# HUMAN ASPECTS OF HEALTH CARE INFORMATION SYSTEMS

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**Keywords:** human-computer interaction, user interfaces, system design, usability, usability evaluation, health informatics

## Contents





## Summary

Currently the designers and implementers of health information systems face serious challenges related to the complex interaction between human and machine. This chapter

describes essential human aspects that need to be taken into consideration in the design of health information systems. The study of human-computer interaction (HCI) is introduced as it applies to the design and evaluation of health information systems. Advances from the emerging area of HCI are described as well as theoretical frameworks for guiding the design and evaluation of more effective systems. In addition, key principles from the areas of human information processing and cognitive psychology are described along with principles that can be used to guide both the effective input and display of health information. Methods emerging from HCI can be applied throughout the life cycle of health information systems in order to improve their acceptability and adoption by end users (e.g. physicians, nurses, other health professionals and even lay people). The concept of "usability" is detailed and methods including usability testing (involving in-depth analysis of users of health information systems interacting with these technologies) and usability inspection are also described. It is argued that improved understanding of human aspects of health information systems is essential in order to ensure systems meet user needs, are safe and provide appropriate benefits to health care.

## 1. Introduction

In health care, a wide range of information technologies have appeared, ranging from advances in patient-monitoring to the advent of the computerized patient record (CPR) system – an electronic repository of patient data that is designed to replace the traditional paper patient record (Shortliffe & Cimino, 2006). These types of systems promise to revolutionize healthcare and form the basis for further advances in health care information processing and care. The potential of these systems, once health data is stored electronically, includes provision of automated alerts and reminders to physicians (to warn of potential problems with patient care) and the interconnection of health data across regions and countries. In addition, a wide range of supporting information systems from digital imaging systems to clinical support systems have been developed and are increasingly deployed in hospital and other healthcare settings. However, perhaps in no other field of research has issues related to human-computer interaction come more to the fore in attempting to disseminate information technologies. Despite repeated efforts at multiple levels, the widespread use of integrated healthcare information systems (including the CPR) has remained elusive. Deployment of such systems has faced a variety of problems, including delayed implementation times, difficulty in integrating new systems with existing systems and even the problem of new information technologies actually introducing error into the healthcare system, if not designed and deployed carefully (Kushniruk, Triola, Borycki, Stein & Kannry, 2005). In this chapter we will discuss issues and advances related to human-computer interaction in health care. This will include discussion of background information about the field of human-computer interaction (HCI) and discussion of how advances in HCI can be applied to improve problematic aspects of health information technology related to the complex interaction between human and machine.

## 2. Background

### 2.1. The Study of Human-Computer Interaction

The study of human-computer interaction (HCI) is concerned with the human, social,

organizational and technical aspects of the interaction between human and machines. It is a broad area of study that deals with a broad range of phenomena, including the design, evaluation and social implications of computer systems (Sharp, Rogers & Preece, 2007). Research in HCI is conducted by workers in areas including psychology, computer science, anthropology, sociology, management and a range of other disciplines. In this chapter we will illustrate how multidisciplinary perspectives to designing and evaluating healthcare information systems are needed in order to lead to healthcare systems that will be more effective and acceptable to their users.

### 2.2. Cognitive Aspects of HCI in Health Care

There are a wide range of aspects of health information systems that are related to cognition and human information processing. One may ask "why study cognitive aspects of health information systems?". In answering this we must consider that the user interface to healthcare information systems can be defined as the component of a man-machine system taken as a whole, responsible for communication with the user of the system. Furthermore, the goal of health systems are to carry out tasks where information is accessed, manipulated or created for human use. Thus HCI can be considered to have a large cognitive component in that it involves processing of information by humans, in close conjunction with computer systems. Therefore the application of ideas, theories and methods emerging from the field of HCI are highly relevant to the design and implementation of more effective healthcare information systems from the perspective of human users, for whom such systems are ultimately designed to support and serve. There are a number of ways in which knowledge of human cognitive processing is important for improving healthcare information systems. These include the following: (a) providing knowledge about what typical users of systems can and cannot be expected to do, (b) identifying and explaining the nature and cause of user problems, (c) characterizing the problem solving and decision making processes of healthcare workers, (d) assessing the cognitive needs of users in designing systems and user interfaces, (e) feeding input back into system re-design and improvement, and (f) providing models and frameworks for conducting HCI research in healthcare (Patel & Kushniruk, 1998).

### 2.3. Human Information Processing and Distributed Cognition

A variety of models of human cognition have been applied to help understand human-computer interaction in general and the complex interaction between humans and health information systems in particular. One of the most influential models has been the "Information Processing Model" (Sharp, Rogers & Preece, 2007). The theoretical framework of this model has enabled predictions to be made about user performance. One such model, called "model human processor" consists of three interacting systems: the perceptual system, the motor system and the cognitive system. The model provides a way of characterizing the cognitive processes that underlie the performance of a task. An influential application of the information processing model in human computer interaction is the GOMS model, which characterizes the interaction of humans with computer systems in terms of user goals (e.g. to enter a medication in a medication administration system), operations undertaken (e.g. typing on the computer), and methods of achieving goals. This granular approach to understanding use of computer systems by human users involves identifying each specific step a user takes (e.g. selection of an option from a menu on a

computer screen) in carrying out a task using a computer. The GOMS model has formed the underlying basis for usability inspection methods, described below as they have been applied in the study of users of health information systems.

In recent years new theoretical models of HCI based on "Distributed Cognition" have appeared, proponents of which have argued that the interaction of humans with computers in carrying out real world tasks typically involves a complex interaction among various people and one or more computer systems (Sharp, Rogers & Preece, 2007). This is quite applicable in healthcare where use of information systems typically involves numerous "actors" (e.g. healthcare team members including nurses, doctors, technicians and patients) carrying out numerous "activities" (e.g. monitoring patient progress, giving medications to patients, performing surgeries etc.) using a wide range of information technologies and systems. The emergence of a framework known as "activity theory" has appeared and is beginning to be applied in the analysis of complex healthcare activities in order to characterize the activities of healthcare workers and workflow (Engestrom, Miettinen & Punamaki, 1999).

### 2.4. Skilled Performance, Expertise and Learning

Another area where HCI has been informed by research in areas including education and cognitive psychology is the application of models of skilled performance, expertise and learning. For example, the progression from novice to intermediate to expert in a wide range of domains, including science, medicine and nursing has been characterized by research in to skilled acquisition. In healthcare this has included identification of differing reasoning strategies used by physicians as they progress from novice (i.e. medical student) to intermediate (i.e. resident) to expert (Patel & Groen, 1991). Some relevant findings indicate that as expertise in using computer systems also involves a transition, from conscious practice of procedures required in using a software system to automatic performance of skilled procedures and operations required in using a computer system (Anderson, 1990). The implications of this research for the training of computer users in healthcare is an area that has received little attention, although it is a critical human aspect of health information systems and is highly related to user satisfaction and adoption of new information technology. Furthermore, the application of learning theory to improving the uptake and acquisition of computer skills in learning how to use and master such complex health information technologies as the CPR remain to be explored (Patel, Kushniruk, Yang & Yale, 2000).

### 2.5. Perception and Attention

Perception is a fundamental aspect of the interaction of humans with health information systems. Information displayed by computer systems has to be visually perceived in a meaningful way. In addition, a variety of other perceptual modalities (including sound and touch) are beginning to have increased importance in domains like healthcare. The psychological study of perception in particularly important in healthcare, where large amounts of complex visual information must by presented to healthcare workers in a way that it can be perceived and understood in an unambiguous way. Also, related to perception is attention, which refers to our ability to filter out and make sense of the large amount of information that we are bombarded with. However, the ability of humans to focus on

specific information is limited, which has important implications for the design of health information systems. In healthcare effective user interfaces must help users attend to and focus on information that is most important to be dealt with (e.g. alerts from a bedside patient monitor, or unusual patient laboratory results in the display of a CPR system).

Principles that have emerged from the study of HCI that are paramount to be applied in healthcare include the following: (1) information should be presented should be readily understandable to users, (2) attention getting cues should be used to highlight the most relevant or important information on a computer screen, (3) the information on the display should be arranged in logical areas (Tang & Patel, 1994). These principles will be expanded on in the discussion below.

### 2.8. User Interaction Style

The presentation of information to healthcare workers, patients and lay people must reflect the meaning of the data and be sensitive to the context of the provider, patient and task. Interaction styles in HCI have evolved over the past several decades and this has a number of important implications for the design of health information systems. The predominant style of HCI for many years involved keyboard input by users of commands, requiring knowledge of command languages by users of systems (for example the DOS interface of the early IBM compatible computers). By the 1980's a new form of interaction had evolved -- the GUI, or graphical user interface (Sharp, Rogers & Preece, 2007). GUIs offered more flexible user interaction styles by which the user could point and click on physical objects displayed on the computer screen (e.g. folders, icons etc.) – which has been termed "direct manipulation interaction". This style of interaction allowed computer users to recognize objects on a computer screen, rather than recall complex computer operations. In healthcare, both styles are still in use, however, the GUI is becoming increasingly used and current versions of CPR systems use a GUI. In addition, with the advent of the WWW a new user interface style and metaphor has appeared, with many Web-based information systems appearing, designed to be accessed both by health professionals and lay people.

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**Dr. Andre Kushniruk** is an Associate Professor and Director of the School of Health Information Science at the University of Victoria. Dr. Kushniruk conducts research in a number of areas including evaluation of the effects of technology, human-computer interaction in health care and other domains as well as cognitive science. His work is known internationally and he has published widely in the area of health informatics. He holds undergraduate degrees in Psychology and Biology, as well as a M.Sc. in Computer Science and a Ph.D. in Cognitive Psychology. He focuses on developing new methods for the evaluation of information technology and studying human-computer interaction in health care and he has been a key researcher on a number of national and international collaborative projects.

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