Integrating Cognitive and Socio-Technical Theoretical Perspectives in Health Informatics

Abstract
The purpose of this presentation is to present our approach to integrating cognitive and socio-technical theoretical perspectives for assessing the impact of health information systems. The objective of this work is to lead to the design of health information user interfaces and systems that better meet the information and workflow needs of health professionals. Previously, health informatics research has typically focused either on the cognitive or the socio-technical aspects of health information systems separately. In this workshop we demonstrate how evaluations of health information systems can be designed that take into account theoretical aspects related to cognition as well as socio-technical aspects, including the impact of systems on workflow. Using a case study, we illustrate use of clinical simulations to bring in and integrate both cognitive and socio-technical theoretical perspectives in evaluating health information technology prior to and after system release.

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Human Factors; Health Information Systems; HCI

The authors wish to pay for the work to be open access.
Introduction
Two important theoretical views that have influenced HCI research in health informatics research have been the cognitive perspective and the socio-technical perspective. Each of these theoretical perspectives has had an important impact on the design and evaluation of health information systems and HCI in healthcare.

1. Cognitive Perspectives: Cognitive perspectives for understanding HCI have been dominant for the design of interactions with health information systems, with the application of the human information processor model in many studies. Much of this work has focused on the impact of health information systems on individual cognition. For example, early cognitively focused work in healthcare [1] found that the screen design and layout in an electronic medical record could profoundly affect health professional’s information processing activities (i.e. including decision-making and reasoning processes). This work documented a close relationship between the design of an electronic medical record user interfaces and cognitive processes such as diagnostic reasoning and medical decision making [2]. This work led to a wide range of studies that examined the implications of interface design and HCI on health professional cognition.

Along these lines, Kushniruk, Patel and colleagues [1,2] took a cognitive approach to examine the effects of interface design upon the knowledge, organization and reasoning strategies of physicians when working with health information technologies. In this work it was found that electronic medical records could “shape the way in which health care workers obtain, organize and reason with knowledge” [2]. The layout of information in the electronic medical record was found to affect diagnostic processes. Furthermore, even after physicians returned to using a paper patient record after using an electronic medical record, the residual effects of using the electronic record format were documented. Extensions of this work were conducted in the 1990s where doctor-patient-computer interactions were video recorded and analyzed as the health professional interacted with electronic health records [2]. These studies also showed that physician interaction with the electronic medical record during doctor-patient interviews was greatly influenced by the electronic medical record’s organization of information and the design of the user interface. Such studies have been used both to evaluate systems in use as well as to predict usability problems with systems before release.

2. Sociotechnical Perspectives: In the 1990’s new theoretical perspectives began to emerge and be applied in design of health information systems. For example, distributed cognition, which views information processing in human-machine systems as being distributed across a number of different “agents” (including both human and machine) began to emerge. In addition, socio-technical perspectives in health informatics began to appear as greater consideration of social and organizational context began to appear. This was in part due to the failure of many implementations of health information systems worldwide. Ash, Berg and colleague’s [3] work and the work of other socio-technical researchers such as Aarts [4] have argued that the origins of many of these implementation failures are socio-technical in nature. In particular, poor fit among health professionals, information systems and the organization where the systems are implemented led to a range of adoption and appropriation failures involving the technology (i.e.
unintended consequences). Changes in organizational structures (e.g. management structures, organizational power structures) were reported as a result of implementation of health information systems, including changes to the organizational environments and alteration in the relationships between patients, health professionals and health professional teams in these healthcare organizations.

In support of the socio-technical view, Wu’s [5] meta-analysis of the effects of health information systems on the quality and safety of healthcare has shown that socio-technical fit may be key to achieving positive health care outcomes after implementing health information technology. Furthermore, many purchasing healthcare organization have ended up adopting the processes and practices of the organization on which the design of the technology was modeled, often leading to poor technology-organization fit [5]. This may have led to implementation failures and end user issues including bypassing system functions, failure to use system functions, boycott of systems and functions being used in unintended ways. This may even have lead to inadvertent changes in the way care is delivered and limited improvements in the quality of patient care after implementing systems [5]. Overall, the socio-technical approach has argued for greater understanding of use of technology within the complex environments it is deployed in. However, such study has typically been conducted after systems have been deployed (i.e. late in the system development life cycle).

**Case Study: Integrating Cognitive and Socio-technical Perspectives Through the Use of Clinical Simulations**

To bridge the gap between work conducted from a cognitive perspective with the need to consider workflow and organizational issues related to HCI in healthcare, in this workshop we will present a recent case study. The study illustrates the need for identifying where instances of poor cognitive, socio-technical or cognitive-socio-technical fit may not lead to health care improvements. The case study also illustrate how an integrative theoretical perspective that integrates both cognitive perspectives with socio-technical approaches can lead to improvement in the usability and safety of healthcare information systems.

In this work we have employed methods based on a combination of study of user interactions at the cognitive level with clinical simulations that allow researchers to examine both the cognitive and socio-technical impact of the introduction of systems. In this case study a medication administration systems [6] was studied, which included both laboratory-based artificial studies and clinical simulations. This approach initially involved conducting usability tests under artificial laboratory conditions. Although this phase identified cognitive issues related to usability it did not take into account the complex socio-technical aspects of use of the system in carrying out work tasks. To address this, the initial testing was followed by high-fidelity simulations that we conducted in-situ in the organizations where the technology to be studied was to be implemented. By linking results of cognitive studies (involving usability testing) with subsequent studies conducted in real health environments, we have been able to identify and predict a range of serious
issues (e.g. users unable to find medications, locking out of multiple users etc.) with HCI before widespread system implementation. In an extension of this work we conducted both usability testing and clinical simulation studies of users of a new medication administration system [6]. Participants (nurses and physicians) were first presented with realistic cases in a usability testing laboratory in order to identify low level cognitive usability issues and impact of the system on health professional's decision making, using the "think aloud" method. After a round of improvements and customizations based on this work, participants were observed interacting with the system in the real organizational context (i.e. in-situ in the context of the hospital setting). After video recording of user interactions from multiple perspectives, cued recall and interviews were conducted with all participants post-task to provide insights into participant's individual perspective.

Video analysis of the participants interacting with the system in isolation as well as analysis of human-computer interaction with the system involving patients were integrated to obtain a more comprehensive picture of the effects of the device and system upon health professional-patient workflows than would be obtained by using either approach in isolation. At the socio-technical level it was found that the system dramatically impacted health professional's workflow and interaction with other healthcare professionals and patients (in particular causing the workflow to become rigid and highly sequential). Furthermore, under situations involving emergency and stress the new system could lead to predictable error and this information was fed back to the implementation team.

Discussion
The approach described is based on different theoretical perspectives and blurs the distinction between study of cognitive aspects and simulation to explore socio-technical issues. From our experience an integrated approach to understanding HCI in healthcare is needed and can lead to improved system design. The clinical simulation approach also allows for consideration of socio-technical aspects prior to full deployment of systems (when changes are more likely to be made to the system). The researchers suggest the integration of these approaches can allow for a more comprehensive and integrated view of how information systems affect health professional work in organizational contexts. This "cognitive-socio technical" perspective is presented and discussed, along with practical experiences in using a combined methodological approach based on integrating differing theoretical perspectives.

References