Context Sensitive Health Informatics: Many Places, Many Users, Many Contexts, Many Uses
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Development of a Video Coding Scheme for Analyzing the Usability and Usefulness of Health Information Systems

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Abstract. Usability has been identified as a key issue in health informatics. Worldwide numerous projects have been carried out in an attempt to increase and optimize health system usability. Usability testing, involving observing end users interacting with systems, has been widely applied and numerous publications have appeared describing such studies. However, to date, fewer works have been published describing methodological approaches to analyzing the rich data stream that results from usability testing. This includes analysis of video, audio and screen recordings. In this paper we describe our work in the development and application of a coding scheme for analyzing the usability of health information systems. The phases involved in such analyses are described.

Keywords. Usability, video analysis, human engineering, simulations, patient safety, human factors

Introduction

In recent years methods such as usability testing and clinical simulation have been increasingly applied to the design and deployment of more effective and usable health information systems [1]. Usability testing typically involves collection of screen and audio recordings of users as they interact with systems to carry out work tasks. The resultant screen recordings of user interactions are captured by continuous screen recordings. The audio portion of the interactions may consist of study participants' thinking aloud or making other verbalizations while carrying out tasks [2-4]. This approach has been applied in order to identify usability problems from data that is collected.

The Think Aloud protocol analysis approach has been found to be very useful for identifying usability problems with healthcare information systems [1-4]. In addition, clinical simulations have extended this approach and have produced data that includes recordings of user's screen interactions and audio from user's verbalizations while carrying out realistic tasks [5]. In the area of medical cognition, a number of coding schemes have been presented that may be used to examine cognitive aspects of user interaction and patient safety [6]. In addition, work from the general area of human-computer interaction has relevance for analyzing video data from a theoretical perspective (e.g. work based on the human information processor model [7] as well as

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work based on distributed cognition [8]). For example, categories that can be used for analyzing video data can be modified from heuristics developed and scientifically validated by Jacob Nielsen [9] for a different purpose – namely for coding video data obtained from conducting usability tests and clinical simulations [1]. Also, Norman's concepts of user slips and mistakes can be modified for inclusion in video coding [15].

In recent years, there has been an ever increasing number of usability tests being conducted with health information systems [1]. However, despite the increased use of this type of data collection (which typically involves recording of user interactions with a health information system while carrying out tasks) and a scientific basis from the human factors and other related literatures [7-8], there are few published works that focus on providing researchers and investigators with extensible coding schemes that can guide the combined analysis of digital video and audio data. In this paper we describe a coding scheme we have developed for this purpose.

1. Methodological Approach

There are a wide range of approaches to coding and analyzing data that results from video collected during usability testing. These include approaches such as grounded theory, where codes are inductively developed from the data itself. On the other hand coding approaches may include content and protocol analysis where pre-existing codes are used to identify patterns in the data (e.g. use of strategies in interacting with a computer system). In this paper we focus on an approach that borrows from both perspectives. In particular, a set of pre-existing codes that have been used on many of our projects will be presented. Also, in line with an approach known as direct coding, both a set of pre-existing codes are used to analyze data, as well as emergent codes (i.e. codes not previously discussed in the literature) that are akin to the inductive codes of grounded theory. The ideas for coding categories in this paper came from examination of different coding categories that have been developed from the HCI literature, evidence-based sources and our experience over 20 years of video coding in healthcare usability. These have included:

- Modification of categories from standardized questionnaires [10] to be used for a new purpose – i.e. video analysis
- Video coding categories emerging from modifying approaches to cognitive analysis in medical decision making theory and research [6]
- Categories that have emerged from our own prior work (as previous emergent codes that have been added to our growing list of codes) [1]
- Categories that have been borrowed from Nielsen's heuristics (for heuristic evaluation) that we have modified for use as video coding categories [10]
- Categories from research on evidence-based user interface guidelines [11]

The development of the coding scheme presented in this paper was not the result of a single effort at one point in time, but rather has evolved from our first publication in this area in 1995 [12], through to publication of a methodological overview paper in 2004, and our subsequent work in areas related to studying the links between usability and technology-induced error in healthcare IT in 2005 [13]. In this section of the paper we describe the coding categories that we have used and incorporated into our coding scheme for analyzing video data resulting from usability tests and clinical simulations.

The codes are used to tag and identify sections of video and audio log files that can be characterized by the categories (as will be illustrated in a subsequent section of this paper). The codes are given below, with the codes themselves capitalized along with their definitions, thus forming a coding dictionary that is referred to by an analyst when going through and tagging video and audio data.

Usability Problem Codes

These codes are used to describe usability problems and issues identified when analyzing video usability data. The codes focus on aspects of the user interface and the user-system interaction and were derived from application of usability categories developed for other purposes (e.g. questionnaire scales, heuristic evaluation research and cognitive theory) but uniquely modified for use in coding video based process data.

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.

VISIBILITY 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 the 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.

Usefulness of Content Codes

These codes are used to describe issues regarding the usefulness of the user interface or system being evaluated from analyzing the data. The usefulness of the content of health information systems is extremely important to end users and can be differentiated from usability problems (e.g. a system may be usable but contain data or information that is not deemed useful to a healthcare worker).

APPLICABILITY – Coded when a review of the video data indicates that information presented is not applicable to real healthcare practice or cases encountered.

ACCURACY/CORRECTNESS – Coded when review of data or user comments indicates information or advice provided by system is not correct or accurate.

RELEVANCE – Coded when a review of the video data or user comments indicate information presented by a system is not relevant to their carrying out their task.

TIMELINESS – Coded when a review of the video data or user comments indicate that information is not timely.

IMPACT ON WORK ACTIVITIES – Coded when a review of video data or comments indicates unexpected impact of the system on work activities.

Safety and Technology-Induced Error Codes

These codes are used to identify and tag errors made by users when analyzing data [13].

SLIP – Coded when a review of the video data indicates the user has made a mistake but corrects the mistake.

MISTAKE – Coded when a review of the data indicates the user has made a mistake that is not corrected.

WORKAROUND – Coded when the user is not using the approach to carrying out work that is recommended by the healthcare organization or computer system. These can be sub-coded as NEGATIVE (e.g. use of incorrect, suboptimal or dangerous approaches), NEUTRAL (i.e. no impact on safety) or POSITIVE (i.e. increases safety).

2. Phases of Video Analysis

Transforming video data (resulting from usability testing and simulations) into a form where the above coding scheme can be applied involves several stages described below.

Transcription and Log File Creation Phase

Data obtained from usability testing and clinical simulations typically includes screen recordings from the application the user is interacting with (obtained from screen recording software such as Hypercam®), along with the audio recordings of user verbalizations (which may consist of think-aloud verbalizations, or audio recordings of the user interacting with the researcher or other users). In our approach we begin by having the audio portion of the interaction first transcribed in its entirely to begin creation of a log file (initially this file just contains the text of user and test monitor verbalizations). The log file may consist of a Word file, or as will be described, the log file can be imported into one of a number of qualitative coding tools.

Annotation (Coding) Phase

In this phase of analysis, the analyst(s) plays back and review the video recording of the user's interactions from usability testing or clinical simulations. As the user interaction is reviewed, the analyst marks up the log file (resulting from the transcription phase) with annotations and time stamps (obtained from watching the video recording) to demarcate key user actions (e.g. entering a new function in a

system, or exiting the program), system responses (e.g. system crash), or other interesting aspects of the user-system interaction. These annotations are entered directly into the log file of user verbalizations as the appropriate point in the audio transcriptions. In addition to marking up or annotating key user-system interactions of interest, this is the phase where the coding scheme described above in this paper can be applied to identify and mark specific types of usability problems, usefulness issues and safety related codes (e.g. slips or mistakes).

In addition, to marking up and coding the video data using the above categories of codes, problems or issues may be identified that were not predicted from a pre-existing coding scheme (i.e. "emergent" issues or problems). These emergent codes should be demarcated in the log file and annotated to indicate they were not contained in a coding scheme but rather "emerged" from the data itself. This can be referred to as "inductive" coding and from a practical perspective can be integrated with the predetermined coding scheme as described above (which can be referred to as "deductive" coding). The approach described above (that may include both deductive and inductive coding) has been referred to as "direct coding" in the qualitative analysis literature [14].

Summarization Phase

In this phase, the log files (from each user-system interaction) are analyzed to create a summary of usability problems, usefulness concerns or issues and safety problems both within and across users. This may include tabulation of the number of user problems, their severity, and their potential impact. How many users had a particular problem can also be taken into account when providing recommendations from the data for system or user interface redesign or optimization. The summary can be used for providing input to system developers and implementers as well as providing a basis for publishing technical and academic reports about types of healthcare information applications.

3. Example of Use of the Coding Scheme

In this section of the paper we provide an illustrative excerpt to show how the coding scheme described above can be applied to analysis of a user's (i.e. a physician) interaction with a new medication administration system. The excerpt below gives a section of a coded log file of user interactions. The participant's verbalizations are given in quotations and the log file has also been annotated with time stamps and marked up to indicate what actions the user is doing on the computer in italics. In addition, codes have been added to the log file and are indicated in caps:

00:00:00 *Start of testing session – user is given instructions to enter the medication "Darvon"*

"I am waiting for the medication entry screen to appear, I have clicked what I think is the enter medication icon, but I am not sure"

MEANING OF ICONS/TERMINOLOGY PROBLEM

00:00:45 *Medication entry screen comes up*

"Ok, it finally came up, but it seems like it took forever"

SPEED/RESPONSE TIME PROBLEM

00:01:05 *Participant begins to enter medication name into the text box that appears*

"Ok, here we go, the patient in your scenario has back pain and I am going to prescribe him the medication Darvon, which I sometimes prescribe for this problem"

00:01:30 *The system responds with names of medications that start with the letter "D" and user scans the list*

00:01:35 "Ok I will select from this list, but my eyesight is getting poor and this font is too small"
FONT PROBLEM

00:01:45 *User highlights and selects the medication "Diovan" from the list displayed*
MISTAKE – WRONG MEDICATION ENTERED – "Diovan entered instead of Darvon"

4. Discussion

The coding scheme presented in this paper is not meant to be exhaustive nor to be recommended to be the only approach to coding usability data. Indeed, in our studies we have modified and extended the basic coding categories described in this paper to suit the analysis for a specific category of health information system (such as study of electronic medication reconciliation). However, the categories and approaches described in this paper have proven generalizable enough to have been employed on a wide range of projects that involved collection and analysis of data from usability studies as well as clinical simulations. We have developed and presented the categories in this paper as a template that can be modified for use in different study contexts.

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