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Development of a Video Coding Scheme Focused on Socio-Technical Aspects of Human-Computer Interaction in Healthcare

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Abstract. The objective of the work described in this paper was to develop a coding scheme focused on socio-technical issues and considerations for the analysis of video data collected in usability studies of health information systems. The usability and safety of health information systems such as electronic health records, decision support and patient facing applications has become a critical issue. Although a variety of studies and methods have appeared in the literature involving video-based analysis of human factors data from healthcare, few have reported the coding scheme used to analyze the data. In this paper we describe how we have developed and continue to refine a video coding scheme that extends basic usability engineering by considering socio-technical aspects of system use that have become critical to assess in evaluating the effectiveness and efficacy of health information systems in real use.

Keywords. Usability, human-computer interaction, video analysis, health information technology

1. Introduction

A great many different types of health information systems and applications have appeared and continue to be deployed worldwide. However, issues around the usability and safety of systems has come to the fore and there is concern that many systems deployed are difficult to use, potentially unsafe to use and may be frustrating for users (both health professionals and lay people). As a consequence of this, the authors have worked on developing new methods for analyzing the usability and safety of health information systems. This began with work in refining low-cost portable usability engineering approaches to recording and analyzing end users of systems (such as electronic health records) as they interact with the systems to carry out key tasks the system was designed to support [1,4]. Since then, many such usability studies have been reported in the literature, with many involving the video recording of users as they "think aloud" or otherwise interact with the system under study [2,3]. The results of such study have been fed back into redesign and improvements to the usability of the systems. However, there is far less in the literature on how video data (e.g. from computer screen recordings of interactions) from healthcare usability studies can be formally evaluated in

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a principled way. In response, our group has worked on a number of projects where we have developed and refined ways of "looking at" video data from such study that is both replicatable and objective. To do this, we have worked on devising and applying a range of video coding schemes [4]. A video coding scheme consists of coding categories that can be used by those analyzing video recordings of user interactions. The scheme is used to characterize specific user interaction types, problems, issues and suggestions for system improvement that come about from observation and video recording of user interactions in testing or real-world healthcare settings [1]. The authors have previously reported on an initial coding scheme they developed that was grounded in categories and ideas from several sources, including the human computer interaction literature, categories borrowed from seminal work in other areas such as from lists of usability heuristics, usability questionnaires and from prior experience in a number of our projects involving the need to analyze video and identify and classify potential usability problems and issues [4].

Our initial schemes focused on a basic level of human-computer interaction – namely the interaction between a single user of a system and single computer system. The development of the categories (each of which for defined for use by the analyst applying the scheme) used in this initial scheme were very much in line with categories that can be found from different types of human factors research focusing on low-level usability issues, including Nielsen's heuristics, questionnaire scales and guidelines for effective interface design [5]. The categories were mainly useful in identifying surface level usability problems and basic cognitive issues. In this paper we describe new coding scheme categories, focused on socio-technical issues and concepts and describe studies we have conducted that have led to the expansion of the original categories. There was a need to expand our initial categories to include ones related to social aspects, collaboration and the greater use of systems and applications by patients as well as healthcare professionals. In addition, over the past few years the number and range of applications we have tested has grown considerably, from stand-along systems in hospitals to mobile applications for use collaboratively in the community. Our long-term objective is to provide a useful basis for those conducting video-based analyses of a range of health-related systems and information technologies. It is hoped that a new scheme will broaden our previous work (which was focused on identifying and classifying low level usability issues) by extending it with new categories that can be used to identify key issues related to adoption of healthcare IT from a socio-technical perspective.

2. Methodological Approach

The coding scheme described in this paper emerged from collecting data from a variety of sources including the following:

a) Recognition of gaps in the initial coding scheme we developed (which was focused on evaluating surface level usability problems that emerged from our work on usability engineering in healthcare) from conducting numerous empirical studies [6-9]. These gaps were related to key aspects of human-computer interaction that were not defined or described that are related to impact of systems on socio-technical aspects of user interaction.

b) Extending coding scheme categories to include categories related to users's perceptions about issues such as privacy and consent (which were not focused on in our previous work).
c) Addition of categories that emerged in considering the communication of health information systems (in relation to usability) that have come to the fore and were identified as major issues.

Our previous core video coding categories focused on aspects of the surface level user interface and the user-system interaction (see Table 1). As described above they were predominantly derived from application of usability categories developed for other purposes (e.g. questionnaire scales, heuristic evaluation research and cognitive theory) and were then modified for use in coding video based usability data using the "coding dictionary" that we have developed and applied in numerous studies to characterize user-system interactions and identify potential problems and issues that could be targeted for being rectified [4] - see Table 1. As can be seen most of the categories deal with surface level usability issues and considerations. These were the categories that formed the basis for the current work in extending them to include additional emerging aspects of human-computer interaction.

The development of new categories described in this paper has evolved over time, with a number of recent studies we have conducted leading to new categories, in particular studies that have involved patients and lay people as end users [e.g. 6-9]. These studies clearly showed the importance to both health professionals and lay end users of considerations like concern about privacy, use of information for legal purposes and other such considerations that would affect adoption, trust and use of new healthcare IT.

This new work has been used to develop a new framework for considering additional aspects of user interaction with healthcare IT has evolved from study and practical considerations in the analysis of a Web-based applications for input of patient information by patients and health professionals. In addition, development of categories for studying near live use of clinical guidelines and studies of health apps on mobile devices [6,7,8]

The new categories described in this paper were refined through an iterative process of review by at least two PhD level researchers in arriving at a stable set of categories over the course of a number of empirical studies. This involved a process akin to development of categories through application of grounded theory approaches, where new categories not defined in the list above, were identified from repeated end user verbal statements and user interactions [4]. Commonly encountered instances of categories of interaction were then grouped together, given a label and definition and given an example that could be used in coding future interactions on new projects (see [1,4] for the overall approach taken to arriving at new categories inductively from verbal data and transcripts).

Table 1. Coding categories for identifying surface level usability issues (adapted from Kushniruk et al., 2015 [4])

VIDEO CODE	WHEN APPLIED
NAVIGATION	Coded when a review of the video data indicates the user has problems moving through a system or user interface
CONSISTENCY	Coded when a review of the video indicates the user has problems due to a lack of consistency in the user interface
MEANING OF ICONS/TERMINOLOGY	Coded when a review of the video data indicates the user does not understand language or labels used in the interface
VISBILITY OF SYSTEM STATUS	Coded when a review of the video data indicates the user does not know what the system is doing
UNDERSTANDING ERROR MESSAGES	Coded when a review of the video data indicates the user does not understand meaning of error messages
UNDERSTANDING INSTRUCTIONS	Coded when a review of the video data indicates the user does not understand user instructions
WORKFLOW ISSUES	Coded when a review of the video data indicates when there are issues with system workflow negatively impacting user interaction
GRAPHICS	Coded when a review of the video data indicates there are issues with graphics
LAYOUT	Coded when a review of the video data indicates there are problems with the layout of screens or information on those screens
SPEED/RESPONSE TIME	Coded when a review of the video data indicates the system is slow or response time is an issue
COLOR	Coded when a review of the video data indicates user does not like color or color schemes used in the interface
FONT	Coded when a review of the video data indicates the font is too small or not readable
OVERALL EASE OF USE	Coded when the user comments on overall usability of the user interface

3. Results

Based on our analysis of both audio recordings of end user interactions, in conjunction with viewing of corresponding video recordings of end user interactions (using an overall approach to category development described in Kushniruk and Patel [1]), a number of coding categories were identified that represent aspects of interaction that go beyond our previous lower level usability considerations. These represent recurrent "patterns" or "themes" that we have identified in a range of recent studies and extend our prior categories, which are listed below in the format of a "coding dictionary" format that can be used in essence as a "manual" by researchers in analyzing video-based usability data. The examples that go along with each category were obtained from a range of studies we have conducted [6-9], and are presented to give a reader an idea of what aspects each code refers to, and to give coders an idea of how to apply the code:

3.1 New Categories Related to Trust, Ethics and Security

TRUST – Coded for when users comment about issues related to trust in using the system. For example, "I don't trust that the information contained in the medication list is accurate or complete, as the patient may be taking other medications prescribed elsewhere which are not in this system"

PRIVACY – Coded for when issues related to the concept of privacy are raised during user interactions with a system. For example, "I am not sure who else is going to see this information I am entering about my past sexual history so I will not fill in all the information – is this information really private?"

CONFIDENTIALITY - Coded for when issues or concerns related to confidentiality come up. For example, "I hope the information I am entering into my personal health record will be kept confidential and end up in some record in some other system"

LEGALITY – Coded for when legal issues are raised by users. For example, "As a psychiatrist I would recommend use of stress monitoring apps to my patients for monitoring their anxiety, however I am concerned about the legal implications of me doing so if something goes bad with the patient".

CONSENT - Coded for when consent issues are raised in the interaction. For example, "I find the health information exchange less than useful because of the process for consenting them – if patients are not properly consented no data will show up for them".

SECURITY – Coded for when users comment about or have issues with security. For example, if a participant has problems using a system, or cannot even access it due to forgetting passwords – e.g. "I rarely use the system as I forget the password.", or issues about concern about security e.g. "I am worried about how secure the information I enter is, can it be hacked?"

3.2 New Categories Related to Cost and Logistical Issues

COST – Coded for when the issue of cost or expenses comes up. For example: "I would recommend this for my patients but the only problem is most of them can't afford a tablet like an ipad"

UNINTENDED USE/HARM – Coded for when users comment about potential unintended us, access or harm related to the technology being tested. For example, "I am

worried that this system may inadvertently lead to potential harm if the patients are not given enough education or training on its use at home, or misunderstand its limitations"

STRESS – Coded for when the user refers to stress or cognitive overload when using a system under study. For example, "Given all the alerts that appear in this system when I log in, I feel like I am going to have a nervous breakdown - there are too many patient issues listed and once I access one I have to go through all of them and I find that overwhelming"

TRAINING – Coded for when comments are made about training or education (including the need for it). For example, "This is a complex system to learn how to use – I hope I will be getting sufficient training on its use".

COMMUNICATION/COLLABORATION - Coded for when the user comments about communication or collaboration needs or issues. For example, "The interface is useful but I wish to work collaboratively on genomic problems with researchers at other institutions, and this system is more stand-along without features to support such collaboration"

ORGANIZATIONAL/POLICY ISSUES – Coded for when organizational issues are mentioned by the user. For example, "The application would be of value in this hospital, however management would have to approve of it and tell us that it is consistent with the hospital's policy for registering patients"

3.3 New Categories Related to Technical Issues

ACCESSIBILITY – Coded for when issues around accessibility of information are raised. For example, need of access by family members on behalf a patient, for example, "This would be a useful application for the elderly at home but would probably be need accessed by the caregiver as well as the patient".

INTEROPERABILITY – Coded for when the user comments about integration or interoperability issues or concerns. For example, "The problem with this system is that is not connected to the other systems used in this hospital or to the provincial drug database".

MOBILITY – Coded for when the accessibility or mobility of a healthcare application is commented about. For example, "I would use this system if it were made available on my smart phone as I would use it away from the hospital".

LOCATIONAL ISSUES – Coded for if issues around the location of use of the system are raised. For example, "We still have spots in the hospital where we cannot use wireless so I think that would be a problem in accessing the system"

CONTEXT – Coded for when technical issues related to the actual context of use (including setting) are mentioned. For example, "I can use the speech recognition interface to the EHR for dictation when I am in a quiet office, but it does not work well in a noisy clinical setting".

4. Application of the Scheme in Coding Usability Data

The usability studies we have conducted typically result in full video recordings of users as they interact with systems under study. In our current work in applying coding categories we have greatly streamlined the approach. Equipment include screen recording software and a microphone for inputting the user/participant's verbalizations while using the system under study. User participants are typically asked to "think aloud"

or verbalize their thoughts [1,3]. The process involved in the coding of this audio and video of user interactions with health information systems involves several stages described below:

1. The audio portion of the video is first transcribed in its entirety, creating a log file that will be annotated (with time stamps and video codes)
2. The analyst(s) reviews the video of the interaction (i.e. screens and audio) in its entirety and while doing so considers the video in terms of the codes in the coding scheme (using the coding dictionary to guide them)
3. When a sequence in the video illustrates one or more of the codes in the scheme, the corresponding log file is annotated with the time stamp and the corresponding code
4. The number of codes for each category in the scheme are tabulated, with results fed back to system developers and implementers for ideas on improvement and refinement

Inter-coder reliability scores can then be calculated for studies applying the above codes. This can include having one or more analysts code the same sections of video independently and the calculating either percent agreement, or more formally calculating Kappa coefficient to indicate degree of reliability of the coding. An alternative approach is to have two more coders collaboratively code a section of video and when disagreements in the selection of coding categories (to characterize a section of the recorded video) occur solving them through discussion.

5. Discussion

The authors have been involved in a range of usability studies involving the coding of resultant video data for over twenty years [10]. This has included analysis of a range of technologies including clinical guidelines, web-based portals designed to allow information to health information exchanges and development of apps for use by patients and physicians in negotiating treatments and care. One of the issues in working to provide useful and reliable feedback to system developers and designers is the need to develop effective methods for analyzing video-based data from usability studies. Such data now typically consists of digital video recordings of all user screen interactions, along with a recording of their verbalizations (e.g. using the think-aloud method). Although many such studies have now been conducted, the authors have been asked by many healthcare organizations to provide help and insight into how to analyze such data. In our work we began by focusing on developing coding schemes for the purpose of characterizing basic user interaction with healthcare technologies. Although coding schemes focusing on the interaction between the user and system are needed, a broader range of issues have emerged during the analysis of usability data. As a consequence, categories related to topics such as privacy, consent, communication and collaboration are emerging as areas that need to be included when analyzing video-based usability data. Indeed, the ultimate acceptance or rejection of technology in healthcare often appears to be strongly related to these issues, and hence improved and broadened methods and frameworks for analyzing usability data are needed. We are continuing our work in this area and we are currently working on developing a comprehensive framework for

considering an increasing range of issues/problems in user interaction with systems in healthcare.

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