Cognitive Evaluation of Innovative Medical Technologies

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The challenge faced by designers of medical information technologies is to create usable and learnable systems that enhance and expand cognitive competencies. This abstract describes our work in the cognitive analyses of emerging health care technologies. Such technology offers an ideal testbed for the development and testing of cognitive theory due to its complexity, and the richness of cognitive and behavioral data resulting from its interaction. Our theoretical and methodological framework is rooted in the study of medical cognition and cognitive approaches to human-computer interaction. The objective or our work is two-fold: (1) to develop and apply methods that can be used to characterize the decision making and reasoning processes of subjects as they learn to use and apply medical information technologies, and (2) to conduct further theoretical work, considering emerging information technologies as an extension of physicians' cognitive system. It is our contention that medical information technologies, such as computerized patient records and medical decision support systems profoundly transform the task of medical practice. We need to be able to characterize and identify such change in order to be able to enhance and harness the potential of such innovation.

Studies of medical expertise have shown clear differences in the way in which physicians of varying levels of expertise develop diagnostic hypotheses, apply evidence and deal with complex information. Our framework borrows from this research and from work in a number of related areas including cognitive task analysis, which we use to characterize the decision making and reasoning of subjects of varied levels of medical expertise (e.g. physicians or medical students), as they perform various tasks while using computer technology. Tasks are representative of on-the-job performance in the medical domain, and range from interaction with decision support systems, to conducting a patient interview while entering patient data into a computerized patient record system. We can decompose a task into sets of goal-action hierarchies and identify potential mismatches between observed and intended effects. In performing tasks subjects may be asked to think-aloud, leading to rich data amenable to principled methods of protocol analysis. We employ video recording and computer-supported video analysis of all physician-computer interaction, as well as discourse analysis of any physician-patient interaction. The objective of our cognitive analyses are to characterize the skill, reasoning, and problems of subjects of varying levels of expertise, as they perform tasks representative of real-life situations. The approach draws on the theoretical and methodological framework developed from studies of medical cognition over the last decade. We are currently using the results of such analyses to inform the design of computer-based tools and training. In our work we also use cognitive task analysis for evaluating enduring effects of technology on human cognitive processes.

Our work involves iteration along two dimensions: (1) Iteration among complementary techniques: we employ a technique known as a cognitive walkthrough, which involves theory-based bench-testing of computer software, identifying potential user problems. We then apply the results of this type of analysis in developing principled coding schemes for examining video-based data collected from actual physician-computer interaction; (2) Iteration from laboratory-based to real-world settings (and back again): the studies range on a continuum from controlled laboratory testing, involving presentation of constructed medical cases to subjects, to studies in naturalistic settings (e.g. physicians entering "live" patient data into a record system).

Our overall approach is described, along with details from two studies, illustrating a progression of research from laboratory-based to real-world clinical environments. In the first study, video recording and collection of think-aloud protocols were made from two groups of subjects (medical students and physicians) as they explored a multimedia tutorial containing information about lipid disorders. In a second study, we employed a range of techniques in the study of computerized patient record systems, including use of case scenarios, followed by analysis of physicians' interaction with the system while interviewing a patient, and comparison of expert and novice users of a computerized patient record system. Essential differences in reasoning and decision making strategies were observed between users who have varying levels of exposure with such systems, with the reasoning and decision making of experienced users being guided to a large extent by the system's sequence and organization of information. Initial results from this study are currently contributing to the design of further laboratory-based testing, completing a full research cycle.