PART 1

Informatics Usability — Introduction, Scope and Importance

CHAPTER ONE

HUMAN FACTORS FOR INFORMATICS USABILITY — BACKGROUND AND OVERVIEW

BRIAN SHACKEL AND SIMON RICHARDSON

1. Introduction

The purpose of this chapter is to provide the general background and context for human factors and usability, to present a brief historical outline, and to give an overview of the contents of the book.

Informatics usability is one of the major technical areas within the field of Human-Computer Interaction (HCI). HCI deals with all aspects of the human use of computers, usually in the context of interactive Informatics systems. Informatics is used in this book as equivalent to the term Information Technology, and both terms will often be abbreviated as IT.

Human-Computer Interaction (HCI) is a major part of the larger subject termed Human-System Interaction (HSI) and HSI is a large part of the applied side of the discipline known as Ergonomics or Human Factors — see Figure 1.

So Human Factors for Informatics Usability involves a consideration of all the possible contributions which could be made from anywhere in the discipline of Human Factors (HF) to improve the usability of IT systems. Further, since Informatics Usability is obviously an inter-disciplinary applied field, a proper treatment of this subject must include reference to and relevant inputs from the closely related areas such as software system design and cognitive psychology. Therefore, the contents of this book range from computer-human interface design to organisational issues, from formal models in HCI and designing expert systems to the contributions of cognitive psychology, and from HF strategy and the design process to evaluating usability.

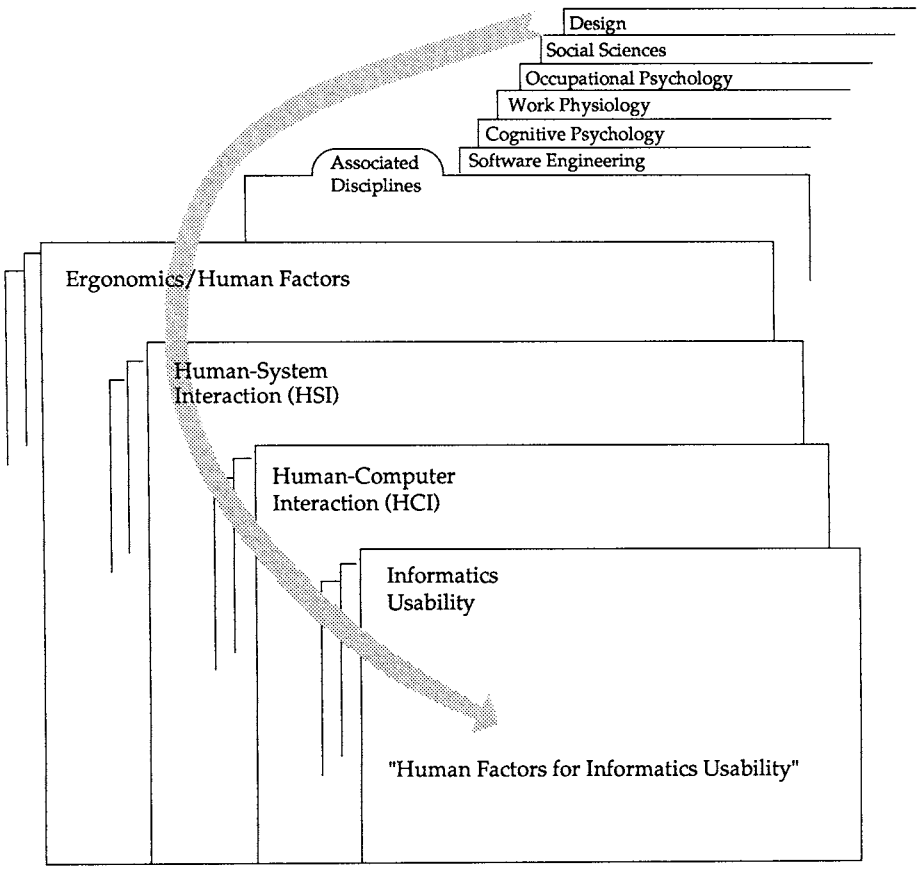

Figure 1: The context of this book and the associated disciplines.

To present the background and overview, we shall proceed from the general to the particular. So, the growth of Ergonomics/Human Factors will first be summarised; then Human-System Interaction (HSI) and the growth of Human-Computer Interaction (HCI) will be outlined; the importance of Human Factors and Usability will next be discussed; and finally the scope and contents of this book will be reviewed.

1.1 *The growth of Ergonomics/Human Factors*

In Great Britain, what is now called ergonomics had its beginning in the scientific study of human problems in ordnance factories during World War 1. This kind of work continued under the Industrial Health Research Board between the wars.

World War 2 led to greater emphasis not merely on matching men to machines by selection and training, but also, much more than previously, to the designing of equipment so that its operation was within the capacities of most normal people. This fitting the job to the man increased considerably the collaboration of engineers in certain fields with the biological scientists. This collaboration, beginning primarily with military problems, because it was there particularly that operators were pushed to their limits, continued after the war and led to the formation in 1949 of the Ergonomics Research Society.

Similar developments occurred in other countries, leading in the USA to the formation of the Human Factors Society in 1954. On the international scene, the formation meeting which accepted the first constitution and rules of the International Ergonomics Association was held during the Annual Conference of the Ergonomics Research Society in Oxford in 1959; the first international conference of the IEA was held in Stockholm in 1961. The IEA now has 16 member societies in nations around the world.

1.2 *Ergonomics/Human Factors — scope and definition*

The principal purpose or philosophy of Ergonomics is not primarily to improve productivity or output or human methods of doing work; these are quite properly the main aims of other disciplines. The prime purpose of Ergonomics is to study and understand the situation of people at work and play, and thus to be able to improve the whole situation for the people. Of course this knowledge may also be used to assist with productivity, and at times managers may need to be persuaded to use Ergonomics by the expectation of some such benefit, but the main thrust of Ergonomics remains always user-centred.

Therefore, Ergonomics is defined as the study of the relation between man and his occupation, equipment and environment, and particularly the application of anatomical, physiological and psychological knowledge to the problems arising therefrom. This definition is in two parts and clearly describes both a science and a technology.

Thus, the scope of work in Ergonomics must clearly embrace both research and practical application. Research is essential to increase our knowledge about how people behave in total situations, how they are similar to and different from engineering components, and how they respond to and are influenced by their task and environment.

In the study and treatment of practical situations, Ergonomics (or Human Factors — the equivalent name used in the USA) places major emphasis upon efficiency in the operation of the equipment as measured by the human performance of actual users. Allied with efficiency are the safety, comfort and

satisfaction of the operator. Because the aim is to optimise the human-machine and human-environment combinations by improving the system and the environment, this aspect has also been termed 'Fitting the System to the User'. Equally important are the personnel factors such as selection, training, and adaptation to environmental and working conditions. These are studied both as part of ergonomics and as separate topics under the headings of Work Physiology and Occupational Psychology. From this knowledge people can be helped to alter themselves, within limits, to improve the human-machine partnership; this personnel aspect has also been termed 'Fitting the User to the System'.

1.3 *Why is Ergonomics/Human Factors essential?*

There are three basic reasons why Ergonomics is essential for modern industry, especially in relation to product and system design.

First the complexity and sophistication of modern industrial technology sets continually higher demands upon the human operatives and controllers; but complexity also causes designers to need too long a training and to be too busy with technical problems either to deal with the human factors properly or to learn enough about how to deal with them.

Second, there is a time and space barrier. The complexity of modern technology also separates designer and user, and thus usually prevents effective feedback from the user to improve the design. Therefore the ergonomist is an essential link who operates as a sort of preventive and predictive feedback channel.

Third, there is the separation of responsibilities and of the cost consequences. A further problem which follows from the complexity is that often the designer, manufacturer/marketer, buyer and user are separate. They may well be in separate organisations and certainly will have separate aims and criteria. The designer (and engineer) will aim for a good machine solution, and will expect to spend all his budget costs on technical machine factors; the manufacturer/marketer will aim to cut the capital cost (but not necessarily the running costs); the buyer will aim to pay a low price and will expect savings to come from the purchase (perhaps by staff reductions); the user will aim to minimise his personal loss (of skill, earnings, etc.) due to the new machine or method of working. Therefore, the separation between them may often cause each of these four people not to use ergonomics, because they cannot see the cost justification within their own cost limits. Only the manager in charge of the user sees the final result, where the true cost of the extra training, and of the inefficiency and losses if the design is not ergonomic, can exceed any savings in purchase cost.

Because each sector of responsibility is separate, as noted above, the cost-benefit evaluation of ergonomics can often be difficult to prove (but for references and

examples see Beevis and Slade, 1970; Corlett and Coates, 1976; Shackel, 1987; and Corlett, 1988). Therefore, a recent new concept may be helpful. Organisations using new systems (i.e., the 'buyers') are beginning to realise that the running and repair costs (including selection, training, maintenance, and labour turnover) may far exceed the capital costs. Some are beginning to ask the manufacturer/marketer not only to give a standard purchase warranty, but also to guarantee the total running costs not to exceed some annual value over an agreed 'life' usage. This is called total 'life-cycle' or 'system-life' costing and should be strongly supported by ergonomists, because it helps to show more clearly the cost-benefit value of ergonomics.

2. Human-Systems Interaction (HSI)

When Human Factors/Ergonomics knowledge and methods are applied to the problems of human-computer interaction, in the context of interactive IT systems, the aim must be to harness all the relevant approaches used to deal with human and organisational problems in all areas of Human-Systems Interaction (HSI). The field of HSI can be characterised as follows.

HSI is concerned with methods, media and mechanisms for enhancing cooperation between people and systems in an interactive organisational environment. This field comprises:

(1) the definition of the organisation and job contexts for the users in and of a system and the consequential job and task situations and needs,
(2) the design of the organisation, of the jobs and of the tasks as an integrated whole socio-technical system,
(3) the design of the human interfaces based upon the organisation, job and task demands and upon the physical and cognitive characteristics and needs of the users, and
(4) the formulation of tools and techniques for designing, constructing, evaluating and monitoring both the organisation of and the individual human user parts of interactive human-machine systems.

In addition to the human-system contact points, HSI includes the study of those aspects of the humans, the organisation, the job, the tasks, the machines, and the environment which directly influence the effectiveness and acceptability of systems for the user.

The term HSI itself requires a brief comment. In order to improve the design of the interfaces between people and systems one must study the requirements of particular users doing particular tasks, i.e., the human-system interaction. Often,

such studies of functional interaction must come before the new physical interface can be produced. In accordance with current practice, therefore, the term HSI is used to mean both the human-machine processes and functions (HS Interaction) and the hardware and software components which facilitate these interactions (i.e., the HS Interface).

Finally, we must remember that we are concerned with human-machine systems rather than humans or machines separately. That is to say, human and machine form a 'socio-technical system' in which they must be complementary components working to a common goal. HSI is not just concerned with the displays and controls that an operator uses to interact with a machine — essential though these are. True socio-technical systems are designed to serve a purpose and that purpose is provided by people. On the one hand, inside the system, the people may be system specifiers, designers, constructors, purchasers, managers, supervisors, operators or maintainers. On the other hand, in the wider context of those served by the system, the people are the users of the products or services provided. HSI is concerned with each and every aspect of these various human interactions with machines. All advanced IT systems, therefore, have an HSI dimension.

3. Historical changes and their consequences for usability

3.1 *Growth of and changes in computing*

There have been rapid growths and changes in computing which have fundamentally altered the predominant type of users and their expectations so that the user population is no longer homogeneous. For a fuller review see Gaines (1985), and for useful references see Burch (1984) and Shackel (1985).

At the beginning of the digital computer era, the designers of computers were specialists and the users of computers had to become computer specialists. The potential power of this new machine and the speed of computation was so useful for certain scientific disciplines that some scientists found it worth the cost of time and effort to learn how to use it.

In the late 1950s the potential for the computer in industry and commerce was recognised, and the first serious business machines were developed; again, they were designed by computer specialists for use by data processing professionals. From the mid 1960s the minicomputer and remote terminal access to the time-sharing mainframe brought computer usage nearer to the layman. However, already the difficulties for the non-specialist and the problems of human-computer interaction were recognised (Nickerson, 1969; Shackel, 1969; Sackman, 1970).

The advent of the microcomputer in 1978, in widespread use from 1980, caused

much growth in the use of computers for many different purposes by non-specialists of all types — from bank clerk to business executive, from librarian to life insurance salesman, and from secretary to stockbroker and space traveller. This rapid growth in computing, leading to widespread usability problems, is summarised in Figure 2.

The result of this rapid growth is that both the market for the IT industry and the users of IT equipment have changed significantly. The market has become much more selective, partly through experiences of poor usability. The users are no longer mainly computer professionals, but are mostly discretionary users (Bennett, 1979). As a result, the designers are no longer typical of or equivalent to users; but the designers may not realise how unique and therefore how unrepresentative they are.

Moreover, with the growth of IT, the many new users bring different needs to be satisfied. Earlier users were committed to using computers because of personal interest or job requirements. But the potential new users are such people as managers, physicians, lawyers and scientists who are committed to their tasks but not at all to the computer. They have choice and will only use computers if they are appropriate, useful and usable. So the market now contains important new categories of users. Moreover, some predict that these end users will be the primary decision makers in the future about acquiring equipment. Thus to be

Computer Type	Approx. Growth Era	Main Users	User Issues
Research machines	1950s	Mathematicians Scientists	Machine reliability; users must learn to do all the programming
Mainframes	1960s & 1970s	Data-processing professionals supplying a service	Users of the output (business managers) grow disenchanted with delays, costs, lack of flexibility
Minicomputers	1970s	Engineering and other non-computer professionals	Users must still do much programming; usability becomes a problem
Microcomputers (plus applications packages)	1980s	Almost anyone	Therefore usability is the major problem

Figure 2: Growth of digital computers and user issues.

successful, the IT industry must improve the usability of interactive systems, and to do so the understandable orientation of designers in the early years must now be completely reversed; designing must start with the end users and be user-centred around them. Therefore the human factors aspects become paramount.

3.2 *Human-Computer Interaction and usability aspects*

However, the growth of attention to the consequential human factors and usability aspects was slow to develop (see Figure 3). Some attention was being given to the ergonomics aspects of computers as early as the late 1950s, although this was primarily involved with military systems. However, some work was being done on the ergonomic design of commercial computers by 1960 (Shackel, 1959 and 1962), and the possible vision for the future of close-coupled symbiosis, which may be near to being realised today in 1990, was proposed by Licklider (1960). Through the 1960s such work as existed was scattered and mostly, in the USA especially, was still related to military systems. Attention at that time was mainly focussed upon hardware issues, large systems and process control rather than on office and business systems.

The first international meeting was held in 1969 in Cambridge UK (International Symposium on Man-Machine Systems), and the first journal for the area was established in the same year (International Journal of Man-Machine Studies). The first research group to be established with its main focus upon this subject started in 1970 (HUSAT at Loughborough University, UK). Through the 1970s significant work developed though still largely in small, somewhat isolated groups. The first specialised workshop meeting was held in 1976 as a NATO Advanced Study Institute on Man-Computer Interaction. Considerably greater attention to ergonomics and usability issues was stimulated by the arrival of the micro-computer in 1978. Thereafter, there was rapid growth in work on the human factors of computer systems for office, business and commercial use.

In 1980 the recent considerable growth was crystallised in four books (one from a conference), to be followed by several books each year thereafter, by a second main journal in 1982 and by seven major conferences in 1982–84 (see Figure 3). The first international conference on Human-Computer Interaction was sponsored by IFIP as INTERACT '84 (held in London in September 1984) and the second, INTERACT '87, was held in Stuttgart; the third, INTERACT '90, will be held in Cambridge UK, and INTERACT '93 is already being planned.

Another sign of growth in any field is the appearance of interest groups and scientific societies. National groups have now developed in a number of countries, for example: the Computer-Human Interaction Special Interest Group of the Association for Computing Machinery (ACM SIGCHI); the Human-Computer

1959	First recorded paper in the literature (Shackel, 1959) as reported by Gaines (1984)
1960	Seminal paper by Licklider (1960) on 'Man-Computer Symbiosis'
1969	First major conference ('International Symposium on Man-Machine Systems')
1969	*International Journal of Man-Machine Studies* started
1970	Foundation of HUSAT Research Centre, Loughborough University
1970-73	Four seminal books published (Sackman, 1970; Weinberg, 1971; Winograd, 1972; Martin, 1973)
1976	NATO Advanced Study Institute on 'Man-Computer Interaction'
1980	Conference and book on 'Ergonomics Aspects of Visual Display Terminals' (Grandjean and Vigliani, 1980)
	Three other books (Cakir, Hart and Stewart; Damodaran, Simpson and Wilson; Smith and Green (eds.))
1982	Journal *Behaviour and Information Technology* started
1982-84	Seven major conferences held in USA, UK and Europe with attendances ranging from 180 to over 1000 with an average of nearly 500
1983	European ESPRIT and British Alvey programmes begin
1985	Journal *Human-Computer Interaction* started
1985	ESPRIT HUFIT Project No. 385 begins 1st December
1985	From 1985 the conferences of national societies ACM and BCS, on CHI and HCI respectively, become annual
1986	Three HCI Centres launched in the UK under the Alvey initiative
1987	Second IFIP INTERACT International Conference on HCI
1988	Major Handbook on HCI published (M. Helander (ed.))
1989	IFIP establishes Technical Committee on HCI (IFIP TC 13)
1990	Third IFIP INTERACT International Conference on HCI

Figure 3: Growth of Attention to Ergonomic Aspects of Human-Computer Interaction (see Gaines, 1985, for a review of early development).

Interaction Specialist Group of the British Computer Society (BCS HCI SG); the Fachausschuss Software Ergonomie of the Gesellschaft für Informatik (GI FSE); the joint Man-Machine Interaction group of the Dutch Computer and Dutch Ergonomics Societies (NGI and NVvE MMI); and the IT Special Interest Group of The Ergonomics Society (ES ITSIG). Some further details of the growth and scope of HCI, to supplement this brief outline, are given by Gaines (1984), Shackel (1985) and Bullinger *et al.* (1987).

3.3 *Recent and current research initiatives*

The rapid growth of IT since 1982 was particularly assisted by the major funding programmes for research and development. These programmes did give more attention and support to human issues than any hitherto. For example, the Japanese Fifth Generation Conference Report (Moto-Oka, 1982) states: "Human beings communicate using a wide variety of forms: natural language, both spoken and written, pictures, images, documents, and the like. It is not easy for current computers to respond to them intelligently since they are not equipped with