DISCOVERING THE HUMAN ACTORS IN HUMAN FACTORS[1]

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1 Introduction: A Question of Perspective

This essay discusses some problems and prospects for the field of human factors or ergonomics, specifically the more recent, and diversified field of human-computer interaction. Its main aim is to develop awareness of how an often unarticulated, though dominant perspective in the field can blind us to other more fruitful conceptions of human-computer interactions, and to emphasize the importance of shifting perspectives in the design process.

1.1 What's in a Name?

The terms we use to describe the objects of interest in a domain can be seen as reflecting our underlying conceptions about the domain. Naming things, as well as being a primordial human activity, has often had important social consequences (eg, being called a "witch" in the Middle Ages had rather unpleasant consequences for the person so named!). Through naming we can make the unfamiliar familiar, and vice versa, we can categorize, and reflect and act on the basis of these named objects. Once accepted, these terms can become a barrier to the reality that lies outside. For this reason, it is a useful exercise from time to time to re-examine the language we use to express our understanding of the world. Some of the concepts in the field of HCI are worth examining in this context, albeit briefly.

1.2 From Human Factors to Human Actors

I have chosen to highlight the human factors -human actors distinction in the title of this essay as it emphasizes the fundamental shift in perspective that can be brought about through naming. In other words, I claim that traditional human factors work, although it undoubtedly has merit, and has produced many improvements to existing technological systems, is often too limited in scope with respect to its view of the person. Within this approach, the human is often reduced to being another system component, with certain characteristics, such as limited attention span, faulty memory, etc. that need to be factored into the

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design equation for the overall human - machine system. This form of piecemeal analysis of the person as a set of components de-emphasizes important issues in work design such as human motivation and personality characteristics. People are more than a sum of parts, be they information-processing subsystems or physiological systems,they have a set of values and beliefs about life and work. It is the case that some researchers include such issues as work motivation and the desire for meaningful work under the topic of human factors, but this more encompassing interpretation of the human factors field is not signalled by the name, nor the bulk of studies appearing under this topic in the journals so designated. By shifting the term to "human actors" stress is placed on the person as an autonomous agent that has the capacity to regulate and coordinate his or her behaviour, rather than simply being a passive element in a human-machine system. The shift in terminology produces a shift in our perspective, emphasizing the wholistic nature of the person acting in a setting, in contradistinction to the view of the person as a set of information processing mechanisms that can be analysed in conjunction with the information processing mechanisms of the technology. (Related concerns about the role of human factors can be found in the work of Bjørn-Andersen, in a paper entitled "Are human factors really human?" (1984). He also mentions this human factors/ human actors distinction, which I develop here, in Bjørn-Andersen (1986)).

1.3 The Concept of "Users"

Continuing our brief review of terms in the field and their hidden assumptions, take the concept of "users" that is ubiquitous in articles about the field. This general term refers to all people who use a particular computer system, or application. It can be distinguished from the term "operators" in that the latter implies a greater involvement with the machine or system, presumably one where the person is more uniquely assigned to the device. From the system design or human - computer interaction (HCI) research point of view, the term "user" can be seen as very egocentric. Our focus is on the technology, and our view of people is often simply as "users" of this piece of technology, and "naive users" at that! This can lead to problems. People may not know the technology, but they are not "naive" as to their work, rather it is the system designers that are "work naive"! There is nothing inherently wrong in taking this stance - talking of "naive users", though I prefer the less judgmental terms "casual" or "discretionary users" - for periods when designing computer applications, but there is a danger in thinking of people as nothing but "users". This can blind us to the fact that the "users" view of the technology we are developing may be very different to that of the designer's. From another perspective, the user is often a worker that has a set of tasks to perform, and their use of the computer may only be one element necessary to the accomplishment of their work. Neglecting this can lead to unworkable systems, due to the fact that necessary interactions between people and devices in the workplace may not be supported on the system, since the system designer never viewed the use of the system from this perspective, but persisted in having a machine-centered view of the overall human-machine system. It is the ability to shift perspectives, to be able see a problem from more than one viewpoint, to be able to empathize with, and understand the viewpoint of the users of the intended system that mark the good design team.

To try and encourage this shift in perspective away from a machine-centered to a user-centered view, we can witness the explicit usage of such "user-centered" terminology (see e.g. the title and contents of Norman & Draper (1986)). I just wish to flag this issue here to note that although talking of a "user-centered" approach to system design is an improvement, perhaps reflecting on the term "user" itself at times, as we do above, might be rewarding, and help us take a more appropriate view of users as people with work tasks and relationships which need to be also taken into account in the design of systems, especially those computer systems that are designed to support more general office functions, for example.

1.4 Active Users

While focussing attention on the user may be a positive step, we also must note that users (we will use this term frequently in the paper, though with the above caveat in mind) are not passive organisms which we must study and design for, but that they are active agents, wishing to accomplish tasks, to understand what is going on, and willing to jump ahead and explore on their own if the material is unclear or too pedantic. If the system does not give an explanation for its behaviour, the user will often try and make one up, in order to render the doings of the system comprehensible. People are always struggling to make sense of their world. Developing instruction sequences for users that are to be followed by rote, with inadequate explanation, fail to satisfy, or to work in most real situations. By way of illustration, here are the words of an office worker I interviewed that capture her wish to understand, to learn what's going on, that we should be aware of, and design for, in system design .

"People have to know how to understand, they have to be able to rationalize things out, to work things out, in a logical sequence. If they don't understand something, or how it works, then they have to go back to either just learning it by rote, or by asking, or by just making the mistake, and going back, and asking, and then correcting. But if you understand the system a little bit then sometimes you can think it out ....and if you can reason it out then it stays with you longer - it's easier to understand, to work with. But if you are just learning piecemeal, then you can't. If you are just learning by rote.....someone tells you, this is the way to do it,then you can memorize it, but you'll never fully understand it, and [never] be able to expand from there." (Direct quote from an interview I did at UCSD, 1983, with an office worker. See Brown (1986) for further argumentation on this point).

This is one area that has been the subject of investigation, with Carroll and his colleagues at IBM especially prominent (see Carroll and Rosson, 1987, for a synopsis of this work). Faced with this information, we should be careful about how we think about the capabilities of users. Just because thay do not understand how the machine works, or have difficulty with the system designer's terminology does not imply that they are stupid. The idea that we must design system' s so that "any idiot can use them" needs to be subjected to close scrutiny, quite apart from any moral reservations one may have about viewing people as idiots. Taking this as a serious design goal can often result in systems that necessarily produce such stupid behavior (see Bannon, 1986a, for further comment). Again, it is suggested that the system designer start out with the belief that workers/users are competent practitioners with whom the system designer must collaborate with, in order to develop an appropriate computer system.

2 The Field of Human Factors and Human-Computer Interaction

2.1 Origins

The field of human factors is ostensibly concerned with building machines and artifacts in general in a way that fits more appropriately to human capabilities. While this goal is a laudable one, the particular context in which the field arose and developed is interesting. One can really trace a central strand in the human factors movement back to the work of the American engineer Frederick Winslow Taylor at the turn of the century, whose concern about the "one best way" of doing things involved him in very detailed analysis of manual worker's tasks and the tools they used to accomplish those tasks. From such studies, Taylor devised new artifacts for particular use situations, and determined the exact motor movements that the worker should perform to be efficient and maximize output. He was concerned about rationalising production, and concentrating knowledge of the work process in the hands of management, who could then instruct workers in the "correct" and most efficent means of carrying it out. Ideally, the workman would not be required to think about his actions - the separation of the conception of the work from its execution would be complete. To emphasize this, Taylor admitted that his ideal workman (for the manual tasks he had been studying at the Bethlehem Steel Foundry) would be "an ox"! Although his approach was called "Scientific Management", his interest was very much geared to the needs of managers and maximizing througput, rather than with scientific exploration per se, and certainly not with humanizing the workplace. Indeed, the whole concept of Taylorism became a cause celebre between labour and management due to the degrading way in which the "human element" was treated , with little emphasis on what motivated people to work other than straight economic gain. The later work of Frank and

Lillian Gilbreth, who performed more scientific time and motion studies on workers in various occupations and are more openly accepted as founders of the human factors movement, was not as closely connected with the needs of corporate business, but more research oriented, (see Giedion, 1948, for a brief account of their work) although many of their findings were useful to management.

So we see that from the very beginning the human factors movement has had a somewhat ambiguous connection with the improvement of the human condition, although it certainly contributed to more efficient human-machine systems. Much of the work was done at the behest of management and used to constrain worker freedom and autonomy. People were fitted to the machine, rather than vice versa. The same story was true in the area of selection of personnel for various jobs, where testing was performed by industrial psychologists to weed out those deemed unsuitable. Human values, the idea of meaningful work, did not enter into these schemas for some considerable time, and are missing in much of the classical-type work to this day. It appears that much of the basis of design in our society proceeds with a very strange mix of ideologies concerning work design, one part of which is concerned with de-skilling work and reducing labour to more peripheral and elemental processes, and the other that seeks to improve the quality of working life for these same people! This is a topic that has been commented on very succinctly by the engineer and scientist Howard Rosenbrock (1981). He deplores the gross misalignment between human abilities and the demands of many jobs and argues for the development of more "human-centered" systems, systems that allow workers to develop and build their skills in conjunction with the technology, and not systems that make these earlier skills redundant, with often a consequent loss to the world of such skills after a generation.

2.2 From Human Factors to Human -Computer Interaction

In the early days focus was more on getting machine systems to do something useful, and the concern with how easy it might be for someone to learn how to operate the system to do it, or invoke the required functions of whatever form, was not considered a high priority. People could be trained to perform whatever operations were required. As computing developed, the same was true, as those using the device spent years learning an arcane language to communicate with the system. This began to change as more people from disciplines outside of computing realised that the computer was just a symbol processing device that could be used on many different kinds of projects, not simply mathematical or statistical analyses. So the user community changed from one that was focused intrinsically on studying the properties of the machines themselves to discretionary users, people who saw themselves as having a job or profession that was not primarily geared to the computing medium itself, but wished to use it as a useful tool. This shift was encouraged by the spread of personal computers into the commercial world, making computational resources available to a much wider variety of people than heretofore.

Faced with this expanded user base, companies realised that the interface to their systems could make a huge difference to their attractiveness, indeed determining if the system would be used at all. It was in this context that the field of human-computer interaction (HCI) developed, encompassing a broader range of people and disciplines than the older, more traditional ergonomics or human factors type groups which had existed earlier in some settings, mainly working within military high-performance environments e.g. fighter aircraft cockpit displays, or in general occupational heath and safety environments, e.g. determining noise safety levels. Major influences in this expansion were cognitive psychologists, who realised that making a good computer interface was a matter not simply of physical, but increasingly, of cognitive ergonomics, and of software engineers, who were experimenting with the design of highly interactive interfaces, becoming concerned about how to conduct dialogues with users and how to present complex information to users effectively.

Over the last decade the area of human-computer interaction has grown enormously, both within academic research environments and corporate research laboratories. Despite the widespread interest, there is no clear set of principles that has emerged from this work. The experience of certain designers has been loosely codified, various long lists of design guidelines are available, and a large number of evaluations of existing systems have been produced, but the attempt to place this applied science on a more rigorous footing have not born fruit. Cognitive psychologists have studied particular issues, and we now know a lot about how people learn to use word processors, about the kinds of errors they make on different systems, about the mental models they attempt to construct of systems, but the application of such findings to new situations is not obvious. From the perspective of the designer, the work to date can highlight some pertinent issues, but in the search for new ways of thinking about and developing systems, there is not a lot that the field can offer.

3 Beyond current conceptions of HCI

Despite the legitimate advances that have been made in various arenas of human computer interaction (see Shneiderman (1987) for a collation of some of this material), there has been serious criticism of the field for its lack of relevance to practitioners in the systems design field. Commenting on a recent collection of papers (Carroll, 1987) that purported to sample current theoretical contributions to the HCI area, the reviewers' (Gray & Atwood, 1988) noted the lack of any examples of developed systems in the papers and the general lack of contact of the work with "real world" design situations. They explicitly state that the skeptical designer will not be convinced of the relevance of the cognitive sciences to the design of better human-computer systems based on this work. Within this collection, a discussion section by Whiteside and Wixon (1987) makes a number of pointed observations about the limitations of cognitive theory in its application to everyday design situations. There are a number of limitations in much of the current thinking about HCI that need to be remedied in order for the field to be more useful to designers in practical situations. I believe that the field must be seen from other perspectives, if it is to become more useful in the design and use of computer systems. Specifically, I believe we need to shift our focus somewhat, in the following directions:

3.1 From the Individual to the Group

The majority of HCI studies to date take as their focus the individual user working on a computer system. This is adequate for certain purposes, yet the uncritical acceptance of this situation as the norm in the field has meant that technical support for the ongoing conversations and work-related activities that span groups of people in real work situations have often not been handled properly. Workers often have difficulty in coordinating their activities through the computer system. The system then becomes a barrier rather than a facilitator for the co-ordination of work. Extending the focus of concern from the human-computer dyad to larger groups of people and machines engaged in collaborative tasks has emerged as an important area for research in the next period. The quick growth of this field, labelled Computer Support for Cooperative Work (CSCW), attests to its importance (see Greif, 1988, for a selection of papers in this area, and Bannon & Schmidt (1989) for an overview of the field).

3.2 From the Lab to the Field

Much of the early research done in the HCI field was confined to rather small controlled experiments, with the presumption that the findings could be generalised to other settings. Examples of such studies were those done on command naming conventions (see Barnard & Grudin, 1988 for a review of this research). It has become increasingly apparent that such studies suffer from a variety of problems that limit their usefulness in any practical setting. Firstly, by the time these studies are done the technology may make the original concerns outdated. Also important contextual cues for the accomplishment of tasks were often omitted in this transfer from the real world to the laboratory, and so the results of the lab studies became difficult to apply elsewhere. Increasingly, attention is shifting to in situ studies, in an effort to "hold in" the complexity of the real world situations, and a variety of observational techniques are being employed to capture activities, especially video.

The need to go outside the lab has been admitted by many HCI researchers in the past few years, including cognitive psychologists with a tradition of more rigorous laboratory studies (see Landauer, 1987). For example, Thomas and Kellogg (1989) discuss the ecological "gaps" that exist between the world of the research lab and the real world. We can see an increasing focus on the concept of "usability" among the research community - whether people can and do actually use the resulting systems designed for them.(For an excellent tutorial on designing for usability see the chapter by Gould in Helander (1988). The Chapter by Whiteside, Bennett, and Holtzblatt on usability engineering in the same volume is also worth studying.) What these articles note is how difficult it is to evaluate the usability of an artifact without investigating the situations of use of that artifact (See Bannon & Bødker (1989) for an extension of this argument). From a design perspective, this means that we need to have a prototype or test system for users to experience in order to get information on the usability of the resulting system.

3.3 From Analysis to Design

Early human factors work tended to focus on evaluation of existing systems, and analysis of features that had been found in the use situation to be good or bad. However the concern of people in HCI now is how to build better artifacts, so we don't just want to know about systems after they have been built, we want to know how we should build them in the first place, and even what we should build. HCI should be a design science....."design is where the action is" to quote a memorable phrase of Allen Newell. So the question is how can HCI contribute to the design of more usable and hopefully useful artifacts? One approach in HCI to this problem is represented in the work of Newell and Card (1985) who argue for the importance of approximate calculational models of the person performing a task that can be useful in the design process. The argument about the practicality and utility of such calculational models in general, and especially the claim that this is the the most important, if not the only way in which psychology and cognitive science can contribute to design, has been rather exhaustively discussed (Newell& Card, 1985, Carroll&Campbell, 1986, Newell & Card, 1986) and we will not re-hash it here, other than to voice support for a "science" of HCI that is broader than that conceived in the path-breaking, but limited work of Card, Moran, & Newell (1983).

Many groups are currently active in "user modelling", looking at the structure, content and dynamics of user cognition at the interface. Much work in the area continues the GOMS model tradition of Card, Moran, and Newell (1983), extending it in various ways. While meeting with some success in very narrow domains, there are acknowledged to be a number of rather serious problems in trying to extend the technique. The question is whether these problems are ones that can be overcome, or whether they are fundamental barriers to the use of such an approach in actual design situations. Our view tends towards the latter, as these are ideal models, of what users should do, not what they actually do, and they cover a very narrow range of user activities.

In this regard, the recent wave of interest in Programmable User Models (PUMs) (Young, Green & Simon, 1989) which are based on a generalized architecture of human cognition seem to be also unduly narrow. Rather than moving designers closer to actual users, such a device, if it existed, would seem to support the view that real contact with users was unnecessary, as the designer could just program the PUM in order to understand the "human constraints"! The very vision of a PUM seems to us a rather abstract view of human activity in the world, and to imply a rather strange relationship between designers and users. As Reisner (1987) notes in her discussion of earlier modelling work, such work can never replace prototyping and actual empirical user testing, although it might have a role at a certain stage in the design of a new system.

3.4 From User-Centered to User-Involved Design

As noted earlier, the term "User Centered System Design" has been used for some time, in order to focus attention on the needs of the user rather than on the system hardware and software possibilities. Yet what this phrase really means, or how it can be achieved, is far from clear. In some cases it dissolves into platitudes such as "Know the User". Such kinds of general guidelines are of little use in practical situations of design, due to their lack of specificity. A more radical departure from much current thinking within the mainstream HCI world is to look on users not simply as objects of study, but as active agents within the design process itself. This involvement of users in design is seen not only as a means for promoting democratization in the organizational change process, but also as a key step to ensure that the resulting computer system adequately meets the needs of the users.

Adequate input from users has been presumed to have been captured in the requirements analysis phase of the project, and task analyses done earlier by the system team. Over the years, it has been acknowledged that these are often inadequate, and the question has begun to be asked whether this is because of some problems in the way of doing the studies locally, or whether there is a fundamental problem with the very assumption that we can map out users needs and requirements successfully in advance through simple techniques of observation and interviewing. Many now argue that users need to have the experience of being in the future use situation, or at least an approximation of it, in order to be able to give comments as to the advantages and disadvantages of the proposed system. So, some form of mock-up or prototype, needs to be built in order to let users know what the future use situation might be like.

4 Conclusion: HCI in Systems Design

The need to understand the user's needs, and to understand the tasks performed by the user is basic to the system development process. However, it is a mistake to think that simply having a human factors person on the design team is by itself sufficient to ensure that the "human factor" has been adequately taken into account, in the sense that is being discussed here. Even in companies where there exist groups specifically targeted to give "human factors" advice on projects, one often finds that they have little influence over the design process, often regarded as "add-ons" by the engineering staff. This state of affairs has been unfortunately encouraged by the human factors personnel themselves, who often seem unwilling to really understand the complete project, or product, but focus on the narrow aspects that are adjudged to require human factors input.

Human factors, or ergonomics considerations tended to be incorporated into the design process simply as a set of specifications that the delivered system must adhere to. The actual work of the human factors personnel consisted of operator task analyses to be fed into these specifications and perhaps some interface re-touching near the end of the development cycle, when the system design had already been fixed. In general the role of these personnel was seen as ancillary to the main task of building the system.

What is being advocated here is an approach that, while acknowledging the contribution that different disciplines can make to the design process, ultimately depends upon the users themselves to articulate their requirements, with the system design team, composed of a variety of specialists, acting in the capacity of consultants to the project. Designers and users must be prepared to acknowledge each others competencies and to realize that effort must be made by both parties to develop a mutually agreed upon vocabulary of concepts that can be shared across the different groups that comprise the project. It is no easy task for different disciplines and work activities to accomplish this, and it is in this area that additional research would be valuable.

Some of the efforts in Scandinavia (see for example the papers in Bjerknes et al, 1987) on involving users in design provide a promising start towards the alternative systems design paradigm advocated here. Within such an approach, the starting point, and the end point of the design process is with the users themselves, from what they require, to how they evaluate the prototype, and the iterations that follow. Along the way, the services of a variety of disciplines may be required, not just the software engineer and the ergonomicist, but perhaps also architects, sociologists and anthropologists. These disciplines should come together in the overall design process as required, and not dictated by some arbitrary flow model by which the system design gets handed around sequentially from one discipline to another. It is in the mutual interaction of these different perspectives, focused on a particular design project, that good design may emanate.

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