Information and Management Systems

By Börje Langefors*)

Summary

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A list of desirable further research items associated with the theme of the paper is presented.

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of it, nota bene. At the same time, the theory pointed to two distinct kinds of limiting factors: The *"executively effective simplification"* (an information-economic principle) and the *"infological equation"*. All three aspects are associated with decision-making but also with management, more generally. Thus information systems theory and theories of management are integrated in a very fundamental way.

Executively Effective Information

The theory of executively effective simplification (1966, 1967) demonstrates that it may be wrong to involve some information in a decision even when it is pertinent, in some rationalistic sense. This may cost more than it pays but it may even reduce the quality of the decision, e.g. by delaying it.

Directive information

"To support the decision may then be effective instead". The observations behind the infological equation clarify that some of the information that is *"objectively relevant"* to a decision, or to an act, may not be *"subjectively relevant"* to the decision-maker and hence useless to him.

External and Internal Properties

The three aspects provide theoretical insights, not only into how to specify and design information systems but, likewise, how to organize and manage. And the two activities must go together. However, the design conclusions to be derived, based on those three aspects, will have to be combined with a fourth aspect offered by analytical systems theory, that of *external vs. internal* properties of systems and subsystems.

External properties are those properties of a system – or any of its subsystems – as a whole, properties that we chose to be interested in. The internal properties are properties of the parts of the system and the interrelations among those parts. The importance of the internal properties lie mainly in the external properties that they give rise to. A system may be seen as a structure of subsystems such that the external properties of the whole system will derive from the external properties of the subsystems, that constitute the subsystems' structure. Thus, from the perspective of the whole system, it is only the external properties of the major subsystems that need be considered. Two subsystems with

equal external properties are equivalent, regardless of differences among their internal properties. An important consequence is that from the point-of-view of the whole, one may leave it to each manager or designer of a subsystem to chose the internal structure and properties as he finds best, as long as the external properties are as requested. (On a deeper analysis one will find that the concept of external properties is just one view of the concept of abstraction, so *basic to mathematics and much other scientific thinking).*

1) The theory of executively effective simplification demonstrates that in non-formalized decision situations it is "executively optimum" to employ "satisficing behavior" (in Simon's sense) (1966, 1967).
2) The theory also demonstrated that directive information will appear in distinct levels with slower variation in levels corresponding to higher management levels. This is analoguous to the levels described by Anthony though it is not restricted to just three levels. (1966, 1967).

Information Systems

Information and Data

There is a lot of confusion, still today, about the relationship between information and data. Sometimes it is said that data are used as a means to convey information and sometimes that "information is data organized so as to be intelligible to people". However, there seems to be general agreement that "to get information" is to "get informed". To become informed is to get to know something. Hence information is knowledge. Data, all data, are intended as means for informing, thus, as knowledge representation. Clearly, if data are to be designed so as to inform, the product of such informing must be identifiable and evaluated. Thus, the study of this product is fundamental to data design.

Information Systems Provide Information

By now, we are in a position to propose that information systems that provide information to people (or to its object system, whatever kind it is) that is, they are systems that inform people. Data systems, then, are

subsystems of information systems. While the study of data systems design may concentrate on technical questions about handling and processing data, by manual or computer processes, the study of information systems must, in additon, study how people (and any object system) may get informed by data, that is, how they may interprete data, but must also consider how the needs or potential usages of information may be identified. This, clearly, means that it becomes necessary to study also the object system, the organization, its structure, its processes and its people.

Computers make New Kinds of Organizations Possible

When computers began to appear, many people recognized that possibilities would arise to much more than before satisfy the needs for information that their organizations had. But, even if this was regarded by some as too optimistic a view, one could, in fact, point to a much braver outlook. Not only might computers satisfy more of the known needs, they would also, possibly, allow the creation of new kinds of organizations and management, with new and much greater needs for information support. Thus computers would challenge the innovativeness of managers and management researchers. Furthermore, IS-theorists would seem to be potentially new companions in the development of management of the future. (This early concept of information systems is closely related to present-day ideas of the "information society".)

Information out of Data

The Infological Equation

Once it has become clarified that data are just signs used to provide knowledge, that is, information, the fundamental question emerges: How can data provide knowledge? What is required in order that certain data convey specific information? Obviously a process is required that takes the data as one of its inputs. We refer to this process as the "information process" or the "interpretation process" *i*. It is equally obvious that the information user, or the process *i*, must have knowledge of the meaning of the words used to form the data as well as of the formation rules by which data terms (or "data items") are

combined into sentences that may carry meaning. Thus, pre-knowledge ,S, of the language on which the data are formed, is a necessity. Furthermore, in order to make use of the information, the user must have some pre-knowledge of the relevant part of reality. This must be part of S, the pre-knowledge and frame of reference. It is also clear that the process (i) takes time. If the time (t) is limited, the amount of information must be restricted accordingly and so must the amount of data.

We may condense the above conclusions into a "conceptual equation", the "infological equation"

I = i (D,S,t)
I = the information conveyed
i = the information process (or interpretation process)
D = the data (or any perceived configuration)
S = the preknowledge or frame reference of the information receiver
t = the time required or available for the process.

Because I is a piece of knowledge, it will become added to S so that after the process i we have S + I. For instance, if the subject would perceive the same data D a second time, he will obtain the information I = i (D,S + I,t).Further t = T (D,S), that is the time required, depends on the data to be interpreted as well as on the pre-knowledge of the receiver.

Insights from the Infological Equation
Although the infological equation is an extremely simple compilation of some rather obvious conclusions, it brings out a number of very important facts. For our purposes, the most important of these may be the insight that to design data so that they inform the intended users appropriately, it is necessary to have knowledge of S, the pre-knowledge/frame-of-reference of the user. This implies:

To design data so that they inform

a. is an extremely problematic undertaking
b. is independent of computer technology
c. as long as no method for documenting the "S" of individuals is known, the participation of the users in designing the data is necessary.

The infological equation, when understood in depth, is a very powerful, conceptual device. Already fairly brief reflection about it raises many of the deep questions that philosophy and human science has presented in lengthy texts.

The symbol D in the infological equation refers to whatever sign-configurations may be presented to the interpreting subject, or to the process i. Thus any language text, spoken as well as written, is a kind of data in our theory. It follows that just as informing by "data" is problematic, and subjective, so is any language communication. Little reflection suffices in order to clarify that it is not the intention of informing, behind the data, that is crucial here. It is, rather, the act of interpreting the observed data that leads to the situation illustrated by the infological equation. Hence, *any* observation of phenomena instantiates the equation and the phenomena appear as instances of data, D in the equation.
It follows, thus, from the infological equation, that all our acquisition of knowledge, be it from (formal) data, from language texts or from observations of reality, will be totally dependent of our (individual) pre-knowledge. This is very close to the central propositions of modern hermeneutics and paradigm dependency theses (Th. Kuhn): A person's conception of (his) reality depends on his pre-knowledge, or his set of paradigms. S. However, direct sensations (e.g. the finger is burnt) are independent of S and this suggests a way to evaluate paradigms.

Design of Data for Specific Information and People
The infological equation makes it clear that to design data D so as to represent the required information I, one must know both I and the S and t available to the users:

D = d (I,S,t) if I and S are compatible;
where d is the data design process.

Thus, distinct users, having the frames-of-reference S_1 and S_2, respectively, will require distinct data D_1 and D_2 respectively. However, it may also be the case that the intended I is incompatible with the S of some

user. Then no data D are feasible to convey the message I to such a subject. Then, however, it may or may not be feasible to provide a larger amount of supplementary data that may extend the knowledge of the user sufficiently. If A is the supplementary knowledge, such that S + A is sufficient, while S is not, for a certain person, then if D_A is a set of data such that $A = i(D_A, S, t)$ then

$$T = i(D + D_A, S, t + t_A)$$

We note that more time is then necessary for the interpretation. This, of course, means losses in efficiency.

People's Primary and Non-primary Language

It also follows from the infological equation that no two persons may be expected to obtain the same information from some data. The best we can hope for is a *satisficing degree* of getting information. This may correspond to a situation where:

A. People use primarily the same terms for approximately similar conceptions from their observational pre-knowledge associated with the message to receive.

"Primarily" here implies that the terms used (in the data) are those that the subject would naturally choose. This condition will most likely be fulfilled among people working together as a group, when the fact informed on is concerned with everyday work phenomena.

The second best might be obtained when

B. People know the terms used, while these would not be their primary terms for the concept.

One might think that the situation B would be equally satisficing. However, the association to the concept may be delayed when a secondary term, rather than a primary, is employed. Furthermore, to the secondary term may be associated a slightly distinct conception. These suspicions seem to be amply confirmed by research on efficiency losses when people have to employ a non-primary language,

even when they speak the secondary language fluently. For instance, they may need 30% more time for communication (and may loose 100% if the communication is not slowed down) (Dornic 1979). The condition B may be expected when people have been taught the language extensively or have participated in the work group fo a length of time.
The third situation may be when:

C. People don't know the language employed for the data (the terms or the concepts).

The "data profession"[*] seems to ignore the problem of B and seem to believe that there are working, technical solutions to C, in terms of, for instance, data directionaries. We shall argue that those means are generally very poor solutions.
It should be noted that to get the information, that is, get to know what fact was observed, only require that a small part of S must be compatible with the observation of the fact and the reporting of it. To make use of the information, once received, requires further pre-knowledge. The latter, however, should be distinct for distinct users of the same information because they are to draw distinct conclusions from the same fact. (Note that on this observation the mathematical "theory of information" breaks down). We have thus noted that to *receive* information, a subject needs *"observational pre-knowledge"* (part of S) relevant to the observed fact and to the data employed. To *make* use of the information he needs relevant *"inferential pre-knowledge"* as other part of his S.

IRM "Information resource Management"

Losses Incurred

The "old" IS-theory ambition to "provide data to everybody", has in the last few years become widely propagated among data processing departments, under the label IRM ("Information Resource Management"). Unfortunately, one has forgotten about the restriction aspects described already in the early IS-theory: The information economic aspect and the infological aspect. Indeed, even the insight that inform-

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ation is a distinct category from data and the important consequences for any "information resource" study, are entirely ignored in IRM.
IRM maintains that a corporate IR-manager will decide the format of all data in the corporation. Thus a central data standard is assumed. One thereby ignores both the information economic and the infological limitations. As a consequence, many data that for economic reasons should only be used in one place, will become unnecessarily standardized. More serious is that practically all data will be in a secondary language – or in still more unfamiliar language – to most people, because the central standard can't be in accordance with the local language. As a consequence, the use of "IRM" will mean that the usage of data will often imply at least the inefficiencies observed in uses of secondary language. In many cases data usage, under IRM, will necessitate the support of auxiliary data, such as dictionaries or help images. This will bring costs and inefficiencies that are too often simply ignored, whereas they may, in fact, be prohibiting to many intended data uses.

Cost incurred by centralized data standards

1. Defining the standard data
2. Defining and designing the auxiliary data D_A (e.g. dictionaries)
3. Supplying the auxiliary data
4. Maintenance of standard and auxiliary data
5. Training

Losses incurred by enforcing central data standard

A. Information losses by language difficulties
B. Delaying decisions and actions by additional interpretation time t_A
C. Loss of information when the admitted time is too short for the slowed-down interpretation
D. Loss of motivation and stress
E. Loss of opportunities for creativity and innovation

Decentralization/Delegation, a Managerial Means for Solving Information Difficulties

Decentralization Guided by Information Systems Theory

As we pointed out, the datalogical attempts at solving the information problems are very poor solutions. Instead the managerial means, decentralization and delegation in a way which eliminates all unneccessary data standardization, appear as very effective. The design of such a structure may be guided by information systems theory concepts such as information economy (executively effective simplification, directive information structuring) and the infological equation (language aspects of data and of organizations) and sytem-analytic concepts such as external/internal properties of subsystems. Thus, information systems theory provides a new explanation of why many decentralization projects have been extremely succesful. It also brings in new factors of decentralization effectiveness and provides guidelines for how to design decentralization.

From the systems theory and information economy it follows that it is efficient to let the decisions on the *internal* activities in a local body be handled internally. The coordination with the other parts of the organization may be guided by small amounts of directive (and reportive) information. The local data may then be kept locally. From the infological equation it then follows that the local-internal data (which may be the major part) can be formulated in the local language. This will eliminate most of the costs and information losses of data standardization. Thus decentralization and delegation of authority of decision-making to local bodies, is a possible solution – the only one – to the problem incurred by data standardization.

Local Language are Efficient

There is an additional advantage in being allowed to use one's own, local working language, over one's familiarity with it. The local language is likely to be much more efficient. As an extreme example consider the advantage of being permitted, in local communication, to say just "Paul", instead of stating full name + address plus something more – or having to use national civic numbers.

Efficient Company Information Structure

The development of company information systems that is to be expected, from the information systems theory, is one where integrated data systems are reduced to handling corporate steering and control information only. The operation data systems instead will be developed and controlled locally. They will be developed much further when they can utilize the efficient local languages. One part of the expanding local data processing development is likely, in this light, to be in terms of personal support systems, serving one or very few persons which allows the use of data languages that are entirely constructed from the primary work language of each user. Design support systems and Decision support systems ("DSS") are examples to illustrate that such a development is already underways.

The major conclusion from the IS-theory that we have discussed, is that it is important both from data handling efficiency and from infological effectiveness point of view, to carefully structure the information process in an organization in such a way that each data set is only transported to and modelled for those who can make economical use of them and can efficiently and correctly interprete them. Thus, as many data as possible should be handled and utilized within local bodies proper to them, as we have already discussed. Furthermore, such data that must be communicated outside of a local unit, should as much as possible be restricted to communication to just that or those other local units that on analysis appear to be appropriate communication partners. In other words, data that are not local ones should when feasible, be restricted to "translocal data" over as few local units as are appropriate. It should be noted that, in this respect, central or other superior management units are among the local units. Thus e.g. the goals and the budget for one division is translocal information between a local unit and central management. After such a careful analysis, only a small part of the information in an organization may come to be defined as enterprise community information and have to suffer all the drawbacks of central standardized data information.

The (info-economic) concept of directive information, which may be renewed much more seldom than the operative information, has an interesting coupling to the infological equation in that it is less sensitive to time delays. Thus the use of translocal or community data is less

harmful when they represent directive information. This is fortunate, for directive information is basically translocal (or community).

Information Support to Individuals

Many important managerial processes cannot be formalized and, hence, cannot be handled over to a computer. Information systems theory emphasizes, however, that information support by computer should be possible also in such cases. In recent years this aspect has aroused much interest. "Decision support systems", DSS, and "expert systems", are terms used by distinct recent "schools".

Vareing Degree of Permanence of Information

The theory of information systems introduced the concept of information with some degree of permanence or slow variation, the so called directive information. Whereas the operative information in a system, typically, has permanent type but a new value on each occurrence (for instance a costumer order for a certain article type), the direction information has permanent type but semi-permanent value (e.g. optimum order quantity). These concepts invite the definition of two more categories: "Permanent type and permanent value" (for example physical/chemical constants) and, respectively, "changing type and value" (as when a totally new situation is perceived). The resulting four categories have interesting relationship to the above discussions, as illuminated by the table. Obviously, these characteristics should be systematically identified and exploited when structuring the information system – as well as the managerial sytem.

Type/value	info. category	communication scope	major user category	Anthony
Perm/perm.	encyclo-pedic	universal	professional	–
perm./semi-perm.	directive info	translocal	strategic managerial	stratetic tactic/manager.
perm./changing	op. info	local	operational	operational
chang./chang.	ad hoc info	strategic creative	strategic top manag.	–

Needs for Research, Theory and Empirics

Although the concepts discussed above were outlined in early information systems theory work, it is merely in the latest years that they have been made actual by the development in practice. Therefore, much theory development and empirical verification remains to be done. It should improve the possibilities for efficient development of management processes and information support for them.

A short list of some desirable research is presented below. The problem areas listed seem to be, all of them, associated with the meeting place of managerial and information processes.

- Developing of theories and empirical research on
  - executively effective info structuring
  - subjectively and objectively relevant information
  - exterenal/internal properties and info of organizational parts

- Clarify the additional aspects to consider when one recognizes that information is knowledge and data are just signs employed to represent information!

- Theories for how one may design new organizations when information technology advances (instead of just designing better info-support to existing organisations).

- The infological equation provides important insights into the design of concrete information systems so as to take into consideration the S of each user. However the theory need to be extended so as to recognize also that the S of a person may suddenly change when some "cue data" are received. Can the IS present relevant cues? Can hermeneutics contribute to such research?

- Empirical studies of the variations of S from one local unit to another and within local units, as well as among the distinct parties involved in translocal communication (e.g. between two levels of management communicating over objectives, budgets, and reports).

- Theories (and empiries) for designing data according to the infological equation, i.e. D = d (I,S,t).

- Is it realistic to expect that the same information can be conveyed to distinct people with distinct frames-of-reference (S) by using distinct data?
  Study concrete cases!

- Evaluate costs and disefficienies caused by enforced use of standard data that require auxiliary data such as dictionaries to be used by the users.

- Evalute losses from enforced use of an alien language!

- Study differences in work procedures in distinct local units, for the same kind of task. Study also the corresponding differences in S and the appropriate data support for each work procedure!

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