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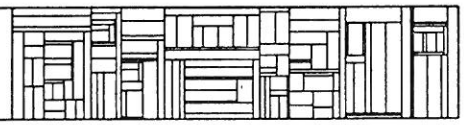

Four Different Perspectives on Human-Computer Interaction

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In this paper the value of a multiperspective view on the use of computers is stressed. It is argued that the ability to apply more than one perspective is valuable both to designers of computer applications, to researchers dealing with human-computer interaction, and to users of a particular computer application. As a means for that the systems perspective, the dialogue partner perspective, the tool perspective, and the media perspective are presented. All four perspectives are primarily characterized in relation to human-computer interaction, and the characterizations are based on a common set of concepts presented at the start of the paper. In the final section the value of applying multiple perspectives is illustrated by means of a few examples.

Introduction

This paper deals with the concept of perspective[2] and its relevance in relation to human-computer interaction. Both to be able to understand the different paths taken by researchers and designers dealing with human-computer interaction, and to be able to use computer applications in a qualified way, it is necessary to be able to apply a number of different perspectives. On that background I will present and discuss the following four archetypical perspectives on the use of computers: *the systems perspective, the dialogue partner perspective, the tool perspective,* and *the media perspective.*

My advise is to try to apply a number of these perspectives in all situations where one is dealing with the use of computers. I see it as a major problem that the systems perspective

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[1]Now at: *Mentor Informatik, Rolighedsvej 67A, DK-8240 Risskov, Denmark.*

[2]See (Nygaard & Sørgaard, 1985) for a discussion of the role of perspectives within computer science.

within large circles of the informatics society per tradition almost is seen as the only relevant perspective on the use of computers. Although being extremely valuable when dealing with understanding of the relation between different components of a computer system, the systems perspective has its limits when dealing with an understanding of the use of computers. My point is, that it is never enough to view the use of computers from the systems perspective only. In this paper it will be argued, that for many computer applications it is not even the perspective which provides us with the most valuable insight. So it is a serious problem that the way development of computer applications is carried out relies so heavily on the systems perspective. According to Ehn & Kyng (1984) a lot of the negative consequences[3] of the use of computers on the jobs of workers can, at least to some extent, be seen as a consequence of the lack of attention to other perspectives during the development process.

A major problem when trying to describe different perspectives is that one cannot avoid having a perspective on them. To make this perspective at least partly available to the reader before going into details, a small taxonomy based on two fundamental distinctions is presented, and the four perspectives are classified according to the taxonomy. The classification is presented in fig. 1.

One basic distinction between perspectives on the use of computers is whether the focus is on *individual* use or on use within a *collective* context. Both when applying the dialogue partner perspective and when applying the tool perspective one tends to focus on individual use, whereas when applying the

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[3]A number of different research projects (see for instance (Ciborra, Schneider & Briefs, 1983), (Kyng & Mathiassen, 1982) and (Sandberg, 1979)) have found the following general trends with respect to the jobs of most workers: less need for experience and skill, less control over and understanding of the production process, increased division of labour, and less planning as part of the job.

systems perspective or the media perspective one tends to focus on use of computers within a collective context.

A second basic distinction deals with the source from which design principles for user interface design are seen to arise. When applying the tool perspective or the media perspective one sees the contents of the interaction process (i.e. the meaning of the work process or communication process) as the primary source of design principles. When applying the systems perspective or the dialogue partner perspective, the perspective itself is seen to give rise to some design principles. Computers and humans are seen as comparable. Viewed from the systems perspective humans are seen as equal to other (automatic) components of a system, and viewed from the dialogue partner perspective computers are seen as being able to show human communicative behaviour. Both these views give in themselves rise to some design principles for user interface design which are independent of the contents of the interaction process.

Using terms borrowed from linguistics we can say that this second distinction deals with whether the *contents level* or *the expression level* is seen as the primary source of design guidelines for user interface design.

After this short introduction to the theme of the paper and the perspectives that will be dealt with, I will introduce a few additional concepts. Following that I turn to discussions of the area of human-computer interaction as seen from each of the four perspectives. I start out by considering the systems perspective, go on with the dialogue partner perspective and the tool perspective, and conclude with the media perspective. For each perspective I start out by giving a general characterization. Following that I deal with the relation between the interaction process and some related structures, with user interfaces, and with models, as these matters are considered when applying this particular perspective. Finally I discuss research on human-computer interaction as seen from the perspective under consideration. In a separate section at the end of the paper the relevance of multiperspective reflection is

use context / *source of design principles*	*collective*	*individual*
expression level	*systems perspective*	*dialogue partner perspective*
contents level	*media perspective*	*tool perspective*

Figure 1: A categorization of the four perspectives.

illustrated by means of a few examples.

Basic Concepts

To be able to make the discussion uniform among the different sections of the paper I introduce a set of basic concepts concerning the interaction[4] process.

When dealing with the **functionality** of a computer application we are dealing with, what can be done with a computer application, with the set of possible products, and with the

[4]By using the word interaction one gets associations to processes in which tasks are performed by common efforts from equal participants. Seen from my perspective this is a bad association when dealing with a process involving human beings and computers - humans and machines are not equal at all - but because of the well established position of the term and because I lack a better word, the term will be used anyway, namely to denote characteristics of the processes taking place when humans are using computers (i.e. processes of computer use).

purposes for which the computer application is valuable for the user. An application is developed to fulfil some purpose within a **domain**. Functionality relates to **tasks** performed within the domain and is primarily characterized in relation to these tasks; e.g. a word processor is developed to support activities within the domain of document preparation, and the functionality is primarily related to tasks such as typing and setting.

When dealing with the **user interface**, we are dealing with how to obtain a desired effect, and with the possibilities to control the computer application. Several general frameworks for the purpose of characterization of user interfaces exist. In this paper I use a framework[5] introduced by Newman & Sproull (1979) who see user interfaces as consisting of the following four components: *the user's model, the command language, the information display,* and *the feedback*.

A specific part of software might contribute to the definition of both functionality and user interface; so software cannot be split into disjoint parts by means of the concepts. *Functionality* and *user interface* simply define two different perspectives on a computer application.

Inspired by some influential schools within psychology and cognitive science the concept of **model** has come to play a major role within the area of human-computer interaction. According to these schools humans create mental models[6] of the phenomena they are dealing with. This view has lead a lot of cognitive scientists and user interface designers to believe, that basing the design of a computer application on a **conceptual model**[7] will

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[5]Another framework is for instance introduced by Foley & van Dam (1982) who speak about *conceptual, semantic, syntactic* and *lexical design* of user interfaces.

[6]Within cognitive science the term mental model is used to denote an internal representation within the human brain of aspects concerning phenomena in reality. See for instance (Gentner & Stevens, 1983) for a broad discussion on the role of mental models. (Norman, 1983) is especially dealing with the subject in relation to the use of computers.

[7]According to (Wilson, 1984) a conceptual model is an explicit

make users develop a mental model similar to this conceptual model.

Not being a psychologist I prefer not to take part in the ongoing discussion on the feasibility of this view. But being aware of that its basic assumptions are strongly challenged by some well-known authors within the field[8] I prefer not to talk about mental models and instead use more neutral terms which are not based on any detailed assumptions about the organization of the human mind. However, this does not mean that I desist from talking about conceptual models. Both literature[9] and my practical experience[10] tells me that this is an important concept when discussing user interfaces and human-computer interaction. In fact one important difference among the perspectives I am considering in this paper is their view on the role and nature of conceptual models in relation to the use of computers.

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interpretation of qualitative aspects of a phenomenon.

[8]See (Winograd & Flores, 1985) for a critique of the view that humans develop mental models.

[9]See for instance (Smith, Irby, Kimball & Verplank, 1982) for a description of development of computer applications (the Xerox Star office system) based on conceptual models.

[10]I have participated in the UTOPIA-project (in the Scandinavian languages UTOPIA is an acronym for "Education, technology and product in a quality of work perspective"); a project on the use of computers for text- and image processing in newspaper production, in which the aims were to develop powerful tools for skilled graphic workers. The original ideas behind the project are presented in (Utopia, 1981). Results from the project are documented in approximately 20 reports written in Swedish and Danish. An english summary of basic ideas and results is presented in (Utopia, 1985a) and in (Bødker, Ehn, Kammersgaard, Kyng & Sundblad, 1986). In the project development of conceptual models called *user models* or *use models* played a central role. Such models are seen as playing a role both in relation to design, in relation to teaching and learning, and in relation to the use of computer applications. Some ideas especially concerning development of conceptual models are presented in (Ehn & Kyng, 1984), (Bødker, 1985) and (Kammersgaard, 1985).

Let us now look at the characteristics of the interaction process. When humans are interacting with computers, processes take place within the human user as well as within the computer; but these processes are fundamentally different by nature.

As an inseparable part of a users actions human thought processes providing the user with new knowledge takes place. Human thought processes takes place in dialectical relation to a persons **preunderstanding and background**[11]. On one hand our preunderstanding and background limit our ways of thinking, but on the other hand it is established as a consequence of our thinking and acting. Furthermore the directedness resulting from having a preunderstanding and background is a prerequisite for being able to think and act.

Only a limited part of our preunderstanding and background is relevant during a particular interaction process. This part, which inspired by Nygaard & Sørgaard (1985) throughout this paper is called the **operative cognitions**, is a subject for change during the interaction process.

Within the computer program executions take place. Through these processes two important types of change might occur. Interaction processes typically lead to changes within the **domain representation**; i.e. the representation of domain-related phenomena within the computer. Furthermore the **media structure** (i.e. what one can see on the screen, which sounds one can hear, how one can use input devices, etc.) is continuously changed as a result of the user's interaction with the computer, typically either to affect a change in the underlying domain representation, to present different aspects of the domain representation in different ways to the user, or to guide the user during interaction with the computer.

So far I have listed some concepts with relation to human-computer interaction. To summarize and present an overview over the relation between these concepts a framework developed by

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[11]As mentioned I prefer not to make any detailed assumptions about the nature of human thought processes. The terms used here is borrowed from (Winograd & Flores, 1985).

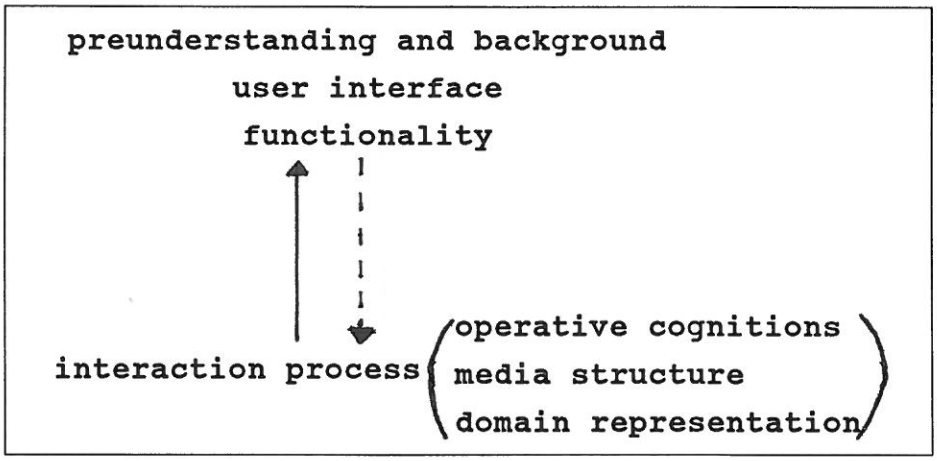

Figure 2: The interaction process and its related structures.

Mathiassen (1981) is used. Within this framework the relation between a process (for instance the interaction process) and its related structures can be illustrated.

Some structures are intended to be changed during the interaction process. Among these *interior structures* are the **operative cognitions**, the **media structure** and the **domain representation.**

Other structures limit and restrain the interaction process; they define the setting in which the interaction process takes place. Among these *superior structures* are the **preunderstanding and background** of the user and the **functionality** and **user interface** of the computer application. Although these structures are rather stable they might of course be changed; for instance because of needs arisen from one or more interaction processes.

The described relations between the interaction process and its related structures are summarized on fig. 2.

The Systems Perspective

When applying the systems perspective[12] one considers a phe-

[12]Different expositions of the systems perspective exists. One of the more famous ones is given by Churchman (1968). A good theoretical exposition can be found in (Holbæk-Hanssen, Håndlykken

nomenon as consisting of different components which basically have the same properties. All components are characterized by a set of data types and a set of actions which might involve the component itself as well as other components. Components can transfer data to each other, and each component can process data according to predefined rules.

Viewing the use of computers from a systems perspective makes one focus on use within a collective context. One takes a bird's eyes view on the organization, so what one sees is a collection of human and automatic components which through their interrelated actions perform some tasks. The relevance of the tasks can be expressed at the organizational level; not at the individual.

Seen from this perspective it makes sense to give guidelines for the design of user interfaces without analysing the contents of the interaction process; i.e. without knowledge about the task being performed by means of the system. All interaction is seen as transmission of data between a human and an automatic component, and the essential thing to worry about when designing user interfaces is to make this transmission effective and efficient; i.e. to make it possible for the user to act in a way similar to the automatic components.

As an example let me try to give a brief description of a Point-Of-Sales system (POS-system) as seen from the systems perspective. A POS-system might be considered as consisting of the components cash register terminal, shop assistant, file of goods in stock, administrative terminal, report writer, order writer, i/o-administrator etc. The shop assistant is considered as a part of the system and the functioning of the system requires that she, as all the automatic components, executes the operations defined for her as a component of the system. Among her operations are for instance "register number of goods",

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& Nygaard, 1975). Practical applications of the systems perspective to methods for systems development also exist; see for instance Lundeberg (1979), DeMarco (1979)/Yourdon (1982), and Jackson (1983).

"register amount of goods", "receive payment", "pay back", etc. When executing "register number of goods" and "register amount of goods" data are transmitted to the i/o-administrator, making this component execute actions like "tell file of goods to update", "receive price from file of goods","display price on cash register terminal". Again data are transmitted to other components which might make these other components perform some of their actions, etc.

As said earlier human-computer interaction as seen from a systems perspective deals with exchange of data between a human and an automatic component of a system. Transmission of data in both directions might take place. From the human to the automatic component transmission of data primarily takes place to change the *domain representation* or to ask for transmissions in the other direction. The *media structure* undergoes only minor changes, e.g. because characters are echoed on the screen or because errors are being reported. It is not seen as an explicit goal to change the media structure in a way which might lead to changes within the *operative cognitions* of the user; i.e. one does not deal with *how* the media structure is being changed.

Transmission of data from the automatic to the human component might take place either to document changes within the *domain representation* - for instance to reduce the error rate, to guide the user in a way which speeds up the transmission of data, or to deliver data which are intended to be used outside the system. The *media structure* is being changed during this process, but one does not deal with *how* it is changed - there is no concern with how data is presented to the human component. Data transmitted to the human component are intended to be used outside the system - not to change the *operative cognitions* of the user.

The above general statements can be illustrated by means of the POS-example. In POS-systems most interaction take place in a process where the shop assistant inputs numbers identifying goods with the result that the file of goods in stock (the domain representation) is updated, and text, prices, etc. is

written on the sales ticket, on the revise, and in the display (the media structure). It is at most a positive side-effect of this transmission of data intended to be used outside the system (i.e. by customers), if the shop assistant learns something (gets her operative cognitions changed) about prices.

When applying the systems perspective one sees the essential quality of a *user interface* as the ability to make sure that the transmission of data between the human and the automatic component takes place according to predefined rules. Standardization of the user interface and disciplining of the users is seen as a good solution. Interaction with a cash register terminal for instance typically takes place by means of function keys and optical scanner. This ensures a standardized interaction process with a limited risk for errors when the user delivers input to the system. Furthermore the lack of customization makes it easy to have the shop assistant shift between different cash register terminals.

Using the terms of Newman & Sproull (1979), we can say that seen from the systems perspective a user interface shall have standardized *command language*, use *feedback* primarily to report errors, and use the *information display* to make the transmission of data as effective as possible.

Now, what is the role of conceptual models as seen from the systems perspective? If we look at how systems development is being carried out the answer seems to be, that they play no role at all. Of course models of the system are designed during the development process, but they are typically expressed in information processing terms. Such models are of course not useless; they might be very useful for instance for implementation purposes. The problem is rather the lack of conceptual models suitable for the user, leaving it as the only possibility for the users to think and talk about the system by means of information processing terms. Theoretically it seems easy to develop system-oriented conceptual models. In the Utopia-project

we have for instance developed a description tool[13] with which it is possible to provide users with an overview of the system (i.e. how people, computers, tasks and material relate to each other) in a terminology which is rooted within the task domain. Such models are necessary for the user to feel secure when acting within the system, and to enable the user to handle unexpected situations. The organizational toolkit developed in the Utopia-project is suited for newspaper production, but similar tools might be developed for other domains.

Research on human-computer interaction based on the systems perspective has as its primary goal to find principles for interaction which speed-up and reduce the error-rate in the transmission of data between human and automatic components of a system. Many of the so-called "human factors experiments" have for instance had as their goal to find the fastest and most safe way to transmit data in different types of systems. Shneiderman (1979) mentions some experiments of this type. For instance, some which have shown that screen-oriented editors under certain conditions are faster to use than line-oriented editors, and some which have shown that a mouse is faster and safer to use for selection of text than joystick, step keys, or text keys.

Research of this type is of course not bad in itself. But it is necessary to understand, that quantitative research never can stand alone. It must only be a small part of the whole picture in which more qualitative aspects play a major role. Qualitative aspects become visible if the use of computers is viewed also from other perspectives than the systems perspective.

The main advantage of applying a systems perspective is that it becomes possible to get an overview of the totality. One becomes able to see the different components and how data flows between these components. So analysis and design of data flow is well supported by the systems perspective.

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[13]See (Utopia, 1985a) p. 37, or, if you read Swedish, (Utopia, 1985b) p. 97-111, for a description of "the organizational toolkit".

In relation to human-computer interaction the essential disadvantage of the systems perspective is that it does not allow to consider interaction as anything else than data transmission. Another major disadvantage is that humans as well as computers are viewed as data processors. The user interface is seen as just another interface between two components. So, during design it becomes more essential to find out how to distribute the required data processing among the human and the automatic components than to deal with design of user interfaces. A third disadvantage is that the organization is viewed from the top, and that the organization is viewed as a structure whose important aspects both can and shall be formally described. So when applying the systems perspective one tends to reduce the jobs of the human components within the system to algorithmic procedures, because one is not allowed to consider aspects of a job which cannot be described as data processing. This makes the systems perspective bad suited as the only perspective applied during design of a computer application.

The Dialogue Partner Perspective

A perspective on the use of computers which plays a role especially within the AI community is the dialogue partner perspective. When applying this perspective humans and computers are regarded as partners in a dialogue. The interaction process is regarded as a communication process in which user and computer application act as both sender and receiver, and the computer application is seen as being able to show communicative behaviour similar to that of its human partner.

When applying the dialogue partner perspective one focus on use within an individual use context. What one sees is one user communicating with a computer application to get some task performed. It is seen as meaningful to give guidelines for the design of user interfaces without knowing the contents of the interaction process. It is seen as the essential quality of a user interface, that it is able to make the computer application

act like a human being in a communication process.

As an example let us look at a computer application for ticket reservation within an airline company. With such an application it is possible to ask questions about for instance flights, destinations, routes, prices, discounts, etc. and to reserve seats on flights. Seen from a dialogue partner perspective the ideal is, that a user can "communicate" with this application in a way similar to the way communication between humans takes place; i.e. based on knowledge about the domain but without knowledge about the domain representation within the computer.

As human-computer interaction is considered similar to interpersonal communication the interaction process is seen as mainly changing the set of informations available to the dialogue partners. So the essential changes occur within the *domain representation* and the *operative cognitions*. The *media structure* serves as a kind of communication media between the two partners, so changes within this structure occur only to provide the dialogue partners with information. Changes within the media structure play no role independent of the way they are able to affect the other interior structures. When for instance interacting with the computer application for ticket reservation the important changes are either of the domain representation (for instance when reserving a ticket) or of the operative cognitions (for instance when gaining information about the flight schedule). Changes of the media structure are only important if they support the other changes; so they loose their meaning short after they have occured.

When applying the dialogue partner perspective the focus is on the user interface rather than on the functionality. It is the user interface which has to be designed in a way which makes it possible to have the computer application act as a dialogue partner. This does, however, not mean that people who adhere to this perspective find it applicable to all types of computer applications independent of the functionality. The dialogue partner perspective is typically used when developing computer

applications to be used for what in a very broad sense of the term might be called "consultation purposes".

As communication between humans is seen as the ideal natural language of course is seen as a very important component of the user interface. Both spoken and written communication must be possible. In the terms of Newman & Sproull (1979) the ideal is a *command language* as close as possible to natural language, *feedback* which allow for meta-communication on for instance the functionality of the application, the focus of the conversation, etc., and *information display* similar to natural language constructs.

When applying the dialogue partner perspective one does not see any need for explicitly designed domain-specific conceptual models. Independent of domain and functionality one can always use the same model as basis for the use of a computer application; namely that the computer acts like a human being in a communication process. So to use a computer only requires communicative abilities. If one is unfamiliar with certain aspects of the user interface or the functionality one can just ask - the computer application is considered able to explain everything about itself. Similar, if one does not understand what is "said" by the computer, one can ask for further explanation.

Research on human-computer interaction based on the dialogue partner perspective primarily deals with how to make computer applications good dialogue partners. The "graceful interaction" research program[14] is a good example of research within the area which is based on this perspective. It deals with problems like how to make communication with a computer *robust*, how to allow for *flexible parsing*, how to represent *domain knowledge* within a computer application, how *explanation facilities* shall be designed, how to keep track of *goals and focus* during a conversation, how to *identify entities* from ambiguous or

[14]This research program is carried out at the Carnegie-Mellon University. See for instance (Hayes, Ball & Reddy, 1981), (Hayes & Reddy, 1983) and (Hayes & Szekely, 1983).

unsatisfiable descriptions, and how to *generate sentences* which fit into the context of the conversation. Not all of these research areas are limited to be of interest only if one shares the underlying perspective. Many problems concerning flexible parsing, domain knowledge and explanation facilities are for instance relevant to be concerned with, even if one as argued by both Weizenbaum (1976), Winograd & Flores (1985) and Dreyfus & Dreyfus (1986) find that a perspective, in which computers are seen as having human capabilities, is doomed to fail as basis for design of computer applications.

As I see it the major strength of the dialogue partner perspective is that one becomes aware of, that it is possible to learn *something* about how to design user interfaces from analysing human communicative behaviour. Unfortunately this is also its major drawback because, as it can be seen from many AI approaches to user interface design, there is a risk that this approach is used far beyond its limits. It is simply contempt for the power and complexity of natural language use, when it is claimed that computers are able to act as dialogue partners in processes similar to interpersonal communication. Winograd & Flores (1985) argue that breakdowns always will occur during an interaction process. Only applying the dialogue partner perspective when designing user interfaces means not taking this into account. And potential breakdowns not dealt with during design are often hard to deal with during use. So, the dialogue partner perspective is only to be used for very specialized purposes, and only when combined with other perspectives.

The Tool Perspective

When viewing the use of computers from the tool perspective one focus on individual use. A computer application is seen as providing the user with a toolkit containing tools which under complete and continous control of the user can be used to fashion materials into more refined products. One does not

see the characteristics of the computer and the human user as comparable. So it makes no sense to use analogies between humans and computers as basis for the formulation of design principles for user interface design. On the contrary the user is seen as a person who has skills relevant within the domain, and the development of computer-based tools is based on, that the tools are to be used by skilled users to create high quality products. So design principles for user interface design are seen to be based on detailed insight into the contents of the interaction process.

The tool perspective is deeply influenced by the way the development of tools has taken place within handicrafts. The ideal is that a new tool is developed as an extension of the accumulated knowledge of tools and materials within the domain. So, viewed from this perspective development processes must be carried out by common efforts of skilled, experienced users and computer professionals. Users possess the tacit skills necessary as basis for analysis and design but they also have to get insight into technical possiblities to be able to develop technical fantasy. The computer professionals have to spend much time trying to get insight into the domain to be able to act constructively during design. At the same time technical skills at a high level is required because tools which from a users point of view are simple and powerful might be technically complex. Göranzon (1983), for instance, compares the role of the designer with the role of the constructor of tools for surgery, who necessarilly must have deep insight into surgery, must work together with surgeons, and must have the relevant technical skills (i.e. know materials and design techniques, etc.).

New tools are not designed by analysing and formally describing skills and knowledge of the users. According to the tool perspective essential parts of the qualifications relevant when using tools are tacit skills, which neither can nor shall be described at all. The intention is not to automate parts of the work process but to develop more powerful tools to be operated by skilled users.

In the Utopia-project the tool perspective has played a central role in the design of computer-based tools for page make-up and image processing[15]. Let me as an example give a brief description of computer-based page make-up. Page make-up is the process in which a make-up person puts together articles, pictures, ads and graphic materials to form a full newspaper page. To design computer-based make-up tools means focussing on presentation of materials and design of a tool-kit. Materials must be shown as close as possible to the way they really look. Tools must be formed by combinations of interaction devices and programmed operations, and they must be formed to give at least as good possibilities as with traditional tools for page make-up. There must be tools, for instance, for selecting, moving, centering, indenting and leading materials. But also new and more powerful tools, for instance for positioning and creation of graphic materials must be designed. During the work process the make-up person might for instance use the mouse (and a drag operation) to move materials from the work area to the page ground and position the material by different tools for instance for flowing into columns or for exact positioning.

Seen from the tool perspective choosing a tool, using it, and evaluating the result of its use is a typical sequence of actions repeated over and over when using a computer application. Interaction with a computer application is a process of applying a tool to some material and evaluating the result. The *media structure* has to reflect the way materials get changed when a tool is used. So changes within the media structure play an important role for the user's possibilities to evaluate effects of actions taken, and in this way also how the *operative cognitions* might be changed as an effect of the actions. The *domain representation* is of course also affected, but it is typically important to the interaction process only when it is reflected in the media structure.

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[15]Detailed descriptions of these applications can be found in (Utopia, 1984) and (Utopia, 1985c). An overview is presented in (Utopia, 1985a).

When doing computer-based page make-up it is important that all changes are reflected in the media structure, because the make-up person continuously evaluates (gets her/his operative cognitions changed) the effects of applying a tool to the material. Of course the domain representation might be changed without being immediately affected in the media structure, if for instance the make-up person performs a sequence of operations, which he/she feels completely sure about the result of. What is important is that the make-up person always has the possibility to choose to have the media structure reflect such changes.

Applying the tool perspective requires that it makes sense to talk about materials and tools within the domain. Not necessarilly in the literal meaning of the terms; but at least when using the terms in a broader meaning. An essential quality of the *user interface* is that materials can be presented to the user in a direct way. So, in the terms of Newman & Sproull (1979), *information display* primarily deals with presentation of materials, but of course also with how to present the set of tools available. The *command language* must allow for choosing among tools and applying tools to materials. How to apply tools to materials will depend strongly on the domain. For some domains, as for instance page make-up, direct manipulation by means of analogue interaction devices will be in line with traditions, but for other domains it might turn out that textual commands are a more natural solution. The *feedback*-component of computer applications very much overlaps with the *information display*-component, because direct presentation of materials also provides the user with immediate feedback on operations.

A theoretical understanding of the qualities of a user interface seen from the tool perspective can be gained by considering the theories of Polanyi (1958). Polanyi distinguishes between two points of awareness for the user of a tool: the *focal point of awareness*, defined as the interface between tool and material, and the *subsidiary point of awareness*, defined as the interface between user and tool. What a user really wants to worry about is what happens when a tool is applied to some

material, not how the tool is to be handled. So according to Polanyi a good user interface is one which "disappears" during our use of tools (i.e. one which we do not have to deal with intellectually during our use of tools). Only when a *breakdown*[16] (i.e. an unexpected situation) occurs it becomes important for the user to be able to deal with the user interface.

From the point of view of the tool perspective conceptual models play a key role in relation to both design and use of computer applications. **User models**[17] based on traditional concepts of the domain but enhanced with concepts, necessary to understand new possibilities and restrictions imposed by computer technology are relevant for multiple purposes. They are useful as means to support design of both functionality and user interface. In education they support activities aiming at the creation of conceptual competence. And during use they support the user by making it possible to filter away technical distortion; i.e. to deal intellectually only with the focal point of awareness.

In diSessa's (1985) terms user models are structural models. They will typically be based on one or more analogies relevant within the domain. The desk-top model of the Xerox Star (Smith et al., 1982) and the Apple Lisa/Macintosh (Williams, 1983) is one of the best known user models, but also within more restricted domains than office work there have been attemps to develop user models; the "desk-and-lense-models" for page make-up and image processing developed within the Utopia-project being an example of that.

A user model is more than a model of a computer application. Having its roots within the task domain it plays an important

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[16]See (Winograd & Flores, 1985) chapter 3 for a discussion of Heideggers theories on *break downs*, i.e. the situation which arises when a phenomenon shifts from being *ready-to-hand* to being *present-at-hand*.

[17]See (Kammersgaard, 1985) for a detailed discussion of the role of models as seen from the tool perspective.

role in the process of augmenting the professional language[18] so that aspects concerning the use of the computer application can be expressed within this language. So it is reasonable to say that a user model is a model of how and for which purposes the computer application can be used within the domain.

Literature on human-computer interaction is rather scarce on reports on research explicitly based on the tool perspective. Of course a lot of results from basic research especially within computer graphics are relevant seen from this perspective because of its focus on interaction processes which affects the media structure heavily. But, results concerning interaction can according to the tool perspective only be generalized to a limited extent; so, research primarily has to take place in relation to specific domains. The Utopia-project[19] is one such example, and recently another project, called the Dialog-project has started research on human-computer interaction in relation to computer applications for architects[20] and for graphic workers[21].

An unfortunate tendency in much research concerning user interfaces is that it seems to be the overall goal to make applications easy to learn. This leads to a tendency towards development of computer applications which possibly are easy to learn, but which are not sufficiently powerful to accomplish the task they have to deal with. Learnability instead of efficiency becomes the main goal making such applications unsuited for skilled work. Research based on a tool perspective has to be heavily concerned with functionality. User interfaces supporting learnability is of course a good thing; but as development of

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[18]See (Andersen & Holmquist, 1985) for a discussion on the impacts of computerization on professional languages.

[19]Aspects especially concerning human-computer interaction are described in (Blomberg, Frenckner, Kruse, Lönnemark, Romberger & Sundblad, 1984).

[20]See for instance (Ekeberg, Engblom, Kjelldahl, Lundequist & Thörnblom, 1984).

[21]See (Sundblad, 1984a), (Romberger & Sundblad, 1984), (Sundblad, 1984b) and (Sundblad, 1986).

powerful tools must be the main concern, domain-specific skills is always a prerequisite for a computer application to be easy to learn. So for an amateur computer-based tools are not necessarily easy to learn.

The main advantage of the tool perspective is that it views the skills and qualifications of the future users as the most essential prerequisite for design. Its focus on individual use only is its main disadvantage. Only aspects concerning relations between user, tools and materials are taken into account, making it impossible to deal with aspects at the interpersonal or organizational level. So, even the tool perspective is badly suited as the only perspective applied during design.

The Media Perspective

Viewing the use of computers from the media perspective means considering the computer as a medium through which humans communicate with each other; i.e. something which is comparable to newspapers, books, films, television, telephones, video, etc. Many central aspects of for instance mailing systems, conferencing systems, and systems for distance teaching comes to the front when viewed from the media perspective, but also applications where the media aspects play a minor role, as for instance POS-systems, can be understood meaningfully from the media perspective.

When humans communicate we can distinguish between the level of **expression** and the level of **meaning.** A **sender** uses signs intending to express the meaning to a **receiver.** The receiver interprets the signs in order to try to understand the meaning. The computer as a medium for communication can manipulate the level of expression only, but as opposed to most other media the computer might be used both for creating "ordinary" relations between expression and meaning (i.e. plain text, pictures, etc.), and for creating more advanced relations by means of program executions.

Applying the media perspective makes one focus on use within

a collective context. There must be more than one user to make it meaningful to talk about communication. The level of meaning (i.e. the contents of the communication process) is seen as the main source of guidelines for user interface design. One always must try to establish a relation between the level of expression and the level of meaning which makes the level of expression support correct interpretations.

Seen from the media perspective two types of communication are interesting. First of all communication between (groups of) users taking place through the computer application. Secondly, the one-way (mass) communication from designer to user which takes place when an application designed by one person is used by other persons. I will not go further into detail about this last type of communication, but just mention that Oberquelle, Kupka & Maass (1983) talk about delegation of communicating behaviour from the designer to the machine, and then treat the situation as seen from a dialogue partner perspective, whereas Andersen (1985) treats the designer as having the role of one sender in a collective of senders, who gives a contribution to each message sent through the medium.

Let me as an example try to look at a computer-based conferencing system. Suppose there exist an interest group on user interface design. All members of the group receives all letters assigned to that topic. So, each letter has one sender and many receivers.

If I as a member of the group have written a paper on new user interface facilities for reading computer stored documents, I would have the system distribute it to all other members to have it commented. In a well-designed conference system I must, to be able to illustrate my ideas, be allowed to have the paper presented to the receivers by means of the new facilities described in the paper; i.e. I must be allowed to write programs which controls the level of expression, for to make it more likely that receivers will make a correct interpretation.

Viewed from the media perspective interaction takes place

to send and receive messages; i.e. to change the *operative cognitions* of the persons involved in communication. To make that happen the *media structure* plays an important role because its state is viewed as a sign to be interpreted by the receiver. The *domain representation* might be important for the sender to be able to formulate a message, but to the receiver it plays no role unless it is reflected within the media structure. If for instance a person distributes a note on some topic via a conferencing system to the members of a group on that topic this is done to change the operative cognitions of the potential receivers, but this is only likely to happen if the media structure reflects the ideas of the sender in a reasonable way, by means of text, graphics, pictures, "movies", etc. How the domain representation is affected during the interaction process is unimportant to the receiver, and only important to the sender if the domain representation can be used to design the expression level of the message.

If we look at user interfaces from the media perspective the components discussed by Newman & Sproull (1979) fit in nicely. The *command language* defines what is available for the sender to express the message. The *information display* defines how the message is presented to the receiver. And *feedback* is seen as messages from the designer.

Andersen (1985) sees the computer as a medium in the context of speech-acts[22]. In this context he has formulated some general guidelines for the design of user interfaces, concerning the types of speech-acts the user interface (i.e. the means of expression) shall allow for. His overall demand is that the speech-act must have a reasonable chance to succeed. To make that possible it is required, that the expressions clearly must indicate the type and effect of the speech-act under execution, that sender and receiver of speech-acts are clearly indicated, that sender and receiver can gain information about each others

[22]See (Winograd & Flores, 1985) chapter 5 for a brief computer science oriented introduction to speech-act theory, or (Searle, 1969) for an exhaustive description.

context of interpretation, and that the means of expression are designed on the basis of aesthetic considerations about the potential contents level of the communication. Furthermore he claims that it is necessary to be aware of the existence of many different contexts of interpretation when designing the means of expression. Finally, he claims that standardisation shall be restricted as much as possible and only be allowed if good arguments explicitly are given, and that users must have the possibility to modify the means of expression when new needs arise.

As mentioned the basic view on user interfaces is that more specific guidelines for the design of user interfaces derive from the functionality - the expression level must be designed on the basis of knowledge about the contents level. This view is applied both when dealing with communication between different users of the medium, and when dealing with the establishment of connections to the medium (i.e. actions similar to dialing a phone-number), which is considered as designer-user communication.

From the point of view of the media perspective conceptual models are important to develop to make the application fullfil the requirements listed above. Andersen & Holmquist (1985) discuss the role of user models in the struggle between the two professional languages (designer's and user's) involved in design of computer applications. By letting concepts from the user's professional language denote types, variables and operations within the application and having them connote their oldfashioned meaning they become valuable corner-stones in the formulation of user models. It is claimed[23] that this interference of professional languages makes it possible to make situations, where the model "breaks down", productive in the sense that it becomes possible for the user to leave the current frame of reference and create a new one.

Research on human-computer interaction from the point of

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[23]See (Andersen & Holmquist, 1985) p. 43 ff.

view of the media perspective is very limited. At the Department for the Integrated Study of Computer Science and the Humanities, at the University of Aarhus some relevant activies have been going on during the last couple of years[24]. These activities are mainly concerned with the relation to semiotics and language.

An overview of more technically oriented activities relevant to this perspective is given by Bannon (1985), who describes different technical possibilities for computer-mediated communication and gives some concepts to characterize the different types of computerized media available. This characterization is based on a two-dimensional subdivision where one distinction is between synchronous and asynchronous facilities and the other distinction is between the extent to which transcripts are important.

As I see it the main advantage of applying the media perspective is that it makes one focus on the language aspects of the use of computers. In relation to many computer applications these aspects are important to consider, but there are always other aspects which must be considered too. For some applications, as for instance CAD-systems, other aspects are even more important than the language aspects; so, also the media perspective is bad suited to be the only perspective applied when dealing with the use of computers.

Discussion

In the last four sections I have described four different perspectives on the use of computers. It should be clear from the description that I find the dialogue partner perspective problematic. Although it has gained widespread acceptance, I find its relevance very limited. I find the other three perspectives relevant, to a greater or smaller extent, no matter which applications one deals with. To understand for instance how computers are used in newspaper production the systems

[24]See (Andersen, 1985) and (Holmquist & Andersen, 1985).

perspective is useful when dealing with the flow of materials between different departments, the tool perspective is useful when dealing with the use of computers for typesetting, page make-up, image processing, etc., and the media perspective is useful when dealing with the use of computers for communication between journalists, editors, typographers and others.

An exhaustive discussion of cases in which multiperspective reflection will prove useful is outside the scope of this paper. So, I will present a few different situations which illustrate the relevance of multiperspective reflection, and then leave it as an exercise to the reader to rethink own experiences in the light of my standpoint.

Let me start by discussing aspects concerning POS-systems. As I have stated earlier design of POS-systems is traditionally viewed from the systems perspective. This makes one consider many relevant aspects - but not all. If for instance asked by some shop assistants how a POS-system will affect their jobs, one will only be able to tell something about which data they have to deliver to the system and which data they will receive. One will not be able to see the system as it looks when having the job of a shop assistant; something which is useful to get ideas about facilities that can improve their work situation. If, for instance, one also took the tool perspective into account one would be aware of some possibilities to have the POS-system serve as a tool for the shop assistants. Shop assistants are often asked by customers about thing like: where to find the coffee; or if it is possible to find a mouse trap; or the price of a bottle of tonic water. Making it possible to get such information by means of the cash register terminal would be a great help for the shop assistants. If not being able to answer the customer immediately one could make a request to the database, and then tell the customer for instance that the coffee is placed in the back left corner; that the shop is out of mouse traps, but that they will be in stock again in a week at a price of 25 kroner; or that tonic water is sold at 3 kroner a bottle or 16 kroner for a six-pack.

Also the media perspective might prove useful in this situation. A POS-system is used as a medium for communication between, for instance, shop assistants and managers. Through the POS-system shop assistants are transmitting data to managers about for instance how long time they spend at the cash register terminal, how many customers they serve, and how many money they receive. These data will typically be seen as usable to measure the productivity of shop assistants. Viewed from a media perspective this looks problematic. Shop assistants does normally not intend to send messages about their own productivity as a part of their use of the cash register terminal; but the POS-system can be designed so that they cannot avoid it (i.e. they can be forced to communicate). Furthermore shop assistants does not think about their own productivity in terms of earned money or number of served customers per hour. So, they do not think about the messages as telling the truth about their productivity. If the managers do that, senders and receivers have such a different context of interpretation, that the speech-act has no chance to succeed.

Another good example deals with the need for models within newspaper production. Both to be able to design an integrated, computer-based system for newspaper production and to be able to work with newspaper production, one needs system-oriented conceptual models. Obviously one needs to know where different types of information is produced, how it flows around, and in which ways it is manipulated. But when using a typesetting system, one cannot do only by means of such models. One also needs a model which makes it possible to handle the typesetting job; i.e. a model based on the tool perspective dealing with how materials (i.e. types, lines, columns, etc.) is represented and which tools is available to manipulate them.

At the moment the typical situation in the newspaper industry is that a user is presented to some syntactic model (i.e. the command language) which has no or only very few connections to the semantics of typesetting and the connected professional language. The terms used in such models are typically very

closely tied to the applications of one particular vendor. So, instead of giving computers a position within the language of the profession, we arrive at a situation where the professional language at one place is messed-up with one set of vendor-specific technical terms, and at another place is messed up with another set of vendor-specific technical terms.

When applying the tool perspective one would start out by considering the professional language of typesetting to make it possible to develop a model which is both semantically and syntactically consistent with the traditions of the trade. Based on that one could try to enhance the model in a consistent way to make it possible to cover facilities made possible because of computer technology. Given such a model the user interface, of course, still can be designed in many different ways; but no matter which design a vendor choose it will be possible for the users to refer to the same underlying model. In this way computers are given a place within the professional language making it possible for instance to make education in computer-based typesetting much less vendor-specific.

As a final example I will try to add a few comments to the conferencing system example dealt with in the description of the media perspective. I already have argued that applying the media perspective gives valuable insight when dealing with such systems. But one cannot do with that alone. During design one must apply the systems perspective to be able to deal with components of the system, for instance to find out how to distribute messages, how to design an efficient administrative component, and which administrative data users have to deliver.

Also during use one must now and then be able to apply the systems perspective. If for instance one knows when a paper is delivered, one will start wonder if it is not received after two days. To understand that, one must know that the system consists of a network of components many of them interconnected by physical connections, so that an explanation might be that some interconnections or components are "down".

The tool perspective may also be useful in relation to design

and use of a conferencing system. For instance can facilities for creating, commenting and administrating papers meaningfully be considered as tools both during design and during use.

I have both in a theoretical setting and by means of examples dealt with some different perspectives on the use of computer. To summarize: The message is not that one of them is the right one; not even that a single one of them is best suited to understand the use of a given application. The point is rather that by shifting between some or all of the described perspectives it becomes possible to gain a better understanding when designing and using a particular computer application. This standpoint is very much in line with diSessa (1985) who advocates for the necessity to deal with **distributed models** (i.e. models accumulated from multiple, partial explanations when wanting to learn how to use a computer application.

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