Information, Human Activity and the Nature of Relevant Theories

C. J. TULLY
Department of Computer Science, University of York, Heslington, York Y01 5DD

This paper discusses the need for a sound and effective theory about information and human activity, to underpin research, teaching and practice in information systems. It tries to undertake a preliminary clearing of the present conceptual jungle. Definitions are offered of some formal concepts; contributory areas of theory are identified; and the dimensions of the required theory are suggested.

1. INTRODUCTION

Computers have always acted as catalysts of formalisation. To delegate human activities to the computer we must first formalise them; to a considerable extent we must formalise those human activities which use the computer; under the pressure of the software crisis, we have developed a number of useful formal theories about languages, information representations, and programs. Such efforts, however, have been largely fragmented: there has been little discourse between mainstream computer scientists, database theorists, AI theorists, organisational theorists, systems developers (who are builders of theories about individual organisations), communications engineers, and so on. A general theory of information, and of its relationship to human knowledge and activity, would help us to relate these theoretical fragments and to judge their worth; but no such coherent theory has emerged. It is not only the computing community, with its practical interest in information as the raw material of systems, that is deficient in this regard, however: you might expect two millenia of philosophy or a century of psychology to have produced something useful in this field, but you will largely look in vain.

Words like 'information', 'knowledge', 'language' and 'meaning' are in common use in everyday discourse, where (as must be the case) we use them freely and without careful attention to precise meanings. In the same way, we freely use words like 'pressure', 'resistance' or 'schizophrenia', knowing they have precise meanings in the specialist fields of discourse of science and engineering, or of psychology and medicine, but not worrying too much about that. Computer scientists and information engineers, therefore, desperately needing precisely defined fundamental concepts, should not resort to the empty excuse that the words they obviously need to use are fuzzy and ill-defined in everyday discourse. (On the other hand, they should not be naive enough to suppose that the concepts with which they deal are all going to be capable of crystal-clear and undisputed definition: scholarship must negotiate with pragmatism.)

In making a few proposals and observations about a theory of information, this paper is brief by requirement and provocative by intention. The enterprise outlined here may be thought of as the definition of a conceptual schema for the domains of information and human activity – general and fundamental domains indeed. Within them, what are the significant entity types, relationship types and attributes, and what notations may best serve to describe these things? Such a prospectus may reassure some (those who are suspicious of philosophical waffle) and alarm others (those who see in it an ambition to capture truth in first-order logic: they should fear not, however – Wittgenstein's admission of defeat is conclusive for this author). The purpose is a commonsense degree of formalisation, which will assist clarity of thought and argument and provide a basis on which effective science and engineering can be founded.

2. INFORMATION

We start from a preliminary distinction between the realms of the objective and of the subjective. The objective realm is the source of sense data, that which we perceive and is external to us; it comprises physical processes (some of which we may sometimes conveniently regard as entities). The subjective realm is the recipient of sense data, that which perceives and is internal to us; it comprises mental processes (some of which we may sometimes conveniently regard as memories). Even this preliminary distinction is fraught with problems and the risk of dissension, and could be expanded into at least a chapter of a book; but that will be true of almost every definitional step we attempt, and it is a measure of the difficulty of the undertaking and of the importance of attempting it.

Note that, for purposes of brevity and precision, both realms are defined in terms of processes – which is merely to recognise that nothing is permanent, everything is in a state of change however slow. It would be silly and tiresome, however, to conduct our whole discussion in those precise terms; so we shall allow ourselves, in particular, to refer when appropriate to entities as usefully recognisable states of the objective realm.

It might be thought that all phenomena can be accommodated within those two disjoint realms, with our sensor and effector organs acting as the interfaces between them; and there is a level of analysis at which that would be the case. We cannot begin to give a satisfactory account of human activity, however, without introducing information (toward a definition of which we are slowly moving), the concept of which embodies a crucial and special relationship between the two realms. The nature of this special relationship was recognised by Karl Popper, for whom World 1 (the objective realm) and World 2 (the subjective realm) were inadequate and had to be completed with World 3 (closely related to the idea of information put forward in this paper).

With that preamble, here are four fundamental proposed definitions.

SYMBOL An entity (ie a state of the objective realm) which is intended, either alone or in combination with other symbols, (a) to relate a state in either realm to a state of the subjective realm, (b) to relate sender(s) to recipient(s). Symbols have the recursive (or systemic) property of combining to form larger-scale symbols.

This is a difficult definition, which demands a lot of explanation, for which space is not available. It is intended as a technical definition, not one which would serve for all uses of the word in common discourse. The term 'symbol' has been preferred to either 'sign' or 'signal', for reasons which again there is no space to outline here.

MEANING The perception of some part of the objective or subjective realm, embodied in symbols by their sender, and/or effected by symbols in their recipient.

LANGUAGE A set of conventions which are used to assign meanings to symbols and vice-versa.

INFORMATION That which is constructed from symbols, using language, to convey meaning.

Those four definitions constitute a coherent system: make a non-trivial change to any one, and the others will have to be changed. As a system, they are roughly consistent with the positions of Popper (as already indicated), Peirce, Polanyi, Shannon and Stamper (though, as we shall note in a moment, there is an inconsistency with one part of Stamper's position).

Before embarking on any discussion, it is convenient to add definitions for two other terms which are related to information but distinct from it.

KNOWLEDGE That which is contained in the subjective realm.

DATA Information in a form suitable for handling by a specified process or activity.

This definition is deliberately at variance with many currently to be found, which nonsensically claim (for instance) that data has no meaning.

DISCUSSION

(1) It is not clear from the definitions alone how far we can take the recursive property of symbols. In what circumstances can a collection of symbols be itself regarded as a single symbol? Can all sentences, for instance, be regarded as symbols? The sentence 'It is snowing' can usefully be regarded in itself as a single symbol. A sentence such as the one you are now reading, on the other hand, is probably too complicated (semantically more than syntactically) to be usefully regarded as a single symbol. On a larger scale, however, a complete book is often a single, if complex, symbol: 'Lady Chatterley's lover' is an excellent example.

(2) The definitions allow for atomic symbols, in the case of natural language, to be individual characters. Individual characters often themselves carry meaning, but more often only carry meaning in combination with other characters. The definitions, however, are by no means confined to natural language, and are intended to cover all conventions by which we communicate. In some cases it may prove difficult to sustain the definitions – in the language of music, for example, meaning is a difficult notion, and it is hard to know what the atomic symbols are in the language of painting; but I hope the definitions are robust enough to stand as a working hypothesis.

(3) Whereas, as we have seen, not any collection of symbols can be regarded as a higher-level symbol, any collection of symbols constitutes information. Very roughly (and a moment's thought will reveal where the analogy breaks down) information is to symbols as matter is to molecules.

(4) According to private communications, Stamper appears to take the position that any entity is automatically a symbol of itself. For instance, the existence (or the observation?) of ten green bottles hanging on the wall constitutes information that ten green bottles are hanging on the wall. I take this to be (a) consistent with much everyday usage of the word information, (b) inconsistent with Peirce's semiotics (on which a great deal of Stamper's work is based), (c) not useful. The definitions given here are certainly not intended to support that position – though equally they are intended to allow the possibility that in agreed circumstances entities may stand as symbols of themselves. The position I take about the bottles is that their observation in normal circumstances constitutes sense data, which may or may not contribute to an individual's knowledge; but that green bottles are not conventional symbols and will only constitute information if they have been deliberately assigned symbolic status.

(5) The definitions clash loudly with most of the prevailing wisdom on these issues. Arnold and Hope, in their excellent book on management accounting, express that wisdom with remarkable clarity.

"We need ... to draw a distinction between data and information. The two words do not mean the same thing, though they are often used synonymously. The Oxford English Dictionary defines data, the plural of datum, as 'facts of any kind'. We cannot define information in such a broad way. Information has a more particular meaning. It is a subset of data. An item of data is usually classed as information only if it changes the expectations of the person receiving it, or, more specifically, if it changes the probabilities which the receiver attaches to future events or outcomes. For example, suppose that a traveller is told that the 8.12 am train from Manchester to London will leave at 8.12 am, and that, before receiving this message, the traveller fully expected the train to leave on time. This statement possesses no information content, as it does not change the traveller's expectations about the train's departure time."

Again, there is not space to embark on the lengthy discussion which that passage would easily sustain. Only two brief comments can be made. (a) The definition of information implicit in the above passage is drawn from an entirely subjective stance: the same message counts as information for one person but not for another. There is nothing wrong with the subjective view; but we need a word which can be used from an objective stance, to denote the substance of messages irrespective of how their recipients judge them. In my view, an objectively-based

definition is more useful. Using it, there is much less doubt about what is information and what is not; using it, the subjective properties of a given piece of information become (to use database terminology) attributes of the relationship between that piece of information and a specific individual or group. In other words, the objectively-based definition can accommodate subjective views of information (which are necessary) but not vice-versa. (b) The view implicit in the above passage, and made explicit by many writers, that a collection of symbols may only count as information if it removes uncertainty in the mind of its recipient(s) is based on a fundamental misinterpretation of Shannon's statistical communication theory, which is concerned with the amount of objective (statistical) uncertainty about the next symbol(s) in a symbol string.

(6) It follows from the definitions that what counts as information in the domain of human activity does not count as information to any machine which may handle it (such as a thermostat or a computer). The reason is that information can only be defined by reference to the subjective realm, and a machine has no subjective realm. Put another way, a complete account of a computer can be given in terms of matter and energy – the laws of physics; at least for most people, a complete account of the functioning of information in the domain of human activity cannot be reduced to those terms. (This observation will offend almost everyone: the artificial intelligentsia,the determinists, and good pragmatic engineers who will accuse me of wasting time with theological niceties.)

(7) Those of us who are not members of the strong AI school should be clear that, when we use a term like IKBS, we are using a different meaning of the word knowledge. It is again, like the meaning offered above, a 'technical' meaning, but different – and it is essential for language to be able to sustain different meanings for the same word, both in everyday and in specialist discourse. Sometimes, however, it may be necessary for us to recognise the difference by attaching a distinguishing marker to indicate the separate meaning (like 'knowledge*'). The same comment applies to a word like intelligence.

3. HUMAN ACTIVITY

Information and human activity are inextricable. A great deal of human activity (about 50% of economic activity in advanced countries) is concerned primarily with information; and information is essential to render human activity effective. Useful theories of human activity, however, are even thinner on the ground and harder to contemplate than theories of information. The systems approach seems indispensable, and Checkland's taxonomy of natural, designed and human activity systems seems an appropriate framework within which to start. But where then to go? The praxiology of philosophers seems arid; and here are some comments by Keen on other approaches which are better known to most of us.

"Applied fields concerned with effectiveness in organisations have often relied on incomplete, untestable or even invalid frameworks. For example, the Gorry-Morton 'model' of structured, semi-structured and unstructured tasks which played a key role in launching the decision support systems movement is simply wrong. It treats structure as an inherent component of the task itself, but any task can be made structured or unstructured by redefining the goal or social context.... Anthony's classification of organisational processes into three hierarchical layers – strategic planning, management control and operational control – is untestable. Simon's model of intelligence-design-choice is far too closed a view of problem-solving to capture actual behaviour either descriptively or prescriptively".

If anything, the terminological morass surrounding human activity is deeper and more gluey than the one surrounding information; and I do not have a candidate set of preliminary definitions. The requirements are the same as before – to establish limited and clear meanings for a necessary and sufficient set of words, which we can use with those meanings when we are involved in 'technical' discourse. The following is a rather arbitrary list of some of the words which we should be considering.

activity	objective
alternative	operation
analysis	organisation
choice	plan
control	procedure
decision	process
design	project
estimate	purpose
evaluation	requirement
goal	role
management	rule
monitor	specification
	task
	verification

When trying to bring order to the field of information, we find Shannon's theory, though incomplete and mechanistic, an invaluable starting point; and we know that anything we propose must include that theory as a subset and not be incompatible with it. Similarly, in considering the field of human activity, we should take careful account of available work in control theory and cybernetics. Of course it is inadequate in itself; but it offers a basic model of regulation and feedback (comparable to Shannon's model of channels and noise) which seems to cry out for adaptation and incorporation into a broad theory of human activity. (The precedents, however, are not encouraging: Forrester's system dynamics went too far in the mechanistic direction, and Beer went too far in the mystical direction.)

A third area of formalism which we must take seriously into account is that of the formal logics. Again, it would be a mistake to assume (as the IKBS community have largely done) that these can be readily applied to the realm of human activity; but, since much of that activity involves rules, inferences, etc, we should not discard an area of theory that deals with those things, even though at present its practical applicability is to designed systems more than to human activity systems. It is encouraging that Ronald Stamper's current work is primarily in this field.

4. THE NATURE OF RELEVANT THEORIES

The kind of undertaking outlined in the preceding sections can be seen as establishing a necessary and sufficient framework within which existing components of theory from a variety of disciplines can be fitted (after adaptation if necessary). Some of these components will undoubtedly overlap and conflict, and those conflicts will need resolution; equally it will become apparent that there are gaps, which will need to be filled by new theoretical components. If the framework is good, however, the identification and removal of the overlaps and gaps will be made much easier than if the task were to be approached in an unsystematic and uncontrolled way. It is easy to dismiss the kind of scholarship that will be demanded in such an undertaking; if well done, however, it will pay great dividends in terms of the quality of the subsequent research, teaching and practice founded upon it.

The following is a list (again partial) of disciplines which are likely to have useful theory to contribute.

accountancy	mathematics
computer science	operational research
cybernetics	organisational studies
economics	philosophy
electronics	politics
'information theory'	psychology
law	sociology
library science	statistics
linguistics	systems theory

The task then is to draw as fully as possible upon relevant work in those disciplines so as to construct a coherent and useful theory of information, human activity, information systems and human activity systems. The following are some of the questions that such a theory should answer (with, in some cases, some brief notes).

What is the domain of possible values for the ways in which we may perceive or judge a piece of information?

Eg purpose, effect, subject matter, usefulness, comprehensibilty, credibility, structure, meaning, tone, accuracy, logical consistency, language/code, cost value, sender, intended recipient(s), formal access rights, legal status error level ('noise'), carrier medium, resource utilisation.

The categories of conventional semiotics (pragmatics, semantics, syntactics, and – if you follow Stamper – empirics) are far too broad.

The degree of formality with which we can talk about a piece of information will vary among the above categories, and between one piece of information and another.

Each of the above categories generates a number of specific questions associated with it, one or two examples of which follow.

What is the domain of possible values for the level of formality of a piece of information or of a language?

Eg informal/natural; formal; executable.

What is the domain of possible values for the structure of a piece of information?

Eg character string, table, array, formula. list, program, tree, diagram, picture, phoneme string. This is a generalisation of the concept of abstract data types to the field of human activity systems. Each of the above major types is likely to be divisible into subtypes (eg there are a number of established, or formal, types of diagrams, each with its own 'syntax'); and sets of operations can be associated with each.

What is the relationship between 'machine semantics' as developed by computer scientists and the meaning of a piece of information to a human being; in particular, what is the difference in the ways in which we describe meaning in the two cases?

What are the processes by which we attach credibility to a piece of information? What are the kinds of credibility?

Can we do better than the rather arid efforts of the economists and others (eg in quantitative decision theory) at finding ways of attaching costs and values (estimated and actual) to pieces of information?

What is the domain of possible values of the ways in which we may perceive or judge a human activity?

This question would lead to a list similar to the earlier one about pieces of information, and then to a similar set of subsidiary questions.

How orthogonal are the categories suggested for pieces of information and for human activities?

What are the ways in which pieces of information interact with human activities?

What types of information system can be identified? What are the component types which make up an information system?

What types of human activity system can be identified? What are the component types which make up a human activity system?

What (if any) are the special characteristics of those human activity systems which are concerned with the development and evolution of information systems? In particular, can we find an agreed account of the relationship between (for instance) specification, design and verification? How useful is Langefors' theory of system design?

It is appropriate that this paper should end abruptly in a sea of questions.

REFERENCES

1. J. Arnold and A. Hope, *Accounting for management decisions*, Prentice-Hall (1983).
2. S. Beer, *The heart of enterprise*, Wiley (1979).
3. P. Checkland, *Systems thinking, systems practice*, Wiley (1981).
4. D.S. Jones, *Elementary information theory*, Oxford U P (1979).
5. P. Keen, MIS research: current status, trends and needs, paper given at the *First Annual Conference of the Information Systems Association*, Sunningdale, UK, (Dec 1984).
6. B. Langefors, *Theoretical analysis of information systems* (4th edition), Studentlitteratur (1973).
7. B. Magee, *Popper*, Fontana/Collins (1973).
8. M. Polanyi, *Personal knowledge*.
9. N. Roberts and others, *Introduction to computer simulation: the system dynamics approach*, Addison-Wesley (1983).
10. R. K. Stamper, *Information in business and administrative systems*, Batsford (1973).