cognition develops under a cooperative approach to the environment. In biology (von Frisch, 1967; Monod, 1971; Wolsky & Wolsky, 1976) as well as in psychology (Gibson, 1966, 1979; Piaget, 1978; Werner & Kaplan, 1963) it is demonstrated that a general cooperation of the organism with its environment requires a "teleonomic" notion to express the orientation (Monod, 1971). Making knowledge of the world the outcome of a cooperative process presupposes the ability to transmit the effect of experience to the intentional behaviour of an active inquiring agent rather than to some unrelated characteristics of the organism, for example memory or sight.

To feel or to be informed seems to be connected with security for many people. Moreover, to have access to information is necessary for people if they shall be able to develop structured action plans. The development or presence of information structures should, therefore, be studied and analyzed on the basis of the events in which the object of description is involved rather than on the basis of a number of semantic features. For this reason, it should be studied how a set of linked events describe some action cycles. Furthermore, the event-object involvement ought to be analyzed into "textures", i.e. relations which manifest themselves as strands lying in the context. To identify an information structure the research method should make possible a depiction of the event sequence of an object from the moment when, for example, a scientific document starts circulating among researchers and up to the moment when the object returns to its point of origin.

Experiment

Method

If a conceptual structure is to be studied with respect to the position of certain concepts within it, it becomes possible to elucidate structural change not only in the cognitive structure of a particular human being but also in the transformational change of concept structures within and between subject fields or disciplines. The character of becoming conscious of concepts and to gain knowledge will be illustrated on the basis of an experiment that was carried out at the end of the 70th's (Bierschenk & Bierschenk, 1978, 1979). Its main results are of significance in the present context and shall be used to demonstrate the importance of the Kantian schema for information synthesis. The hypothesis of a schema as primary means for a description and representation of knowledge was first utilized by Kant to label some cognitive mechanism, which he postulated necessary as mediator between such cognitive functions as categories on one hand and sensory input on the other. Consequently, Kant labelled the product of a schematization process "imagination" (i.e. "Einbildungskraft"). For the brain to build up a concept, it may be necessary to postulate this a priori principle. The phenomenon referred to by the Kantian schema is the sensuous and/or symbolic representation of things to which space and time especially belong (Bierschenk, 1981; Caramelli, 1987).

The way in which various groups of researchers communicate with their peer researchers within the framework of a system for communicating scientific information will be made explicit by means of a differential analysis. The systemic nature of the schema is expressed by the AaO formula (Bierschenk, 1984a). It will be used to formalize the peer researcher as inquiring agent in the Kantian sense:

Peer researcher	A(1)
observes	a
Aa(O)	O
that	
Peer researcher	A(2)
circulates	a
document	O

The dummy (O) symbolizes an event, which incorporates an agent and an object. In this case it is a scientific document which is circulated by a peer researcher. The relation between the two agents is asymmetrical in the sense that A(2) uses his familiarity with a particular subject field and awareness of the scientific interests of his peer researchers to give the chain of circulation a certain duration, length and direction. An activity such as putting new names on the circulation list or deleting and adding

descriptor words or delaying or speeding up the circulation time are expressions of intention. These are transformed by the AaO formula, i.e. the document is transformed into a scientific expression.

In the sense that for A(1) an unknown abstraction of a document becomes known through the circulation of the fellow researcher A(2) it can be argued that "knowing together", i.e. consciousness, has emerged. As is indicated by the AaO formula, recursive actions are identified by the behavioural outcomes marked on the circulation list. Through the circulation events, which have as their consequence the repetition of acts like addressing and specifying, the schematism in the researchers information search behaviour can be discovered and structural and ecological invariants can be extracted without the need of anticipating an representation of thought or a memory. The fundamental assumption behind the experimental task is that a description of objects and events puts invariants of form and structure into pictorial as well as symbolic expressions. The schema is the basic steering and control mechanism in the development of the researcher's behavioural and cognitive abilities, because the preservation of the schema of an action is expressed by the "quality in the action". The transformation of the action schema constitutes the basis for the extraction and abstraction of invariants and consequently, for the constituent structure of a knowledge organization. It follows that the function of the schema should be observable in the development of knowledge.

Subjects

Thirty-six subjects participated in the experiment. The experimental aim and design was concealed for the participants. Instead, their information search activities were organized as part of a project on the development of a local information system (Bierschenk & Bierschenk, 1978). All participating subjects were at the time of the experiment on the pay role list of the Department of Educational and Psychological Research, Malmö School of Education. Moreover, all subjects belonged to a population of 126 researchers affiliated with the then 13 Departments of Education at Universities and Schools of Education in Sweden. This population was defined in 1972 (see Bierschenk, 1974, 1979). What consequences a particular affiliation may have were in 1979 studied on the basis of a random sample of 40 researchers. The variance analytic test variable of the following three measurements is given in Table 1:

(1) the researcher's contribution to knowledge development, defined as $V = \text{Sum } e_i / \text{Sum } t_i$, where e is the number of published works and t is the number of time periods after the first published work.

(2) acquired knowledge by the researcher, defined as R = Sum p_j/ Sum t_j, where p is the number of cited references.

(3) the researcher's accessible knowledge, defined as K = Sum r_t x v_t / t.

The expression (3) assumes that the researcher's ability to digest other researchers work and his ability to contribute to knowledge development varies during different time periods. Therefore, accessible knowledge is expressed as a mean value of time. The test variable H of the Kruskal-Wallis variance analysis is chi-square distributed. If the calculated value does not exceed a certain criteria

Table 1.
Kruskal-Wallis Variance Analysis of Institutional Affiliation

Measurement	H
Contribution to Knowledge Development	6.21
Acquired Knowledge by Researcher	8.36
Researcher's accessible Knowledge	4.99

(with df = K - 1) it can be concluded that the zero hypothesis has to be accepted. A variance analytic test of the effect of departmental affiliation on the single researcher shows at the chosen significance level (5%) that all values of the measuring variables are below the chi-square value of 12.59. In conclusion, it can be stated that the departmental context is of subordinate import in favour of the individual aspect of knowledge contribution to the scientific discourse. Thus, the same kind of results may be expected if the study would be carried out in other departments.

Materials

About One Thousand and Five Hundred documents were circulated during the academic year 1977/78. At the time of arrival every incoming document was specified by person-descriptor-document multiples and circulated together with a clustered circulation list. All responses during circulation were registered as items and commented on at the time of the document's return to its point of origin.

Design and Procedure

The AaO formula imposes a constitutive function on the context of scientific discourse. This constitutive function has a research department or laboratory, whose single and independent working research groups provide excellent experimental conditions for studying variability in

intention and orientation. Thus, the department has been defined as an experimental set-up of persons, who intend to do research. Their orientation was defined as the extent to which they were able to specify and denote concepts and areas of study.

Procedurally, the experimental subjects were at the end of the academic year 1976 asked to list as many descriptors they wished in describing their research activities. On the basis of this collection the subjects were clustered into the following six groups:

(1) School Environment and Learning Climate
(2) Social Development and Internationalization
(3) Language Development and Language Education
(4) Adult Education and Vocational Education
(5) Communication and Information Processing
(6) Research Organizations and Research Information

The routines for cyclic sorting were developed with the purpose to describe both documents and groups structurally in order to meet the single subject's areas of interest. Moreover, the profiles of the subjects were aimed at providing for a differentiated information supply to facilitate progressive growth. This transformative function was carried out by a peer researcher, who supervised the systematic sorting and structuring during this one-year experiment.

The principle of a higher order function was realized by means of the linkage of Person-Descriptor-Document Multiples. Briefly, this principle were operationalized in the following way: (1) Interest groups were kept constant during the first cycle and the description of the documents were restructured to better fit the groups. The aim was to bring close together what has relevance for the respective group. (2) In the next cycle, the documents are kept constant and the groups are restructured. For that purpose, a bonded Descriptor-Person register was set up, and continually updated.

After one year of circulation, a second collection of descriptors was established for the purpose of controlling the extent to which a differentiation of concepts had taken place. The variance-invariance relations with respect to (1) interest groups and (2) descriptor profiles were expected to indicate growth of knowledge. Differently expressed, the expected experimental result would confirm that the single researcher is in the position to know what kind of information he does not want. Thus, the following hypothesis was tested:

Increased conceptual demarcation increases the researcher's ability to exclude less relevant information.

Because procedural and statistical results have been reported in Bierschenk and Bierschenk (1979) it may be sufficient to give an illustrative account of the conceptual development that has taken place.

Results

In the development toward a high degree of structuring the use of precise concept descriptions and well-defined relations between concepts is unavoidable. It cannot be assumed that these exist from the beginning, so one main purpose with the experiment was to create just those concept relations. The characteristic higher order function of the experiment served the continuous differentiation and cyclic control over the development of appropriate concepts. Because of the experimental control of "self-regulation" it was possible to study their intention through their cognitive mobility. Intentionality was studied by means of the single researcher's definition and redefinition regarding his affiliation with a particular group. The Markov chain processing (Tab. 2)

Table 2.
Transition Probabilities for Observed Transitions from Group to Group

	Fall 1977						Spring 1978					
Group	1	2	3	4	5	6	1	2	3	4	5	6
1	96	01	00	01	01	01	95	02	01	03	00	00
2	10	82	00	00	06	01	11	78	02	03	04	02
3	04	07	87	01	01	01	04	04	86	01	01	03
4	02	00	00	97	00	00	00	01	00	96	02	00
5	04	09	00	00	85	02	00	09	00	00	91	00
6	01	03	04	00	01	90	00	01	07	00	00	92

shows that the groups remained invariant. On the whole, the six groups may therefore be considered as independent samples of one and the same population, i.e. distinct subgroups within the department studied.

A similarity judgment were made between the descriptor collections of 1976 and 1978. It resulted in a protocol of similarities. To avoid any trouble with the definition of similarity (form, content, subject, etc.) the words were judged similar if they were written in exactly the same way, with the exception of inflected forms plus a few characters which may be permitted even in a computer-based pattern match of letter strings. The concept development of Group 6 may be illustrative for this procedure:

Invariant Descriptors	*Descriptors dropped*
Computer-based I&D-system	Bibliography
Computer-based Content Analysis	Documentation
Information Retrieval	Research Organization

Descriptors added
Research Policy
Information and Documentation
Linguistics in Information Search
R&D Evaluation

The trend reflected by this group is significant for all other groups. Termini related to the communication and control of information within

Table 3.
The Variance-Invariance Relation of Descriptors for Six Research Groups during the Time Period of Fall 1976 and Spring 1978

Group	Descriptor Invariant 1	Dropped 2	Added 3
1	7	25	48
	8.46	*27.44*	*44.10*
2	6	35	53
	9.94	*32.24*	*51.82*
3	7	18	18
	4.55	*14.75*	*23.71*
4	8	15	16
	4.13	*13.38*	*21.50*
5	2	8	25
	3.70	*12.00*	*19.29*
6	3	6	12
	2.22	*7.20*	*11.58*

the Educational system emerge, while termini with a static import are dropped. Invariant are those terms, that refer to the interface of the man-machine system. A frequency count over the six groups is given in Table 3. By testing the zero hypothesis, namely, that the six groups do not differ in their concept development, it turned out that the chi-square value of 15.56 with df = 10, is associated with the probability of < .90, i.e. the occurrence of values as large as the observed. The variance-invariance relation of the descriptors apply to one and the same population. The relative development toward new concepts is greater than other noticeable

changes. New concepts emerged through both a greater number of descriptors and a more precise formulation. A fairly small number was changed or had disappeared.

For example, the descriptor *Socialization* was very popular for conceptual demarcation in 1976. After having been acquainted with all documents indexed with this descriptor one researcher became aware that it was extremely wide both in meaning and use. Thus, in the 1978 collection of descriptors, *Socialization* returns but now in more precise formulation *Socialization Process in the Family*. The new descriptor indicates that the conceptual focus is on a study of the process itself and, further, restricted to the context of families and not on social environments. A further example of concept development is the following: *Disturbed Children* is the general problem area within Group 1. In 1978 a restructuring had taken place and was described through *Children with Special Needs*. This change may reflect the researcher's ability to restricting formulations like the example given above. It may also reflect a perspective change in research policy: children are not seen as disturbed any more. They need help, a development which seem to initiate an intentional change of both research method and practice. Group 5 was in 1976 oriented toward Cognitive Psychology, but worked with simulation experiments later on. This internal scientific development was in 1978 marked by the descriptor *Psycho-ecology*. Within Group 4 the researchers described there area in 1976 with the descriptor *Lifelong Education*, but noticed the cognitive trend of 1978 and consequently changed its general descriptor to *Lifelong Learning*. Finally, Group 3 specified its area very narrowly, i e. with project specific descriptors. These would only with difficulty be suitable in a wider information search environment. The researchers dealt with language development with a view on writing abilities. The specification from 1976 were described with *Word Length*, which in 1978 was extended to *Frequency Lists*, i.e. a descriptor denoting a more general kind of language manipulation. Developments like this may very well be a reflection of a conceived need for more general knowledge within an area than just a change in orientation.

Discussion

The ecological approach stands in sharp contrast to the Broadbent and Broadbent (1978) experiment on the organization of facts. Their algorithmization relied on a syntagmatic model for the establishment of semantic features. The experiment demonstrates how syntactic components are taken to be the unquestionable foundation for a propositional representation of knowledge. It is shown how semantic components are used in specifying data base entries. The immediate consequence of constructing data bases as (1) hierarchies or (2) matrices were the expectation of being able to design an error-free, complete, and well-defined cognitive representation that could be explained within the framework of the machinery of logics. It follows, that their experimental

results would demonstrate a cognitive mechanism of a type that would detect "similarity" and establish "boundary conditions". Information processing in this sense means that both explicit and implicit relations are controlled by analytic propositions. Moreover, the foundation of concepts is equated with "logical invariance" (see Bierschenk, 1984b). But informative components emerge only on the basis of the synthetic proposition (Bierschenk, 1984a), i.e. uniqueness can be detected or known information can be transformed only by operations of a schematizing process.

Structured information is created when a communication process results in meaningful information, i.e. information which invites the researcher to change. Change in concept structure and form may be seen as clear indicator of the researcher's ability to understand the scientific language of his discipline and to gain insight into the empirical phenomenon under investigation. Thus, the form taken by a course of events provides a direct link between information and structure.

The Kantian schema was used as the device for establishing relations between events stretching over a series of instances (i.e. "Segmente einer Zeitreihe"). The schema, which on one hand changes with the number of runs in the processing, effects on the other hand the processing itself. Moreover, the cognitive processing of made observations requires that the transformations taking place during the processing preserve the empirical basis.

By making the development of knowledge dependent on the experimental coordination of a cooperative process and the manipulation of structure and form, it was possible to study knowledge as regularity in a constantly changing process. But the regularity in change could be sensibly measured only with reference to a particular researcher's scientific context.

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