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Towards a Social, Ethical Theory of Information[1]

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Abstract: We seek to take some initial steps towards a theory of information that is adequate for understanding and designing systems that process information, i.e., information systems in a broad sense. Formal representations of information are needed in designing, using and maintaining such systems, especially when they are computer based. However, it is also necessary to take account of social context, including how information is produced and used, not merely how it is represented; that is, we need a *social* theory of information. Ideas from ethnomethodology and semiotics, as well as logic and the sociology of science, are used to explore the nature of information. Ethnomethodology also provides guidelines for collecting high quality information on which to base design, especially in situations where interaction is important. In addition, some case studies and some ideas on how to combine methods are presented. We argue that, as a result of its social situatedness, information has an intrinsic ethical dimension, and that this may have some wider implications.

1 Introduction

It is said that we live in an "Age of Information," but it is an open scandal that there is no theory, nor even definition, of information that is both broad and precise enough to make such an assertion meaningful[2]. In particular, such a theory should help us understand and design information systems, in a wide sense that includes computer-based systems, as well as systems that are paper-based, conversation-based, graphics-based, etc., and combinations of these. Any system that interacts meaningfully with humans can be seen as an information system in this sense; in particular, business corporations and government agencies may be included. However, a major motivating example is Information Systems in the narrow sense, i.e., computer-based systems for storing and retrieving information, e.g., database systems; capitalization will be used to distinguish Information Systems in this narrow sense from the general concept.

The need for such a theory is pressing. Society demands ever larger and more complex systems. For example, billions are spent each year on software, but many systems that are built are never used, and at least one third of systems begun are abandoned before completion. Moreover, many systems once thought adequate no longer are. Some sobering examples are given in [14], including the disastrous baggage handling system at the new Denver International Airport; [14] concludes

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[2]Perhaps none is possible. Bowker [7] discusses mythologies that support the notion of information, Schiller [55] discusses the importance of information as "commodity" in postindustrial society, and Haraway [26] gives a daring modern cyborg myth; Bowker's discussion of Babbage's mythology [2] is especially interesting. Agre [1] argues that the notion of information is itself a myth, mobilized to support certain institutions, such as libararies.

that "despite 50 years of progress, the software industry remains years — perhaps decades — short of the mature engineering discipline needed to meet the demands of an information-age society." Since that paper was written, a major computer company has defaulted on an 8 billion dollar contract to build the next generation U.S. air traffic control system. In many such cases, problems with requirements, that is, customer needs, have been implicated as a major source of difficulty. See [16, 18, 22] for discussions of the importance of requirements in developing systems, and of social factors in requirements.

An adequate theory of information would have to take account of social context, including how information is produced and used, rather than merely how it is represented; that is, it must be a *social* theory of information, not merely a theory of representation. On the other hand, the formal aspects of information are inherent to technical systems; computers *are* engines for storing, processing and retrieving formal representations. Thus the essence of designing such systems is the *reconciliation* of their social and technical aspects [16], respectively called the *dry* and the *wet* in [15]. Indeed, we argue that all information is grounded in these dual aspects; Section 3.5 argues further that information has an ethical dimension that cannot be separated from these aspects.

We draw on several different approaches to sociology, as well as on ideas from logic and semiotics; in this sense, it is "post-modern." Nevertheless, it has a goal: to help make the analysis, design and construction of information systems more responsive to users and to social context. If it does not serve this purpose, then perhaps it will at least raise doubts and questions about how system development is usually organized at present.

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1.1 Requirements for a Theory of Information

Before suggesting an approach to information, it may help to present our criteria for success:

1. A theory of information should be useful for understanding and designing information systems, and in particular, Information Systems in the narrow sense.

2. It should address the *meanings* that users give to events, in a broad sense that includes social and political nuances. This is needed because design decisions about information systems have profound implications for how work is done in organizations, and this is something that users of such systems care about very deeply.

3. It must address ethical issues, including but not limited to the privacy of information. These too are important to the members of organizations, as well as to society as a whole, and can strongly impact the success of information systems.

4. It must take account of the fact that different individuals and groups can construe meanings in very different ways. For this purpose, and in order to achieve accuracy, it seems important to have a theory that is strongly empirically based, in two different senses:

(a) the analyst does not enter into a social context with pre-given categories, that are assumed to be relevant to the analysis (such as rank or status);
(b) the analyst leaves a social context with "hard data," such as videotapes, that document social interaction and can later be used as a basis for design through discussions with other analysts.

It follows that a suitable theory of information must be a *social theory of information*, rather than a *statistical theory of information*, like Shannon's theory [56], or a *representational theory of information*, like the situation theory of Barwise and Perry [3]. In fact, a theory of the kind we need cannot be "objectivist" or "realist," in the sense of assuming a pre-given distinction between subject and object, and an objectively given real world. Thus, traditional semiotics is not adequate as a foundation, because it assumes that signs represent things in a real, objective world; we need a social semiotics, rather than a logical semiotics. Although we do use the notion of sign system in our formulation of information, it is in the sense of what Section 3.2 calls a (members') category system, rather than a pre-given system of distinctions. Finally, knowledge representation, in the sense of artificial intelligence, is another objectivist, realist, reductionist theory that cannot meet our needs.

2 Formalization and Information

After some preliminary concepts, this section suggests a definition of information and explores some of its consequences; some ideas from the sociology of science are used.

2.1 Member, Analyst and Designer

Our discussion will proceed more clearly if we first distinguish certain rôles. The basic concept for this purpose is that of a *member* of a social group[3]; in particular, we will need to distinguish the members of group(s) of (potential) users of some information system. The words "designer" and "analyst" will refer to an individual or group engaged in understanding and designing information systems; the term "requirements engineer" is also used in computer science.

Distinguishing the activities of members from those of analysts can be very helpful in clarifying the status of various objects and events that arise during design. Analysts form groups that have their own distinct cultures, and it is necessary to evaluate their actions from this perspective. Nevertheless, analysts can benefit from knowing the methods and categories of members, particularly when they want to understand things that members regularly and ordinarily do themselves. Note that analysts can use categories and methods that members of the group they are studying do not use. For example, analysts of an Information System may consider statistical measures of response time that would be incomprehensible to most users of the system. Our approach to information should not be so dogmatic as to exclude such technical methods.

2.2 Formalization and Metalanguage

Every formalization requires a distinction between an *object* level, for that which is formalized, and a *meta* level, which provides a language for expressing the formalization. The object level models the world of members, while the meta level provides the language of the analysts who do the modeling. The metalanguage may contain technical terms and rules that members would not understand. The distinction between the object and meta levels of description is parallel to the distinction between the member and analyst cultures. Note that the interpretation of

[3] We return to the issues of member and group in Section 3.2 where we discuss ethnomethodology.

analysts' technical terms into the social world is an essential part of a formalization; in general, this cannot itself be formalized, and instead is a tacit part of the analysts' culture. It is also worth emphasizing the obvious point that a *model* of the object level is necessarily situated at the meta level, rather than the object level; it is an analysts' construction.

Perhaps researchers in the social and literary sciences have been more reluctant to use formalization than they should be, because of their deep understanding of the limits of formalization (see Section 2.5). I hope that this work might encourage a wider appreciation of the fact that using a formal language loosely can still be very successful. Indeed, since any use of a formalization must always be somewhat loose, the essential problem is to avoid claiming more (or less) than is justified by the match between the formalization and the domain of interest.

2.3 Information

I suggest the following as a working definition:

> *An item of information is an interpretation of a configuration of signs for which members of some social group are accountable.*

Signs, in the sense of semiotics, do not necessarily have significance, and "mere signs," i.e., "marks," have no significance. However, this is only a theoretical possibility, because the very notion of sign presupposes a category system (e.g., a certain character set, such as ascii) within which it is a sign. Thus any sign has at least the significance of being a sign in a certain system (e.g., the letter "t"). Note that the same mark can appear in more than one category system (e.g., "E" in the Greek and Roman alphabets), and as such has different interpretations. A "configuration" of signs is a "text," existing as one choice among many in a system of such configurations; such a system should not be considered closed (see Section 2.5 for further discussion of the qualities of such systems). "Texts" in this sense, like signs, are already the result of interpretation, and of course are not limited to writing, but also include spoken discourse, movies, mime, comics, etc. The senses of sign and of accountability intended here are based on ethnomethodology, as described in Section 3.2 below.

The above definition ties an item of information to a particular social group through a particular relationship of accountability for a particular interpretation. However, the same configuration of signs could very well be interpreted by different groups in different ways, giving rise to different items of information in our sense. In this approach, it takes *work* to interpret signs as information, and this work is necessarily done in some particular context, making use of the resources available and within the constraints imposed in that context.

Ferdinand de Saussure [9] is a founder of what is now called *structuralism*, with his conception of signs as arbitrary, attaining identity only through differences, that is, through participation in a system of distinctions. For Saussure, these systems of distinctions exist as ideal entities, rather than being emergent through social interaction, as with our notion of category system (see Section 3.2). So called *post structuralism* has attacked structuralism on this ground and others, such as its presupposition of a subject-object distinction, saying instead that such distinctions arises out of discourse.

We can distinguish information that can be understood in a wide variety of contexts from information that is so thoroughly situated that it cannot be understood except in relation to certain very particular contexts. We call these types of information *dry* and *wet*, respectively [15]. Note that there is really a continuum of "humidity" for information, e.g., there is "damp" information, of which cooking recipes are a typical example. In general, information cannot be fully context sensitive (for then it could only be understood when and where it is produced) nor fully context insensitive (for then it could be understood by anyone in any time and place).

In the driest formalizations, the metalanguage is also formalized, so that an object level model is a formal theory in the metalanguage. In less fully formalized models, the metalanguage may simply be a natural language, such as English, or a somewhat stylized dialect of it. Note that rules about objects are part of the model, while rules at the meta level define the language used in the formalization, or else give methodological rules. (Justification for the distinction between object and metalanguage on social rather than logical grounds is considered in Section 3.2.)

A fairly extreme case is the "raw data" collected in a scientific experiment; although it may be just a collection of numbers, it is very highly situated, because those numbers only make sense to a very small group who share a very particular context. On the other hand, an equation that summarizes those particular numbers is relatively more dry, and a general physical law is even drier. These considerations suggest the following, which we call the *formalization hypothesis*:

> *Formalization is the process of making information drier, i.e., less situated, by using a more explicit and precise metalanguage for expressing information.*

Section 2.6 discusses some criteria for measuring the degree of formalization, i.e., the "humidity" of information.

Dry information is usually intended to be interpreted in what counts as the same way for practical purposes in a variety of contexts. However dry it may be, information is always situated in some particular social context: from our point of view, there is no such thing as abstract, ideal information, which is independent of context. In particular, the same configuration of signs can mean different things in different contexts.

The *structure* of information is *how* it is configured; formalization makes that structure more precise and explicit, through use of a metalanguage. The notion of abstract data type [23] uses the very dry metalanguage of abstract algebra for formalizing structure. This approach also formalizes the notion "representation independence," that the same structure can be represented in different ways. An abstract data type defines the space of all admissible configurations for a class of signs, along with methods for creating, modifying and retrieving configurations. The notion of *situated abstract data type* was introduced in [16] to explicate how information can be both contextual and structured.

2.4 Tacit Knowledge

It can be difficult to find good data on which to base the design of information systems. Experience shows that simply asking managers what they want often works poorly. They do not (usually) know what is technically feasible, and they cannot accurately describe what their workers really do, what their clients really do, or even what they themselves really do. This is not because managers are incompetent; on the contrary, they are (usually) genuine experts at their own job. Rather, it is due to what philosophers [49] call the problem of *tacit knowledge*, i.e., the phenomenon that people may know how to do something, without being able to articulate how they do it. In the social sciences, this is called the *say-do problem.* Some examples are riding bicycles, tying shoe laces, speaking languages, negotiating contracts, reconciling personal differences, evaluating employees, and using a word processor[4]. An important reason for this difficulty is the situatedness of the information involved.

But to build a system that effectively meets a real business need, it is usually necessary to find out what workers, clients and managers really do. Note that simply asking workers what they do is subject to the same problems as asking their managers. Instead, if we really need this information, it is usually best to go where the work is actually done, and carefully observe what

[4]Some groups may have specialized concepts and methods for dealing with certain situations. For example, sailors have a specialized vocabulary for knots that would allow them to describe how to tie shoe laces.

actually happens. Various methods from sociology seem promising for this purpose, as discussed in Section 3 below. Of course, it may be necessary to abstract away many details of what workers do, so that a new information system supports what is essential rather than what is accidental.

An important way to take advantage of tacit knowledge is to evolve the design of a new system through a series of prototypes, which small groups of workers are invited to use, and while doing so, discuss what they are doing. These interactions can be videotaped and then analyzed. A first prototype could be as crude as some cardboard boxes with drawnings of buttons, and with changeable pieces of paper to simulate screen configurations.

2.5 Qualities of Information

It seems worth contrasting the view of information and meaning suggested above with the *representational theory of meaning* that is standard in computer science and in the Anglo-American analytic tradition of philosophy with which it is closely allied. According to our social theory of information, meaning is an ongoing achievement of some social group; it takes *work* to interpret configurations of signs, and this work necessarily occurs in some particular context, including a particular time, place and group. The meaning of an item of information consists of the relations of accountability that are attached to it in that context, and as we will see later, the narratives in which it is embedded.

By contrast, a representational theory of meaning claims that a meaningful configuration of signs *represents* something in the real world. In sophisticated representational theories, such as situation semantics [3], what is represented by (say) a given phrase in English can vary with the context where it is interpreted, and need not be a simple object, but can be a complex of interconnected relationships, that is, what they call a "situation." This is adequate for some purposes, but even the most sophisticated representational theory leaves out the work of interpretation and the social accountability that is required for interpretation.

That information is tied to a particular, concrete situation and a particular social group has some important consequences, summarized in the following list of *qualities of information*:

1. *Situated.* Information can only be fully understood in relation to the particular, concrete situation in which it actually occurs.

2. *Local.* Interpretations are constructed in some particular context, including a particular time, place and group.

3. *Emergent.* Information cannot be understood at the level of the individual, that is, at the cognitive level of individual psychology, because it arises through ongoing interactions among members of a group.

4. *Contingent.* The interpretation of information depends on the current situation, which may include the current interpretation of prior events[5]. In particular, interpretations are subject to negotiation, and relevant rules are interpreted locally, and can even be modified locally.

5. *Embodied.* Information is tied to bodies in particular physical situations, so that the particular way that bodies are embedded in a situation may be essential to some interpretations.

6. *Vague.* In practice, information is only elaborated to the degree that it is useful to do so; the rest is left grounded in tacit knowledge.

[5]Of course, an "event" is what some group counts as an event.

7. *Open.* Information (for both participants and analysts) cannot in general be given a final and complete form, but must remain open to revision in the light of further analyses and further events. (At the analyst level, one may say "all theories leak.")

I do not claim this list is complete, let alone superior to other such lists. On the contrary, this list derives its plausibility from its similarity to many other such lists. For example, qualities like these are familiar to anthropologists (e.g., see various comments by Lévi-Strauss in [34]), although anthropologists have not (to my knowledge) been very precise in distinguishing among different qualities. Also, Suchman [59] gives a similar list of qualities for plans, which was a major inspiration for the above list. On the other hand, the categories in the list are themselves vague and partially overlapping, and the list itself should be considered open; that is, this list of qualities applies to itself.

These qualities can be applied in many ways. For example, they lead to some basic limitations of formalization. Because any formalization is information, it must be emergent, contingent, local, open and vague; for further discussion, see [16, 22]. We can also apply the list to obtain qualities of category systems, signs, interpretations, texts, etc.

We can also use the qualities of information to understand why it is not possible to completely formalize requirements: it is because they cannot be fully separated from their social context. More specifically, the qualities explain why so-called lifecycle phases cannot be fully formalized. Indeed, the activities that are necessary for a successful system development project cannot always be expected to fit in a natural way into any system of pre-given categories, and practicing software engineers often report (informally) that they have to spend much of their time circumventing "the system." Robinson and Bannon [50] show that representations pass through multiple "semantic communities" during the construction of complex systems, and suggest this implies that such "work-arounds" should not be surprising in practice.

2.6 Sociology of Science

There have been important new developments in the sociology of science. One exciting voice in this field is Bruno Latour, who has suggested certain properties that distinguish scientific work from other kinds of work [33]. Latour introduces the phrase *immutable mobile* for a representation[6] that can be interpreted in essentially the same way in a variety of contexts; thus, immutable mobiles are information structures that have been dried out. To illustrate this concept, Latour [33] discusses the use of cartographic maps for navigation: given the proper instruments and proper conditions (e.g., good weather), such maps can be used anywhere in the world; but each such use is still a local interpretation.

Representations are often what Latour calls *re-representations*[7], new representations that concentrate previously available information; this is a form of abstraction. For example, a large set of observations of planetary motion might be summarized by a single equation. Latour claims that the qualities of immutable mobility and concentration are characteristic of the information that occurs in the discourse of science. Formalization tends to increase these qualities, and indeed, it is natural to suggest the following *success criteria*:

> *A formalization is successful to the extent that it exhibits immutable mobility and concentration.*

Note that formalized information is not necessarily more immutably mobile or more concentrated.

[6] It is not so clear what Latour means by a "representation," but for present purposes, it should simply be considered a configuration of signs, without any necessary representational connection to "real" objects.

[7] These can be seen as "semiotic morphisms" in the sense of [17].

As Latour [33] points out, the construction of immutable mobiles can be a way to mobilize power. Bowers [6] emphasizes this point particularly for formalisms; he criticizes the modernist rhetoric of emancipation through formalization, and suggests that undoing chains of rerepresentations may be an antidote (I suggest calling this *derepresentation*). As an example of the power of formalization, if an analyst compresses large amounts of information into simple graphical representations, then anyone who wishes to disagree must mobilize the resources to acquire and compress comparable amounts of information. This can be seen in the presentation of dataflow diagrams in requirements meetings; in general, such diagrams are beyond the capabilities of users and managers, due in part to the huge volume of information involved in large projects, as well as its formal character. Requirements engineering has developed special tools, such as gIBIS [8], to help collect and organize arguments for various positions on selected requirements issues. However, these tools are based on normatively given presuppositions about the way that projects should be organized, and serve mainly to increase the power of analysts. A tool that tries to make requirements information more relevant to users and their needs is described in [46], with further motivation given in [18].

Leigh Star [58] introduced the term *boundary object* to describe information that is used in different ways by different social groups. For an information system to be successful, it must often serve multiple groups, and so it seems natural to suggest that boundary objects can be usefully applied, e.g., to Information Systems. Indeed, the notion of a database *view* already reflects the idea that it may be useful to present different information in different ways to different users. Similarly, requirements documents must serve a number of different stakeholders, and thus must be boundary objects. This seems a fruitful area for further research.

2.7 The Retrospective Character of Explanation

The following, called the *retrospective hypothesis*, seems a basic result in our social theory of information:

> *Only post hoc explanations for situated events can attain relative stability and independence from context.*

While events are unfolding (and before they happen), they cannot achieve a final social accountability, since members can always revise their assessment of the significance of past events in the light of new events, or of new interpretations for prior events; even what counts as an event is negotiable, as are the criteria for what counts as significant. Thus, information is always subject to revision, and is often revised as events unfold. Empirical support for this view can be found in work on plans and explanations reported in [39] and [24], and in the important work of Suchman [59] on situated planing.

This explains why it can be so difficult to determine the requirements for a large system: it only becomes clear what the requirements are when the system is successfully operating in its social and organizational context; requirements evolve as system development proceeds, and a reasonably complete and consistent set of requirements for a large, complex system can only emerge from a retrospective reconstruction. It takes work by members to achieve a retrospective reconstruction, and for large systems, it is unusual to do all this work. Determining whether some system meets its requirements is the outcome of a complex social process that typically involves negotiation, and may involve legal action. Thus it is usually entirely misleading to think of requirements as pre-given.

Going further, it could be argued that time, in the sense of a linear ordering imposed upon events, is itself the result of the retrospective reconstruction of causal chains to explain events, i.e., to give them significance in relation to shared values. The use of causal explanations in this way is characteristic of Western culture, and is a basic constitutive shared value of that culture (see Section 3.4 for some discussion of causality in narrative).

3 How to Get Information

This section describes and evaluates a number of methods that can be used to get the information needed to support the design of information systems. More details, including more comparison and examples, are given in [21], from which parts of Sections 3.1 and 3.2 are drawn.

3.1 Some Methods and Their Limitations

Perhaps the most common method for designers to get information about users' needs and habits is *introspection*, which amounts to imagining what kind of system the designer would want. Although this can be useful, the introspection of an expert in a different field, such as computer science, is unlikely to reflect the experience of the intended users. Experts tend to use what they remember or imagine of themselves; for user interface design, this experience can be very far from the questions, assumptions and fears of actual users. For example, an expert might be surprised when a user does not attempt to understand why a word processor unexpectedly centers some material; in fact, users often seem to believe that computers just are sometimes puzzling or irritating, and that it is neither necessary nor valuable to explain their more bizarre behavior. Cognitive scientists may be surprised by this, because their theories suggest that a user who finds that a model is incorrect should correct the model. Designers may be upset because they feel that their designs are not being used correctly.

Moreover, designers cannot reliably introspect what work settings are like, or the conditions under which a new technology will be learned or used. For example, many users must learn and use technology in conditions that require multiple and ongoing splitting of attention; this may be due to complex collaborative relationships.

Questionnaires and interviews are also frequently used. Questionnaires are limited by their stimulus-response model of interaction, which assumes that a given question (as stimulus) always has the same meaning to subjects. (Note that questionnaires can be administered either in writing, or else in an interview situation.) This model excludes interactions that could be used to establish shared meaning between the subject and the interviewer. Open ended interviews allow less constrained interaction between the interviewer and the interviewee, who is no longer considered the subject of an experiment. However, this method is still limited by the need for the participants to share basic concepts and methods, without which they will be unable to negotiate shared meanings for the questions asked. Open ended interviews are also more vulnerable to distortion by interviewer bias. (See [60] for a more detailed discussion of this topic, including some examples.)

These limitations also apply to focus groups, and to their cousins in requirements engineering, called JAD (or RAD) groups. In addition, these methods are vulnerable to political manipulations by participants, as many experienced requirements know from bitter experience.

Protocol analysis asks a subject to engage in some task and concurrently talk aloud, explaining his/her thought process. Proponents claim that this kind of language can be considered a "direct verbalization of specific cognitive processes" ([10], p. 16). Protocol analysis is also used to reflect on problem solving, or some other task, retrospectively, i.e., after it has been accomplished. It assumes that people can produce language that gives a trace of "autonomous cognitive activity." The problem with this assumption is that language is intrinsically social, created for a partner in conversation. (This property is called *recipient design* in conversation analysis.) When an experimenter asks a person to solve a problem and talk aloud, then that person has to imagine a partner with certain desires, and try to provide what that partner wants. (Or the subject may be rebellious, and try to frustrate the imagined partner.) Thus, protocols are an unnatural discourse form, and moreover, are unnatural in ways that are difficult to specify, as well as being based on an incorrect cognitivist model of human thought that ignores social context; [21] gives a detailed analysis of a protocol demonstrating its unnaturalness on linguistic grounds.

None of these methods can elicit tacit knowledge. The principles of ethnomethodology discussed in the next subsection, such as members' concepts and members' methods, provide a powerful framework for a deeper consideration of the limitations of the traditional methods, as well as a basis for methods that do not have the same limitations.

3.2 Ethnomethodology

Traditional sociology has been greatly influenced by what it considers to be orthodox science, where scientists first formulate a theory, on the basis of predictions are made, which are then tested empirically. The aim is to achieve *objectivity*, in the sense that the scientist's desires and biases can not affect the conclusions. Hence, there is a rigid separation between subject and object, between observer and observed. Physics has already moved rather far from this kind of objectivity[8], and so it should not be surprising if sociology, and the social aspects of computing, had to go even further. In particular, if objective information is replaced by situated information, then the orthodox approach of formulating and then testing hypotheses objectively, for example through statistical sampling, will not be valid, because the random events observed can no longer be assumed to be statistically independent. However, statistical methods are the foundation for much of traditional sociology, for example, the design and evaluation of questionnaires. This does not mean that statistics and questionnaires are never useful, only that they are *not always valid*, and in particular, that they should not be used in situations where context plays a significant rôle.

Ethnomethodology began as a reaction against the objective "scientific" and normative approach of traditional sociology [12]. Unfortunately, ethnomethodology can be difficult to understand; however [35], [59] and [21] give relatively comprehensible expositions of certain points. Ethnomethodology tries to reconcile a radical empiricism with the situatedness of social data, by looking closely at how competent members of a group actually organize their interactions. One basic principle of ethnomethodology is the following *principle of accountability*:

> *Members are held accountable for certain actions by their social groups; exactly those actions are the ones constructed as socially significant by those groups.*

A member performing such an action is always liable to be asked for an account, that is, a justification[9]. Accountability is the basis of all social interaction, and thus of society. It means that members are held *responsible* for their behavior.

From the principle of accountability, we can derive the following *principle of orderliness*:

> *Social interaction is orderly, in the sense that it can be understood by analysts.*

This follows from the fact that the participants themselves understand it, because of accountability; therefore analysts should also be able to understand it, if they can discover how members themselves make sense of their interactions.

In particular, ethnomethodology looks at the *categories* and *methods* members use to render their actions intelligible to one another; this contrasts with presupposing that the categories and methods of the analyst are necessarily superior to those of members. The methods and

[8]Penrose [45] gives an elegant and readable exposition that illustrates just how strange the theories of contemporary physics can be.

[9]Of course, this does not imply that such accounts are always requested, or even usually requested.

categories of members are identifiable through the procedures by which members are held socially accountable by other members of their group. We may also say that the analyst is used as a measuring instrument. Through training, such an analyst gradually learns to pay attention to doubts and hints, and to follow them up with further observations and questions. Through immersion in data from some particular social group, the particular competencies are gradually acquired that enable the analyst to be a sensitive and effective instrument in that domain. In this way, subjectivity is harnessed, rather than rejected.

Sacks [51] demonstrated that members' categories often come as part of *category systems*[10], which are collections of category distinctions that members treat as naturally co-occurring. Sacks also gave some rules that govern the use of such systems, and showed how these provide a rich resource for interpreting ordinary conversation. Category systems in this sense are the basis for our notion of information; thus our theory of information is founded on an ethnomethodological semiotics.

Conversation analysis grew out of ethnomethodology through work of Sacks on how speakers organize such details as timing, overlap, response, interruption, and repair in ordinary conversation [53, 54]. Interaction analysis extends conversation analysis from audio to video data, particularly in institutional settings. See [25] for a recent overview of conversation analysis, and [31] for a collection of essays on interaction analysis. Both these fields are strongly empirically based, in the sense that any phenomenon asserted by analysts must be "warranted" (i.e., supported) by evidence that members in some way *orient to* that phenomenon, i.e., noticeably use it to organize interaction.

Although the distinction between object and meta levels (in Section 2.2) comes from logic, I claim it can be warranted in concrete situations by observing how analysts orient to different items of information used in their work, for example during meetings in which they discuss data such as transcripts of interviews. These categories may not be recognized by users, but they are an important part of the apparatus of analysis.

Members concepts and methods can be formalized using abstract data types [16]. This motivates a reexamination of Sacks' categorization devices as *situated abstract data types*, where the relationships between the formal and informal social aspects are taken into account; [16] shows that a great many such relationships are possible; this can be seen as an attempt for further develop and formalize Sacks' work.

It seems promising to apply methods from ethnomethodology to the sociology of science. Work that helps point the way has been done by Eric Livingston [41] on mathematics, and there are also ethnomethodological studies of several other fields of science, e.g., see [13] on the discovery of pulsars. Such an approach could help correct the lack of explicit empirical research in much current sociology of science. Another promising direction is to apply category systems to information systems. However, Sacks only analyzed very simple examples, and a good deal more development would be needed for a large Information System project.

Ethnomethodology can also be understood as providing useful general guidelines for how to collect high quality data about social interaction, and conversation and interaction analyses can be seen as embodying these guidelines in ways that are directly applicable to many practical problems in understanding and designing technology (some further discussion and examples are given in [21]). Also, they can be used to obtain tacit knowledge, because they bypass the unreliable explanations of users and managers, and instead examine what actually happens. However, these are far from the only way to elicit requirements, and may not be the best methods for some circumstances.

[10] Actually, Sacks [51] called these "categorization devices."

3.3 Some Limitations of Ethnomethodology

For present purposes (which are understanding and designing information systems), ethnomethodology and the methods based on it have some significant limitations. These include the following:

1. Ethnomethodology requires the use of naturally occurring data, which is nonintrusively collected in a situation having significant social interaction, where members are engaged in activities that they regularly and ordinarily do.

2. Ethnomethodology requires the analyst to understand members' concepts and methods. Although it is only necessary for an analyst to understand *certain* members' concepts and methods, to a *certain* degree, to achieve a certain pragmatic goal, it can be difficult to determine what must be understood, and to what degree.

3. Ethnomethodology requires grounding observations in the concrete circumstances of their social production. However, the design of technical artifacts requires the use of abstractions and formalizations that are not so grounded. In particular, methods based on ethnomethodology cannot be applied directly to systems that have not yet been built.

4. From a practical point of view, the most important limitation of methods based on ethnomethodology is that they are labor intensive. In particular, it can take a skilled person a long time to produce a transcript from a videotape of live interaction. Typical projects can involve hundreds of hours of work in recording, transcribing and analyzing data.

Regarding the first point, if data is not collected in a natural social situation, then the principle of accountability will not apply, and we cannot be sure that events in the data have any natural social significance. This precludes a number of convenient "quick and dirty" ways of collecting information, such as questionnaires. Controlled experiments are also unsuitable sources of data, as are solitary operators of equipment.

For the second point, there seems to be fairly general agreement that prior to using a method based on ethnomethodology, it is necessary to do some ethnography, that is, to achieve some prior orientation to the social milieu to be studied. Thus, we might look to ethnography for guidelines, as well as ethnomethodology, because the latter presupposes some appropriate level of understanding. Unfortunatel, the ethnographic literature does not provide much help, because ethnographers have not had definite pragmatic goals; perhaps those working on the interface between technology and sociology will have to develop suitable guidelines themselves.

For the third point, note that the design of a technical artifact is typically a formal object. For example, a design may be expressed in a blueprint for a building, or a computer program to control a machine tool or even an entire automated factory. Similarly, the design of an Information System is typically expressed using formal notations; furthermore, the Information System itself can be seen as a formal object in a nontrivial way, because it is (in part) a program written in a formal programming language, running on a formally describable computer.

The fourth point has considerable practical significance, because those who want information systems are often unwilling to wait the long periods of time that ethnomethodological studies may involve; their business environment may be very competitive and fast changing, and they want an effective but not necessarily optimal system in place as quickly as possible. Therefore it is important to develop practical criteria for determining when we have a sufficient understanding of some situation for practical purposes.

3.4 Discourse Analysis

In linguistics, the phrase "discourse analysis" refers most broadly to the study of structures larger than sentences. Both interactional and linguistic approaches have been taken to such structures. The interactional approaches arise from ethnomethodology, and consider how social order arises in conversation. The linguistic approaches arise from sociolinguistics, and consider the internal structure of certain discourse forms; this subsection concentrates on the linguistic approach.

A *discourse unit* is a structural, linguistic unit directly above the sentence. Some common examples that have been studied extensively are the oral narrative of personal experience [32, 37, 48], the joke [52], the explanation [24], the spatial description [36, 40], and the plan [39]. A discourse unit has two criterial properties: defined boundaries, and a describable internal structure.

The property of *definable boundaries* means that the discourse unit is *bounded*; for example, (with some interesting exceptions) we know when a speaker is or is not engaged in a narrative. Of course, there may be boundary disputes, either at the beginning, during which a speaker negotiates with hearers whether the narrative will be told, or at the end, where the speaker may negotiate the proper response to the unit with hearers [52, 47, 48]. However, such negotiations do not mean that the unit is not structurally bounded. Rather, they imply that its boundaries are negotiated, i.e., they are social.

One important effect of establishing of the boundaries of a discourse unit concerns turntaking. Other things being equal, the sentence is the potential unit of turn exchange; i.e., a second speaker may begin to speak when the first speaker has reached a permissible end of sentence. However, if the first speaker has negotiated permission to produce a recognized discourse unit, such as a joke or a story, then that speaker has the floor until the unit is completed. A second speaker may contribute questions, appreciations, side sequences, etc., but the discourse unit and topic in progress will not change until the unit is recognized as completed.

The second important property of the discourse unit is that it has a *precise internal structure*. The description of this internal structure is necessary for understanding the interactional process of discourse construction, because the task of hearers is quite different, for example, in different sections of a narrative. Moreover, discourse structure can be described with just as much mathematical precision as sentential syntax ([39, 24] present an appropriate mathematical apparatus).

The principle of accountability suggests that a member of some group telling a story should establish its relevance to the audience. In a classic paper, William Labov [32] showed that narratives of personal experience, in which the narrator is an agent, are discourse units. For our present purpose, it suffices to consider just two aspects of narrative structure. The first, called the *narrative presupposition*, is that (unless explicitly stated otherwise), the temporal order of events is the order that they occur in the text, in "narrative clauses." The second, called *evaluation*, refers to the justification or explanation of actions, events, etc. through reference to shared values. It may seem surprising that values are an integral part of the internal structure of stories, rather than being confined to an optional "moral" given at the end. Evaluative material sometimes appears in explicit "evaluative clauses," but usually appears in more implicit forms [38], and indeed, its syntactic expression is a significant clue to its importance in a given story.

Narratives seem particularly important for understanding information involved in system development, because much of what is communicated between parties appears as stories, e.g., about what our group does, what we hope to accomplish with the new system, what our problems are, etc. For example, a study of experienced photocopy repair personnel [44] shows that they often use narratives for informal training of novices in problems that are not covered in official manuals and training courses. These "war stories" are an important part of the work life of photocopy repair mechanics, although management may see this activity as 'goofing off' rather than a legitimate part of the job.

Let us illustrate these ideas with a nursery rhyme. This is not a naturally occurring spontaneous story, let alone a narrative of personal experience, as studied by Labov [32]. However, it is often read, or repeated from memory, to children in natural social settings, and thus an analysis of its values should tell us something about our society. Our analysis will omitting many details of argument; otherwise, it could be too tedious to read. Here is our text:

> Jack and Jill went up the hill
>   to fetch a pail of water;
> Jack fell down and broke his crown,
>   and Jill came tumbling after.
>
> Up Jack got, and home did trot,
>   as fast as he could caper,
> Jill put him to bed and plastered his head
>   with vinegar and brown paper.

(The second verse is one among several variations; see [43] for this and other background information.) The first line is a straightforward narrative clause, recounting an action in the narrative past tense, while the second line is an evaluative clause, giving a reason for the action of the first clause. The third and fourth lines give further narrative clauses (there are two in the third line).

A very basic feature of narrative is that the order of narrative clauses is taken as the order of the events that they report, unless some trouble is taken to indicate otherwise. Thus, in the first verse, they first went up, then Jack fell down, then he broke his crown, and then Jill came tumbling after. This basic principle is called the *narrative presupposition*. Note that it is a convention, and *not* a necessary feature of narratives; for example, Becker [4] shows that in Balinese narratives, if no special care is taken then the events reported in a sequence of narrative clauses are taken as occurring *simultaneously* rather than sequentially[11].

Because ordering is significant in English narratives, it is interesting to notice that Jack always comes before Jill. As far as the semantics is concerned, this ordering would not matter in the first line, but because it is part of a general pattern, we can consider it to be an evaluative feature of the narrative. (Note the delicacy, and not quite water-tight quality of this argument; rigorous proofs are impossible in this area.)

I think we can conclude that water is important to this (somewhat mythical) culture, that males are more important than females in it, and that females may take care of males.

This need not be the end of the analysis (although further elaboration might push the limits of patience): we could get some further results by using the so called *causal presupposition*, which says that, other things being equal, given clauses in the order A, B, we may assume that A causes B. (For example, "You touch that, you gonna die.") As an exercise, the reader may wish to apply this to the text above.

Such analyses do not *prove* assertions, or extract the *truth* from a text; rather they uncover a resonance of a text with some context; this is more like literary criticism. Each such analysis is contingent, local and open; it is best done in a group, so that the analyst is accountable to other analysts, in which case the analysis itself becomes emergent and embodied at that level. Any such interpretation can be considered to be some part of the meaning of the text; of course, each

[11] A computer scientist might say that the default connective for a narrative sequence in English is sequential composition (";"), whereas in Balinese it is parallel composition ("||").

interpretation will seem more compelling to some analysts and groups than to others, and some may seem dubious to most.

We can relate this discussion to the work of Jean-François Lyotard [42] on information in the postmodernism age. For Lyotard, *modern* societies rely on the values in *meta-narratives*, or "grand unifying stories," to legitimate their institutions. The grand narratives of Western civilization support the domination and exploitation of nature. On the other hand, *postmodern*[12] societies have many "local language games" that cannot necessarily be unified, or even neatly classified. Lyotard believes the grand narratives of Western civilization are being replaced by a multitude of local narratives, i.e., that we are in a postmodern era. Babbage's dream of emancipation through increased order and ever lasting information [2] seems a good example of a Grand Narrative that is no longer sustainable [7], while Haraway's cyborg manifesto [26] seems a good example of a contemporary local narrative.

A school of "narratology" has developed in France, especially following Roland Barthes, claiming among other things that our sense of subject and object is created by our participation in narratives. In any case, it seems clear that narratives play a strong role in the production and use of information, and even in the belief that there is such a "thing" as information. Such a more human orientation is characteristic of continental philosophy, in contrast to the Anglo-American analytic tradition.

3.5 Ethnomethodology and Ethics

Ethnomethodology does not assume any pre-given value systems for members. Nevertheless, values are important to ethnomethodology: the group being studied has values; analysts have values; and the ambient society has values. In each case, the values are produced, sustained, and modified by members of the relevant group, and are important to its identity and its functioning. In general, the values at each level are different, and may interact in complex ways. One might go so far as to say that groups, values, and information are "coemergent," in the sense that each produces and sustains the others; that is, groups exist because members share values and interactions with each other; values exist because they are shared and communicated by groups; and information exists because groups share values in a dynamic world. No one of these three can be considered more basic than the other two; it is creative acts of interpretation that unify social groups, values and signs, and in that way create information. Thus, values are a necessary presupposition of ethnomethodological analysis: members' accountability to shared values renders their concepts and methods visible to analysts. Jayyusi [29] puts it as follows:

> What emerges from both Garfinkel's and Sacks' work is the understanding that all communicative praxis presupposes, and is founded in, a 'natural' ethic — an ethic, that is, which is constitutive of, and reflexively constituted by, the *natural attitude of everyday life.*

The reflexivity mentioned here is the same as the coemergence discussed above.

The situatedness of information arises from the particular relations of accountability that tie it to a particular social group and the work done in the particular context to produce that particular text and its particular interpretations. Values do not exist as abstract ideal entities, but rather emerge interactively in actual instances of accountability. It follows that *everything* that arises in social life has an inherent ethical component, and attains its *meaning* through the relations of accountability in which it participates. Thus information has an inalienable ethical dimension.

[12] Many other notions of postmodernism appear in the literature, some of which are very superficial; in general, the word "postmodern" has been overworked. Lyotard's definition appeared relatively early, and has some substantial content, using ideas from Wittgenstein's late period.

Values are also critical at the analyst level. Analysts are accountable to other analysts for the accuracy of their analyses, and for how their questions, methods and conclusions fit in with those of other analysts. There is also the important issue of accountability of analysts to members. Because ethnomethodological analysts try to understand members' own methods and concepts, they often communicate with members in order to test their own understanding. Members are naturally concerned to know the motivations of these strangers among them. A common issue is the confidentiality of certain information. In this respect, it is natural for analysts to offer members a power of veto over publication of data in which they are involved.

Trust between members and analysts is often essential to the success of the analysis. Even in cases where such trust is neither sought nor secured, such as Garfinkel's "breaching experiments" [12], a sense of compassion, that is, of being able to sympathize with members, seems essential to the analysis. This is a fundamentally ethical point.

3.6 Case Studies

Case studies have been done to test the practical application of interaction analysis to requirements engineering. One project involved the analysis of videotapes of stock dealers at work, supplemented by ethnographic interviews, including feedback from the dealers on the interpretations of selected video clips. Some results from this study are described in [27]. Another case study concerned requirements for an integrated database system for the fault restoration office of a major telecommunications control center; here we discovered that system development work was being greatly impeded by an ideologically motivated "internal market" which kept system developers from direct communication with users! It is estimated that several million dollars were saved as a result of these two exercises, possibly much more if the internal market is abolished.

Goguen and Linde [19, 20] developed a method for using discourse analysis to determine a value system for an organization (or part thereof) from a collection of stories and jokes told by members of the organization among themselves on informal occasions, such as coffee and lunch breaks. A related method determines work structure from task oriented discourse. These methods primarily use narratives of personal experience, in which an individual relates events that were personally experienced [32]. The first method classifies the evaluative material (in the sense discussed in Section 3.4) of the stories collected, using a formal structure called a *value system tree*, in which higher level nodes correspond to higher level values, and lower level nodes correspond to refinements, applications, or corrections of superordinate nodes. Because members of an organization who tell a story are socially accountable for doing so, the evaluative material that they use to justify their telling that story reveals their shared values.

Figure 1 shows part of a value system tree[13] obtained by Goguen and Linde [19] for a small corporate recruitment (i.e., "head hunting") firm. The tip nodes in this tree are *situated* in the sense that they are taken directly from actual narratives by members and may thus require more background information in order to be understood. Many interior nodes, which express superordinate values, are also situated in this sense, but others were created by the analysts, by clustering nodes into larger and larger related groups, in the general style of the KJ method[14] [30].

The edges in Figure 1 express relationships of subordination; these are situated to the extent that there is evidence for them in the structure of the discourse; moreover, members could have been asked about them. The nodes at the three top-most levels are analysts' constructions, with

[13]Note that this representation differs from trees on earth, which have their roots at the bottom.

[14]This method was introduced by the Japanese anthropologist Jiro Kawakita for classifying artifacts, and it is now rather widely used by Japanese businessmen and computer scientists. It provides heuristic guidelines for combining clusters, separating clusters, etc.

support from the data. The phrases at the fourth level are taken from the evaluative clauses of actual stories and jokes. (Some nodes at the fourth level of Figure 1 have two more levels below them.)

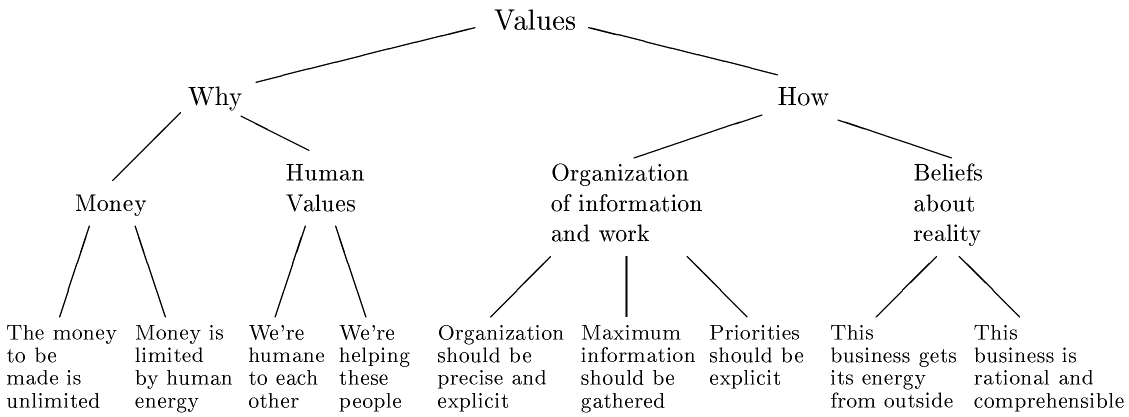

Figure 1: A Value System Tree

Note the contradiction between the first two nodes on the fourth level. This illustrates the fact that real value systems are not necessarily consistent. This seems to be one reason why it is difficult (or even impossible) to elicit values from members just by asking for them. Indeed, value systems, like many other aspects of social life, are tacit knowledge.

Such a structure can help system designers make appropriate trade-offs between conflicting requirements of the client and/or end user. The hierarchical structure of the tree suggests which requirements should be given precedence over others. Also, the nature of any conflicts that appear may be clarified, because the higher level values are more significant. For an even more detailed analysis, weights could be assigned to values based on their frequency in the data that support them.

3.7 Combining Methods and Zooming

Despite the limitations of various methods, I do not wish to suggest that any of them cannot be useful (with the possible exception of protocol analysis). In fact, their strengths seem complementary, so that it could be useful to apply various combinations to particular problems. In particular, it is usually a good idea to start with an ethnographic study to uncover basic aspects of social order, such as basic concept systems used by members, the division into social groups, some typical patterns of work of various social groups, etc. (see [57] for a review of ethnography in relation to requirements engineering). After this, one might use questionnaires or interviews to explore what problems members see as most important, how members place themselves in various classification schemes, etc. Then one might apply conversation, discourse or interaction analyses to get a deeper understanding of selected problematic aspects.

Discourse analysis can be useful when verbal communication is important to the system being developed, as illustrated in the case study on values mentioned in Section 3.6. Conversation and interaction analyses can help to uncover limitations of other methods. Interaction analysis can be used to discover details of nonverbal interaction in real work environments [31]; but the effort required to produce video transcripts suggests that this method should be used very selectively.

Ethnography should be used continually to provide context for results obtained by other methods.

To sum up, I recommend a *zooming* method of requirements elicitation, whereby the more expensive but detailed methods are only employed selectively for problems that have been determined by other methods to be especially important [16]. From this point of view, the various methods based on ethnomethodology can be seen as analoguous to an electron microscope: they provide an instrument that is very accurate and powerful, but that is also expensive, and requires careful preparation to ensure that the right thing is examined. One should not use an electron microscope without first determining where to focus it as exactly as possible, using either an ordinary microscope or, depending on the nature of the sample, a magnifying glass, the naked eye, or a hierarchical combination of these methods. Similarly, in studying information systems, one should first use ethnography, and perhaps interviews or questionnaires. Discourse analysis can also be useful. Ethnomethodology may be necessary when interaction is important.

4 Summary and Conclusions

We have used ideas from ethnomethodology and semiotics to define information as an interpretation of a configuration of signs for which members of some social group are accountable. We have argued that methods based on ethnomethodology overcome many limitations of traditional methods for acquiring information on which to base design; in particular, information acquired in this way can be more accurate in complex situations of collaborative work, because it is more fully situated. However, we have also noted that ethnomethodology and methods based upon it have some limitations of their own, and we have argued that these can be overcome, at least in part, by combining methods; the metaphor of "zooming" helps to explain this. It is not just a complaint about the dangers of methodological dogmatism, but rather a pragmatic suggestion for combining the particular strengths of certain methods.

We have also used ideas from the sociology of science (especially the work of Latour) and logic to explicate the nature of dry information. Dry information often loses the property of embodiedness, and is also less emergent, contingent, and local. However, even the driest information is still situated, and in particular, is open, emergent, contingent and even embodied at the meta level, where analysts are accountable for its formalization. Similarly, even the wettest information about social interaction is necessarily partially abstracted from its social context, in order to be presented to an audience of analysts. In particular, analysts necessarily speak (in part) in a metalanguage.

Operations of abstraction, to a varying extent, sever the resulting information from the social contexts in which it was originally situated. This is not the result of an inadequate method, but rather it is necessarily the case that operations of re-representation, such as classifying, summarizing, abstracting, theorizing and concluding, have such an effect. The construction of immutable mobiles necessarily reduces the situatedness of data and makes it drier, and assertions by analysts necessarily fall into this area. Moreover, dryness comes not merely in different degrees, but also in a wide variety of kinds, resulting from the complex relationships of accountability between different communities, including that of analysts (e.g., see the examples in [16]). This applies to the observations of conversation analysis just as much as anything else.

Information Systems are a particularly interesting site for research. By definition, such systems are repositories for immutable mobiles, and also provide the means for producing new immutable mobiles, for transporting them into new contexts, and for further concentrating and summarizing information. This means they can be sources of power. Consequently, the design of an Information System is a natural occasion for power struggles, and it is important that the human interests of all stakeholders be recognized and protected. A *power struggle* can be defined as a difference among two or more groups in how to interpret some signs, or alternatively, as the failure of an information system to effectively function as a boundary object[15]. Boland [5] gives an interesting case study that illustrates the importance of power struggles in understanding organizations. The failure to take account of such factors explains why many large information systems have failed in practice.

The relationship between the formal and the social aspects of information is not one of antagonism, where one must be rejected and the other accepted; rather, these two aspects of information are both essential for the very existence of information, and are also crucial to successful design. The formal context insensitive and the social context sensitive aspects of information are complementary, and can be very complex in that many different facets can arise in different social contexts, with different levels of abstraction, interconnected in complex ways, as shown by examples in [16].

It is the nature of technical design to construct dry structures, and design necessarily occurs at a meta level, involving a group that to some degree has separated itself from users. However, a slavish adherence to narrowly prescriptive plans and categories is certainly not necessary, and users can be involved in a variety of ways. In general, abstractions (immutable mobiles) have only a practical utility, and must be interpreted concretely in order for that utility to become manifest. Therefore effective design can never be fully separated from the community of users, and indeed, I would say that effective design necessarily involves moments of transcending the distinction between the social groups of users and analysts.

I wish to end with some considerations at a higher, less scientific level. It seems hard to escape the conclusion that the progressive erosion of meaning in modern life arises in large part from the growing formalization of information through mass media, computers, the internet, and the general progress of science and technology[16]. The result has been not only a loss of values in human interaction, but also a devaluation of nature. If nature is seen as fundamentally determined by the laws of physical science, which are mathematical and impersonal, then trees, beaches, mountains, and by extension, buildings, cities, animals, and even people, have no inherent value. This seems to be one source of current environmental and social crises.

Recent trends is philosophy exacerbate these problems. The Anglo-American tradition of analytic philosophy, with its rigorous and even mathematical analyses, has alienated much of its audience, and earned it a reputation for irrelevance. Postmodernism, despite many valuable insights, encourages fragmentation through its attacks on the grand narratives that lend coherence to Western culture; this makes it difficult to respond to, or even conceptualize, contemporary environmental and social crises [11]. Ethnomethodology can be seen as taking a relativistic view that would prohibit discussions like that in this and the previous paragraph.

It is my hope that recognizing the intrinsic ethical dimension of information, and more generally of social interaction, will help us find a path towards greater realization of value and meaning in social life and in nature, without rejecting science and technology.

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[15] Thus, there is no such *thing* as "power"; it is merely a reified way of talking about the social distribution of interpretations.

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