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Post-deployment usability evaluation of a radiology workstation

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ABSTRACT

Objectives: To determine the number, nature and severity of usability issues radiologists encounter while using a commercially available radiology workstation in clinical practice, and to assess how well the results of a pre-deployment usability evaluation of this workstation generalize to clinical practice.
Methods: The usability evaluation consisted of semi-structured interviews and observations of twelve users using the workstation during their daily work. Usability issues and positive usability findings were documented. Each issue was given a severity rating and its root cause was determined. Results were compared to the results of a pre-deployment usability evaluation of the same workstation.
Results: Ninety-two usability issues were identified, ranging from issues that cause minor frustration or delay, to issues that cause significant delays, prevent users from completing tasks, or even pose a potential threat to patient safety. The results of the pre-deployment usability evaluation had limited generalizability to clinical practice.
Conclusions: This study showed that radiologists encountered a large number and a wide variety of usability issues when using a commercially available radiology workstation in clinical practice. This underlines the need for effective usability engineering in radiology. Given the limitations of pre-deployment usability evaluation in radiology, which were confirmed by our finding that the results of a pre-deployment usability evaluation of this workstation had limited generalizability to clinical practice, it is vital that radiology workstation vendors devote significant resources to usability engineering efforts before deployment of their workstation, and to continue these efforts after the workstation is deployed in a hospital.

1. Introduction

To ensure that software has high usability (i.e., allows users to perform their tasks effectively, efficiently and enjoyably), usability engineering methods should be applied throughout the software development cycle: before design, during design and implementation, and after deployment of the software [1]. However, a recent survey conducted among usability practitioners showed that usability activities are performed less frequently during the post-deployment phase than in other phases of development [2]. While pre-deployment usability activities are of course important, and can prevent usability issues in the post-deployment phase, learning from real users using the software in the real world is also valuable [1–5]. Since, iteration and user feedback are core components of usability engineering [1,6], it is unfortunate that these data are being underused.

Post-deployment usability evaluation can be especially useful in domains such as radiology, where it is difficult to perform valid pre-deployment usability evaluations for two reasons. First, it is difficult to obtain a representative user group, because radiologists with different specializations work in very different ways, radiologists are relatively expensive and they often have limited time to spare for usability activities. Second, it is difficult to construct a representative testing environment, because the radiological workflow is complex and differs between hospitals and radiology software needs to communicate with multiple interdependent systems (e.g., the hospital information system, imaging modalities), which also differ between hospitals. This means that even when radiology software vendors apply usability engineering methods before and during design and implementation of their software, it is still likely

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that usability issues occur when the software is used in clinical practice.

Comparative usability evaluations of commercial radiology workstations indicate that there is indeed room for usability improvement [7–9]. However, because the main goal of these studies was to compare the workstations based on a quantitative representation of usability, they provide limited insight into the nature and severity of usability issues radiologists encounter with the workstations. These studies also face the same limitations as the workstation vendors (the difficulty to obtain a representative user group and a representative testing environment for usability evaluation), which raises questions about the generalizability of their results.

Other usability studies in radiology do provide more detailed qualitative usability information [10–13]. However, three of these studies [10,12,13] evaluated systems that do not play a critical role in the radiological workflow and one [11] only performed a heuristic evaluation, which means that no actual users took part in the evaluation. Also, all of these studies were conducted in laboratory settings, so they do not provide information about usability issues encountered in clinical practice.

In this study, we performed a post-deployment usability evaluation of the radiology workstation that received the highest usability rating in the comparative pre-deployment evaluation of Jorritsma et al. [7]. We aimed to determine the number, nature and severity of usability issues radiologists encounter while using this workstation in clinical practice, and to assess how well the results of the pre-deployment usability evaluation of this workstation generalize to clinical practice.

2. Methods

2.1. Apparatus

In this paper, the term 'radiology workstation' refers to the software radiologists use for viewing medical images and reporting their diagnosis. The radiology workstation evaluated in this study consisted of three components: an image viewer (the client for the Picture Archiving and Communication System (PACS)), which included standard post-processing capabilities, a workflow manager (the client for a rudimentary version of the Radiology Information System (RIS)) and a report editor with speech recognition. Technically, these are separate applications, but since they form one integrated whole sold by one vendor as a single package, we consider them here as one system.

Fig. 1 shows the workstation setup used in our hospital. A 30.4″ diagnostic monitor displays the image viewer and a 20.1″ monitor displays the workflow manager and the report editor. Some radiologists have a third monitor that they use to display an image archive of the patient (an overview of all studies of the patient). The input devices are a standard mouse, a keyboard and a handheld speech microphone.

The workstation was deployed in our hospital fourteen months before the start of this study, replacing a workstation of a different vendor that had been in place for about thirteen years.

The workstation vendor applied usability engineering methods throughout the development of the workstation. These methods included pre-design user research, empirical evaluation of prototypes, and iterative design.

The workstation was included in the pre-deployment comparative usability evaluation of Jorritsma et al. [7], in which it was referred to as PACS B. Of the four workstations evaluated in this study, this workstation was found to have the best usability.

2.2. Participants

Twelve users participated in the usability evaluation. Ten were radiologists (mean years of experience: 6.1, range: 0.6–27; specializations: thoracic/cardiac; mammo/abdominal/paediatric; paediatric; thoracic/abdominal; musculoskeletal; abdominal; IC/mammo/thoracic; paediatric/oncologic; 2 neurological) and two were radiology residents (a first- and a third-year resident).

Three users did not work with the workstation that was previously in place in our hospital, but did have experience with workstations from different vendors.

Users were randomly selected from the total group of radiologists and radiology residents in our hospital until a test group of twelve users was formed. During this process one radiologist and one radiology resident refused to participate because they were too busy at the time.

2.3. Design and procedure

Sessions were held with individual users at their own workplace. A session lasted approximately 45–60 min and consisted of a brief semi-structured interview and an observation of the users during their daily work. The interview aimed to assess the users' general opinions about the workstation and to identify the main usability issues encountered. The following questions were used to guide the interview: "how satisfied are you with the workstation (on a scale of 1–10)?", "what is better/worse in this workstation compared to the previous one (or in case the user did not work with the previous workstation: "other workstations you have worked with)?" and "what problems do you encounter?".

After the interview, users were asked to review a number of studies from their current worklist that were as representative of their daily work as possible. They were instructed to vocalize the steps they were taking (think-aloud protocol) and to illustrate usability issues as they were encountered. If users' comments or behavior required clarification, the session observer would prompt them to explain themselves in more detail. A video recording of the screens was made during the observation. Audio was recorded throughout the session.

Informed consent was obtained. Users could give separate permission for the use of their data for this study (inclusion criterion), audio recording during the session, and video recording during the observation. All users gave permission for all three items.

All data collection sessions were conducted by one usability expert (the first author). Because users performed naturally occurring rather than controlled, pre-defined tasks, we did not obtain quantitative measures of effectiveness and efficiency. Instead these usability aspects were evaluated based on the qualitative data.

2.4. Data analysis

The audio and video recordings were synchronized. The audio recordings were transcribed and the fragments describing usability issues were marked and given an issue number (i.e., each issue was identified based on users' verbal data). For each issue, a time stamp was added to the transcript so that it could easily be found later in the video recordings. Excerpts were taken from the video recordings to illustrate the issues that were difficult to understand by description alone. A general description of all unique issues was put in a spreadsheet. Positive usability findings were also documented.

Each usability issue was given a severity rating according to a rating system based on those described by Rubin and Chisnell [14] and Tullis and Albert [15]: severity = impact on the user experience (1 = low, 2 = medium, 3 = high) + predicted frequency of occurrence (1 = low, 2 = medium, 3 = high). The issues were rated by one usability expert (author 1). We used the ratings of one expert rather than