International Journal of Healthcare Information Systems and Informatics

January-March 2015, Vol. 10, No. 1

Table of Contents

ICD-10-CM and the Risk of Re-Identification

Guest Editorial Preface

iv *Liam O'Neill, School of Public Health, University of North Texas Health Science Center, Fort Worth, TX, USA*

Research Articles

1 **Critical Success Factors in Health Information Technology Implementation: The Perspective of Finnish IT Managers**
Nguyen Thi Thanh Hai, Department of Health and Social Management, University of Eastern Finland, Kuopio, Finland
Tommi Tapanainen, Hanyang University School of Business, Seoul, Korean
Diana Ishmatova, APEC e-Government Research Center, Waseda University, Tokyo, Japan

17 **A Decision Support System (DSS) for Colorectal Cancer Follow-Up Program via a Semantic Framework**
Kalpdrum Passi, Department of Mathematics and Computer Science, Laurentian University, Sudbury, Canada
Hongtao Zhao, Department of Mathematics and Computer Science, Laurentian University, Sudbury, Canada

39 **Mining ICDDR, B Hospital Surveillance Data and Exhibiting Strategies for Balancing Large Unbalanced Datasets**
Adnan Firoze, School of Engineering and Applied Science (SEAS), Columbia University, New York City, NY, USA
Rashedur M Rahman, Department of Electrical and Computer Engineering, North South University, Dhaka, Bangladesh

67 **Improving Healthcare System Usability Without Real Users: A Semi-Parallel Design Approach**
Farath Arshad, Centre for Health and Social Care Informatics (CHaSCI), Liverpool John Moores University, Liverpool, UK
Nonso Nnamoko, School of Computing and Mathematical Science, Liverpool John Moores University, Liverpool, UK
James Wilson, North West Deanery, Manchester, UK
Bibhas Roy, Central Manchester NHS Foundation Trust, Trafford Hospital, Manchester, UK
Mark Taylor, School of Computing and Mathematical Science, Liverpool John Moores University, Liverpool, UK

The *International Journal of Healthcare Information Systems and Informatics* is indexed or listed in the following: ACM Digital Library; Australian Business Deans Council (ABDC); Bacon's Media Directory; Burrelle's Media Directory; Cabell's Directories; Compendex (Elsevier Engineering Index); CSA Illumina; DBLP; Gale Directory of Publications & Broadcast Media; GetCited; Google Scholar; JournalTOCs; Library & Information Science Abstracts (LISA); MediaFinder; Norwegian Social Science Data Services (NSD); SCOPUS; The Index of Information Systems Journals; The Standard Periodical Directory; Ulrich's Periodicals Directory

Improving Healthcare System Usability Without Real Users: A Semi-Parallel Design Approach

Farath Arshad, Centre for Health and Social Care Informatics (CHaSCI), Liverpool John Moores University, Liverpool, UK

Nonso Nnamoko, School of Computing and Mathematical Science, Liverpool John Moores University, Liverpool, UK

James Wilson, North West Deanery, Manchester, UK

Bibhas Roy, Central Manchester NHS Foundation Trust, Trafford Hospital, Manchester, UK

Mark Taylor, School of Computing and Mathematical Science, Liverpool John Moores University, Liverpool, UK

ABSTRACT

This paper describes an early stage usability study conducted on a prototype system designed to capture and analyse Patient Reported Outcome Measures (PROMs) activities. The system – PROMS 2.0, was developed by Bluespier for the trauma and orthopaedic department in Trafford Hospital, Manchester, United Kingdom (UK). The Centre for Health and Social Care Informatics (CHaSCI), Liverpool John Moores University (LJMU) examined the system without real users, identified potential usability issues and suggested possible solutions for improvements before final release by Bluespier. Three different approaches were adopted for evaluating user interface (UI) design without users. The first approach is the Cognitive Walkthrough (CW), a task-oriented technique capable of identifying issues through action sequence required to perform a task. The second approach is action analysis which predicts the time a skilled user would need to perform a task. The third approach is heuristic evaluation which tends to identify problems based on recognised standards. Results support the argument from relevant cognitive psychology theories and user-centric design principles that UI evaluation without real users is a useful tool in yielding rapid output for subsequent enhancement. It is concluded that semi-parallel design concept could be the key to timely delivery of software design projects.

Keywords: *Action Analysis, Cognitive Walk-Through, Heuristic Evaluation, Human-Computer Interaction, Proms 2.0, User Interface Evaluation*

DOI: 10.4018/IJHISI.2015010104

1. INTRODUCTION

From April 2009, all licensed providers of National Health Service (NHS) funded treatment in the United Kingdom (UK) were expected to collect Patient Reported Outcomes Measures (PROMs) questionnaires from patients undergoing any of four index elective surgical procedures, namely: varicose vein surgery, inguinal hernia repairs, hip replacements and knee replacements (National Health Service, 2008). PROMs assess the quality of care delivered to patients from the patient perspective via short, self-completed questionnaires before a procedure (pre-operative) and after the procedure (post-operative). The questionnaires use validated disease specific outcome measure tool to provide an indication of the outcomes or quality of care delivered to patients. Until recently, most NHS providers used paper based questionnaires for PROMs data collection. Basically, patients filled in the pre-operative PROMs questionnaires by hand and the completed forms are transferred securely to the contractors responsible for collating all of the information. The forms are then scanned electronically and matched with each patient's NHS number. Using the NHS numbers, the pre-operative PROMs questionnaires are linked securely to the relevant PROMs databases. After three or six months, depending on procedure, the contractor posts out a follow-up post-operative questionnaire to patients. Once again the forms are electronically scanned upon return and linked with the pre-operative data within the PROMs databases.

Trafford hospital believed efficiency could be improved in this ambitious project if the questionnaires were collected and collated online. Bluespier was contracted to develop the software (PROMS 2.0) (Wilson et al., 2013). There was also a need to release the software quickly so the timeframe allocated for the project was very short. Unfortunately such software development projects usually take a user centric approach where requirements are driven by end users and collected by a mix of quantitative and qualitative research methods. Also the design process always require several rounds of modifications through testing with real users (Jakob Nielsen, 1993)(Rosson & Carroll, 2002). According to Nielsen (J. Nielsen, 1993), at least two iterations, yielding three versions is required, before a product is good enough for release. The decision was made by the Trust to adopt what we call a semi-parallel design approach where independent designer(s) examine a prototype system and suggest improvements. Parallel design approach involves multiple designers independent of each other designing suggested user interfaces based on version zero concept which are then merged to a unified design (Card, Moran, & Newell, 1983)(Jakob Nielsen & Faber, 1996).

PROMS 2.0 followed an agile development process so there is little time to conduct testing in real user environment. The user research team from Trafford hospital worked closely with both Bluespier and CHaSCI to identify, capture and address requirements. This paper describes the early stage usability study conducted by CHaSCI on PROMS 2.0 prototype system. The study was conducted without real users and in parallel with the actual system design by Bluespier to produce a final version faster.

2. BACKGROUND

Computerised data collection systems for healthcare have a long history. In the early 1970s, large multi-centre trials such as the Hypertension Detection and Follow-up Program gathered huge amounts of data through hard copy questionnaires completed at physicians' offices and then transferred to a central site where the data would be entered manually onto mainframe computers (Ramsay, 1997). Dramatic improvements were observed in the early 1980s, with studies such as the Systolic Hypertension in the Elderly Program offering better quality and faster availability of data. This was achieved by using personal computers at the local sites for data entry and then for transfer of data electronically via modems to mainframes. Other techniques began to emerge from the 1990s that support online data collection, such as direct mailings of questionnaires through the Internet, and web-based data entry and management systems (Swoboda, 1997), remote entry via handheld devices (Eikemeier, Grütter, & Heitmann, 2000), computer-assisted techniques and telephone interviewing (Yamakami et al., 1998). A good number of online survey tools exist today, that can be applied in various domains for data collection and analysis (SurveyMonkey, n.d.). However, it is important to note that the study reported in this paper is focused on purpose built tools for online data collection, and associated design challenges; and not the availability of their generic counterparts. There is increasing demand on software development companies to increase usability and decrease development time. Unfortunately, these goals conflict with traditional usability approaches, often involving testing with real users and redesigning; thus delaying product release. Our study is motivated by these challenges as outlined in the next section.

3. MOTIVATION

Following the introduction of PROMs collection in April 2009 by the Department of Health (Devlin, Appleby, Buxton, & Vallance-owen, 2010), Trafford hospital needed a system capable of delivering PROMs activities electronically. The major challenges were to:

1. Develop and release the product within a very short timeframe (partly constricted by the funding stream and also available staff to work on the initiative).
2. Anticipate and resolve possible usability issues in the design (without testing on real users).

Therefore, quick production and high usability standard was considered important. For the Trust, successful and timely release of the product will improve efficiency and reduce cost within the orthopaedic area.

4. METHODOLOGY

We examined both user interfaces (patient and clinicians) in the early version of PROM 2.0 system, using a combination of task oriented and task free methods that includes three recognised approaches for evaluating interfaces in the absence of real users. The first approach is the cognitive walkthrough (CW) which is a task-oriented technique that presents a formalised way of imagining peoples' thoughts and actions when they use an interface for the first time (Polson, Lewis, Rieman, & Wharton, 1992). In CW, the tasks that users are expected to perform are examined individually, based on knowledge of intended users. A walk through of the action steps required to complete each task enables the individuals examining the process to specify how each action step is achieved. Effectively, the examiner simulates the action steps required to complete each task, based on knowledge of intended users' web navigation skills. A task is approved if there is no apparent gap (i.e., issue) between one or more action steps to complete it. However, a UI problem is identified when the process is not seamless. This technique has been tested in various situations (Jakob Nielsen & Mack, 1994), and it is recommended for use within a group, preferably skilled designers (Lewis & Rieman, 1994). We (the first two authors) performed specific tasks on the interface and took note of possible problems. It is worth noting that CW is a tool for developing an interface and not for validation.

The second approach is action analysis, that allows a designer to predict the time required for a skilled user to perform a task (Card et al., 1983). This technique forces the designer to look closely at the sequence of actions a user has to perform in order to complete a task with an interface, predict times required to perform each step and then work out the sum for the times (Lewis & Rieman, 1994). This includes average times for physical movement (e.g., using mouse to point at an object), visual perception (e.g., recognise a 5 letter word) and mental action (e.g., associate UI controls to required actions). Standard values have been determined through extensive research for most of the common actions performed on a user interface (Olson & Olson, 1990) and tool are now available that can produce similar computation automatically such as CogTool (John E, n.d.). Cogtool is a general purpose user interface (UI) prototyping tool used to produce a valid cognitive model that predicts how long it will take a skilled user to complete specific task(s) on a system (John E, n.d.). The predictions made by CogTool are based on a psychological theory of human cognitive and motor capabilities, called the Keystroke-Level Model (KLM), which has been used and validated repeatedly by academics and practitioners since 1980 (Card, Moran, & Newell, 1980). We used Cogtool's widget to create a storyboard of PROM 2.0 design with demonstration of specific tasks and calculated how long it will take a skilled user to perform the tasks.

The third approach is heuristic evaluation, a task-free approach that catches a wide variety of problems using general UI guidelines. This approach requires that the analyst(s) have enough UI knowledge to translate the general principles into the specifics of the current situation (Lewis & Rieman, 1994). This technique is often used to catch problems that were missed through task-oriented techniques. Nielsen and Molich have developed a short list of nine general heuristics (Jakob Nielsen, 1993)(Molich & Nielsen, 1990) and a procedure for their use in evaluating a design (Jakob Nielsen, 1992)(Jakob Nielsen & Molich, 1990). The list of nine heuristics was deduced from several but longer lists that have been suggested by other authors and the procedure suggests that no single analyst will find every UI problem. We applied heuristics to the UI individually and then combined results to generate a single list of possible issues.

Finally, we combined the problems identified through the 3 approaches and produced possible solutions. Based on the solutions, we used Cogtool's widget to create a revised version of the design with demonstration of the same tasks tested in the original version; and then compared results. We examined several tasks on both UIs which the intended users would normally perform but for simplicity, only one involving the patients interface was reported in this paper. No patient specific data was accessible or provided for this usability study. [Patients were not involved at this stage of the study].

5. ANALYSIS & RESULTS

5.1. Performed Task: Patient Interface

In practice, patients following consent would be enrolled and a hyperlink to the PROM 2.0 data collection tool would then be delivered by email to the patient (Figure 1 in the Appendix). Once clicked, the patient after successful authentication (Figure 2 in the Appendix) will be presented with the questionnaire with a total of 12 questions. Each of the questions has 5 response options (i.e., 12 x 5 in total). Patients will point and click items to indicate their choices (Figure 3 in the Appendix). Upon completion of the assessment, patients would get confirmation showing their entries have been received or in cases of post-operative questionnaires, an indication of their score, and how they compare to other patients who have undergone the same procedure (Figure 4 in the Appendix). A clinical review appointment is automatically generated if improvement is less than anticipated as shown but this falls outside the scope of this study.

In terms of the representative task being examined for this study, we carried out the same task procedure outlined above. The website requires the user to provide date of birth to access the questionnaire, therefore the action sequence required to complete the task would be:

1. Select assessment link from e-mail,
2. Login by inputting correct date of birth in the specified field,
3. Complete the questionnaire,
4. Submit the form, and
5. Close the window.

5.2. Result: Cognitive Walkthrough

The walkthrough is very similar to telling a story about how and why the user would select an action step in a list of possible actions. The story is then reviewed using the following four questions:

1. Will users be trying to produce whatever effect the action has?
2. Will users see the control (button, menu, switch, etc.) for the action?
3. Once users find the control, will they recognize that it produces the effect they want?
4. After the action is taken, will users understand the feedback they get, so they can go on to the next action with confidence?

Figure 5 in the Appendix is a sample story that illustrates how the four questions apply to the representative task. We assume the user have the required skills to turn on a computer, access their email inbox and navigate to the email but have neither seen the email nor completed the online assessment before.

5.3. Result: Action Analysis

In performing action analysis, we tried to predict human performance with CogTool, by representing the PROMS 2.0 UI as a storyboard. Each state of the UI in the action steps is represented as a frame, each actionable frame item (e.g., link, button) or device (e.g., mouse, keyboard) is represented as a widget, and each complete action on a widget or device (e.g., mouse click, keystrokes on the keyboard) is represented as a transition between frames. A piece of the storyboard for the action sequence is shown in Figure 6 in the Appendix. We demonstrated the task on the storyboard by performing the appropriate actions. CogTool records each action step in the sequence, automatically inserts additional operators – i.e., valid KLM (Card et al., 1980), and displays the next frame. The demonstration continues for each action step until the final step is completed and the entire KLM is built, as shown in Figure 7 in the Appendix (i.e., the task of completing a pre-operative assessment). Upon hitting the compute button, CogTool runs a computational model of what a user would see, think and do to produce a quantitative estimate of the execution time and a timeline visualization of the underlying cognitive model (Figure 8 in the Appendix).

The timeline in Figure 8, represents what the user would see (purple), think (grey) and do (red) to access and complete the Oxford Shoulder Score assessment on the original version of PROMS 2.0 interface. CogTool's visualization window can also be used to compare demonstrations between different versions of an interface. In Figure 9 and Figure 10 in the Appendix, the top timeline represents a user's action steps to access and complete the Oxford Shoulder Score assessment on the original PROMS 2.0 interface and the bottom timeline is of the same task on the revised interface. We discovered similar patterns at the start – *i.e.,* the period between clicking the 'Oxford Shoulder Score' link and successful login to access the questionnaire. However, the patterns changed shortly after that with the original version taking longer time than the revised version (Figure 11 in the Appendix). Notice that cognition is the same between both UI versions which suggests there were no issues associated with the controls (i.e., radio buttons). However, looking behind the numeric predictions (right side of Figure 11), the overall time taken by skilled user to complete the questionnaire and hit the submit button in the revised version is considerably quicker. Although both versions require the same number of clicks to complete the questionnaire, the time required to locate and answer each questions is significantly decreased in the revised version. In fact, the time decreased because less time was spent scrolling up and down the page. This shows that the questionnaire length made a difference and begs the question of why some survey software designers pay insufficient attention to recognised online questionnaire design guidelines (Reynolds, Woods, & Baker, 2007).

5.4. Result: Heuristic Evaluation

In the heuristic evaluation we applied Nielsen and Molich's nine heuristics (Figure 12 in the Appendix) on the UI to identify problems. We combined individual results from two evaluators to produce a single list of possible issues. Since heuristic analysis is usually a task-free approach, the PROMS 2.0 patient UI was examined as a whole entity. Also, we omitted the first action step in the task sequence i.e., click 'Oxford Shoulder Score' link from the email. We assume the user have the required skills to turn on a computer, access their email inbox and navigate to the email but have never seen the UI. Figure 13 in the Appendix shows a sample heuristic analysis of PROMS 2.0 patient UI, in accordance with the guidelines in Figure 12.

6. LIMITATIONS AND RECOMMENDATIONS

The evaluation was conducted without real users using a combination of task-oriented and task-free methods and quite possibly results could be even more encouraging if patient specific usage could have been acquired. With user free evaluation, it is impossible to envisage every possible user action and there is almost never time to evaluate every task a real user would perform; so some action sequences and often some controls are not evaluated. Also, quality of task-free evaluations depends highly on how knowledgeable the evaluators are in user interface design. However, it is important to understand that in the context of an emerging e-health environment, practical system development and evaluation is complex and often involves a long lead in time. The evaluation methods used in this study has been proven to work in several interface development projects (Card et al., 1983). It was recommended that the direction of travel for the demonstrator is to incorporate our results and develop a fully functioning on-line tool which is accessible by a cohort of patients, over a period of time. An evaluation of patient satisfaction using the system has been reported in another study (British Elbow & Shoulder Society (BESS), 2013) (see also (Whiteman, Wilson, & Roy, 2013)). However, it is important to note that the evaluation was mainly on the system utility and not usability. That is, to assess if remote monitoring of patients using the oxford shoulder score would adequately and safely replace clinic appointments whilst maintaining patient satisfaction and enhancing cost effectiveness. Eighty four patients were assessed and the results conveyed that only six individuals (7%) would choose to return to clinic whilst 78 (93%) would be happy not to. Also 100% said they would recommend the system. A statement from the service provider (trauma and orthopaedic department in Trafford hospital), read "… The user interface has not generated comments from patients, and we assume this is a good thing. The user interface continues to evolve to make the system fit new processes …" Perhaps, this is the reason why a usability evaluation with real users has not been conducted yet.

7. SUMMARY

We have looked at three methods for evaluating an interface without users and provided a summary at the end of each of the examples to show that each method uncovered different problems. The cognitive walkthrough identified problems with the questionnaire length and suggested that they be presented differently. The heuristic analysis highlighted some other problems related to control, error handling and labelling. The action analysis provided visual comparison between the original interface and the revised interface and made it clear that there were a lot of actions needed to perform some tasks. Although very explicit, the combined result of the three techniques might have missed some problems which could only surface during real user testing. However, the results were enough to facilitate development and timely release of the full system. Presently, PROM 2.0 has been adopted by 9 NHS Trusts across the north west region in the UK (PROMS 2.org, n.d.) and this number is bound to increase as participating NHS Trusts across the country seek validated ways to effectively deliver PROMSs data. This could generate sufficiently rich data not only about the actual treatment experience, but also how patients respond to the technology and its appropriateness for collecting robust PROMs data following surgery. A full-scale evaluation of the information returned by the patients will indicate the level of efficiency for engaging patients through on-line means as opposed to the paper based exercise currently undertaken by some NHS Trusts in the UK.

ABBREVIATIONS

PROMs: Patient Reported Outcome Measures
UI: User Interface
NHS: National Health Service
UK: United Kingdom
CW: Cognitive Walkthrough
KLM: Keystroke-Level Model
NHS: National Health Service
LJMU: Liverpool John Moores University
CHaSCI: Centre for Health and Social Care Informatics

ACKNOWLEDGMENT

An InnovateNOW, UK NHS North West grant enabled the development of the PROM 2.0 system described in this paper. Bluespire developed the system and CHaSCI provided the review. Professor Gerry Kelleher provided valuable help in shaping the form of this paper.

REFERENCES

British Elbow & Shoulder Society (BESS). (2013). Abstracts for the 24thAnnual Scientific Meeting, BESS. *Shoulder & Elbow, 5*(4), 276–294. doi:10.1111/sae.12036

Card, S. K., Moran, T. P., & Newell, A. (1980). The keystroke-level model for user performance time with interactive systems. *Communications of the ACM*, *23*(7), 396–410. doi:10.1145/358886.358895

Card, S. K., Moran, T. P., & Newell, A. (1983). *The Psychology of Human-Computer Interaction* (p. 469). Hillsdale, NJ: Lawrence Erlbaum Associates.

Devlin, N. J., Appleby, J., Buxton, M., & Vallance-owen, A. (2010). *Getting the most out of proms*.

Eikemeier, C., Grütter, R., & Heitmann, K. (2000). A new generation of remote data entry: Using WAP-phones in clinical trials. *Studies in Health Technology and Informatics*, *77*, 338–342. PMID:11187569

John, E. B. (n.d.). Welcome to CogTool. Retrieved November 12, 2013, from http://cogtool.hcii.cs.cmu.edu/

Lewis, C., & Rieman, J. (1994). Evaluating the Design Without Users. In Task-centered User Interface Design: A Practical Introduction (pp. 41 – 74).

Molich, R., & Nielsen, J. (1990). Improving a human-computer dialogue. *Communications of the ACM*, *33*(3), 338–348. doi:10.1145/77481.77486

National Health Service. (2008). Standard NHS Contract for Acute Services: Schedule 5. *Standard Deed of Variation*. Retrieved May 28, 2013, from http://www.dudley.nhs.uk/sections/publications/documents%5CFOI29384907574.pdf

Nielsen, J. (1992). Finding usability problems through heuristic evaluation. In *Proceedings of the SIGCHI conference on Human factors in computing systems - CHI '92* (pp. 373–380). New York, New York, USA: ACM Press. doi:10.1145/142750.142834

Nielsen, J. (1993). Iterative user-interface design. *Computer*, *26*(11), 32–41. doi:10.1109/2.241424

Nielsen, J. (1993). The Usability Engineering Life-cycle. In *Usability Engineering* (pp. 71–113). San Francisco: Morgan Kaufmann. doi:10.1016/B978-0-08-052029-2.50007-3

Nielsen, J., & Faber, J. M. (1996). Improving system usability through parallel design. *Computer*, *29*(2), 29–35. doi:10.1109/2.485844

Nielsen, J., & Mack, R. L. (1994). *Usability Inspection Methods* (p. 413). New York: John Wiley & Sons, Inc.

Nielsen, J., & Molich, R. (1990). Heuristic evaluation of user interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems Empowering people - CHI '90* (pp. 249–256). New York, New York, USA: ACM Press. doi:10.1145/97243.97281

Olson, J. R., & Olson, G. M. (1990). The Growth of Cognitive Modeling in Human-Computer Interaction Since GOMS. *Human-Computer Interaction*, *5*(2-3), 221–265. doi:10.1080/07370024.1990.9667155

Polson, P. G., Lewis, C., Rieman, J., & Wharton, C. (1992). Cognitive Walkthroughs: A Method for Theory-Based Evaluation of User Interfaces. *International Journal of Man-Machine Studies*, *36*(5), 741–773. doi:10.1016/0020-7373(92)90039-N

PROMS 2.org. (n.d.). PROMS 2.0: System for collecting, analysisng and publishing outcome data for any defined clinical procedure. Retrieved September 29, 2014, from http://proms2.org/

Ramsay, L. (1997). The Hypertension Detection and Follow-up Program 17 Years On. [JAMA]. *Journal of the American Medical Association*, *277*(2), 167–170. doi:10.1001/jama.1997.03540260081041 PMID:8990345

Reynolds, R. A., Woods, R., & Baker, J. D. (2007). Online - Questionnaire Design Guidelines. In *Handbook of Research on Electronic Surveys and Measurements* (pp. 44–64). Idea Group Inc. doi:10.4018/978-1-59140-792-8

Rosson, M. B., & Carroll, J. M. (2002). *Usability Engineering: Scenario-Based Development of Human-Computer Interaction* (pp. 1–28). Academic Press Inc. doi:10.1016/B978-155860712-5/50002-3

SurveyMonkey. (n.d.). Create Surveys. Get Answers. Retrieved November 12, 2013, from https://www.surveymonkey.com/

Swoboda, W., Muhlberger, N., Weitkunat, R., & Schneeweiss, S. (1997). Internet Surveys by Direct Mailing: An Innovative Way of Collecting Data. *Social Science Computer Review*, *15*(3), 242–255. doi:10.1177/089443939701500302

Whiteman, A., Wilson, J., & Roy, B. (2013). Evaluation of patient satisfaction using innovative PROMS 2.0 System to assist follow up of Arthroscopic Subacromial Decompression. *24thAnnual Scientific Meeting, BESS*. Retrieved from http://static.squarespace.com/static/509ad012e4b0592f670ebb81/t/522b1887e4b04879e6b504ba/1378556039219/Presentation for BESS.pdf

Wilson, J., Arshad, F., Nnamoko, N., Whiteman, a, Ring, J., & Roy, B. (2013). Patient-reported outcome measures: an on-line system empowering patient choice. *Journal of the American Medical Informatics Association : JAMIA*, 1–5. doi:10.1136/amiajnl-2012-001183

Yamakami, H., Kiuchi, T., Nagase, T., Ohe, K., Kaihara, S., & Sakurai, T. (1998). Development and trial operation of a World Wide Web-based data entry system for the collection of statistical data on the management of the national university hospitals in Japan. *Medical Informatics*, *23*(1), 19–29. doi:10.3109/14639239809001388 PMID:9618680

APPENDIX

Figure 1. Example E-Mail sent to patient to complete the Oxford shoulder score

Dear X,

Thank you for taking the time to respond to this.
You will remember, prior to surgery, we discussed a system of collecting some data about your surgery which will enable us to measure the benefit that you have had from the procedure. We send you the appropriate questions at predetermined intervals. These are using defined and validated questions that enable you to understand the outcome of your surgery by comparing this score to your pre-operative score. These are known as PROMs (Patient Reported Outcome Measures).

You will also be able to compare your outcome with other patients who have had the same procedure.

If you are doing well and have had the expected benefit from the surgery, you may choose not to come back to clinic, we will continue to communicate with you through email.

We would also request you to complete a few questions about this process of keeping in touch which may enable you to avoid a clinic appointment. We hope this will save you time, and allow us to see patients who need to be seen.

Kind regards,

Dr Y.

Please complete the following assessment Oxford Shoulder Score.

Figure 2. User authentication screen

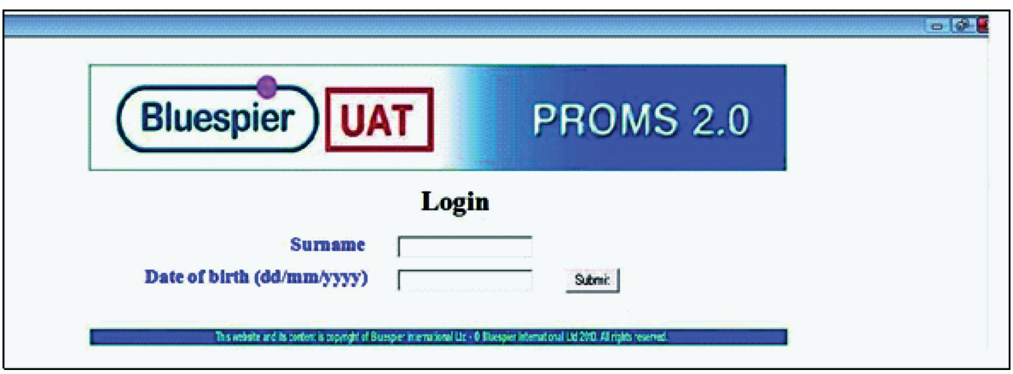

Figure 3. Screen shot of first three questions within the Oxford shoulder score assessment

Figure 4. Example screen displayed upon completion of the pre-operative Oxford shoulder score

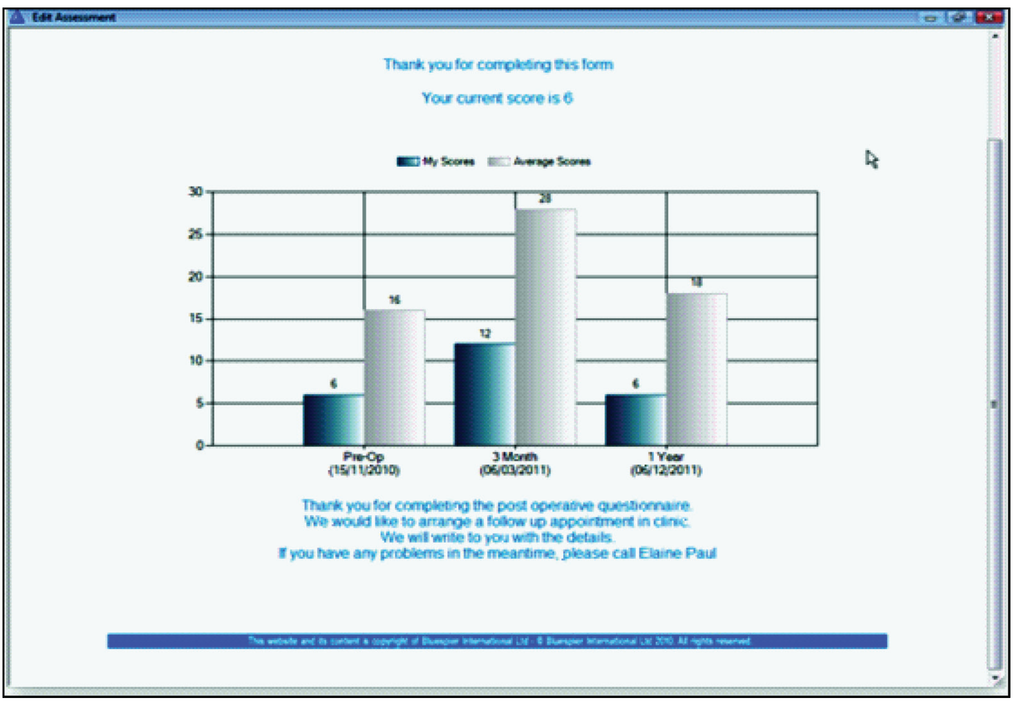

Figure 5. Example representation of cognitive walkthrough on PROMS 2.0

The first action is to "select assessment link from e-mail"

1. Users would be trying to find the correct link to click. The email is explanatory and the content suggests that patients had been informed about the process.
2. Users will see the 'Oxford Shoulder Score' link because it is clearly visible, underlined and with distinctive color
3. Users have basic computer knowledge. The mouse over effect on the link will confirm that the link is clickable.
4. The feedback after clicking is OK – the link changes color from blue to purple and the login page opens in a small window. It seems this action step would not lead to any problem.

The second action is to "enter date of birth and login"

5. Users would be trying to do the right thing because it is common practice within web applications to request authentication especially when sensitive data is involved.
6. 'Login' is a very common term used to request authentication so users will recognize the control.
7. The login widget is standard with clear instructions and a submit button. Users would do the correct thing here.
8. The feedback after clicking is OK – once date of birth is entered and submitted, the user is presented with the assessment within the same window.

Third action is to "complete the questionnaire"

9. We predict that users would be trying to complete the questionnaire because it is the main purpose of the task.
10. Users would only see some of the questions and associated options marked with radio buttons due to the layout. However this is unlikely to result in usability problem because questions in a scrolling screen are very common with online questionnaires and they usually end with a 'Submit' button at the bottom.
11. Users will recognize the radio buttons because they are commonly used in multiple choice questionnaires.
12. The feedback is OK – the buttons are dotted in the centre when selected.

Fourth action is to "submit the assessment"

This seems to be problem free. It is exactly what the user wants to do; the submit button is clearly visible with mouse over effect; and the feedback – a buffering icon appears shortly after it has been clicked to show that the system is processing the result and then finally displays a report.

Final action is to "close the window" by clicking the 'close button' in the upper right corner

Users would not be trying to produce any action. The fact that the questionnaire opens in a window after login seems odd which raises a feedback question. Users will see the 'close button' but it is very unlikely that they would associate it with the right action. Users expect a 'Logout' icon whenever they have to login for access. Since there's no 'Logout' button, users may wonder if just closing the window leaves them vulnerable.

Summary

We assume that a skilled user would have basic web navigation skill to open his/her e-mail and click on the questionnaire link as instructed in the e-mail. The user would easily do the right things until they get to the assessment. Whereas there is no obvious issue with the assessment, it seems like the layout needs to be revised to make the questionnaire fairly short. Users will be motivated to fill the questionnaire if they can see the 'Submit' button on the same screen. A better solution might be to line the options horizontally beneath each question. The other noticeable problem with the interface is the use of a window instead of a dialog box with a 'Logout' button. Perhaps it will be helpful to include a sentence within the report (final) screen stating that user has been successfully logged off the system.

Figure 6. A fragment of the PROMS 2.0 storyboard. Properties such as frames and devices used in this design are shown in the properties pane on the right.

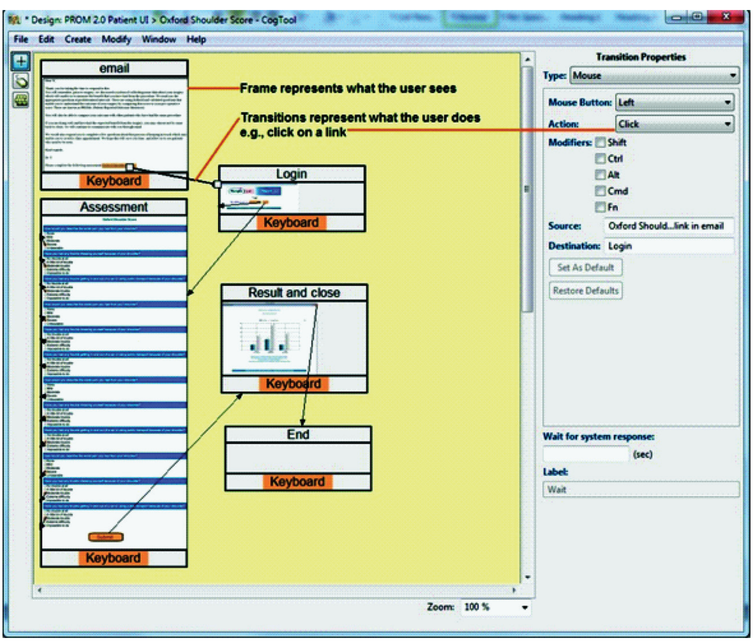

Figure 7. CogTool script window. The frame on the left shows the email sent to patients. The next step is to click on the 'Oxford Shoulder Score' link in that window.

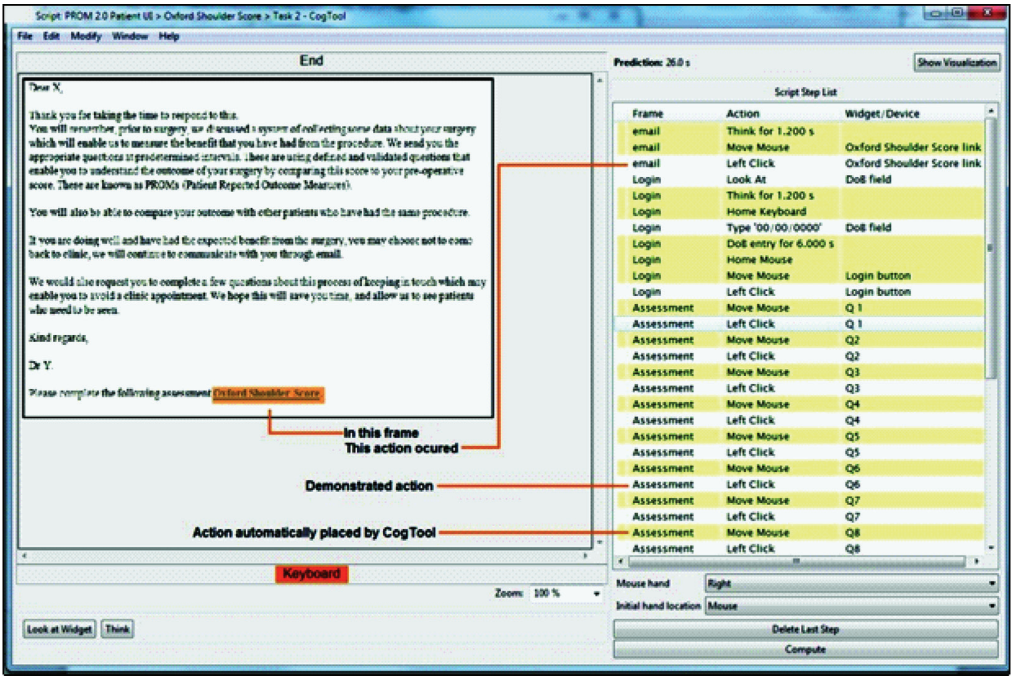

Figure 8. Timeline visualisation of the Original PROMS 2.0 interface

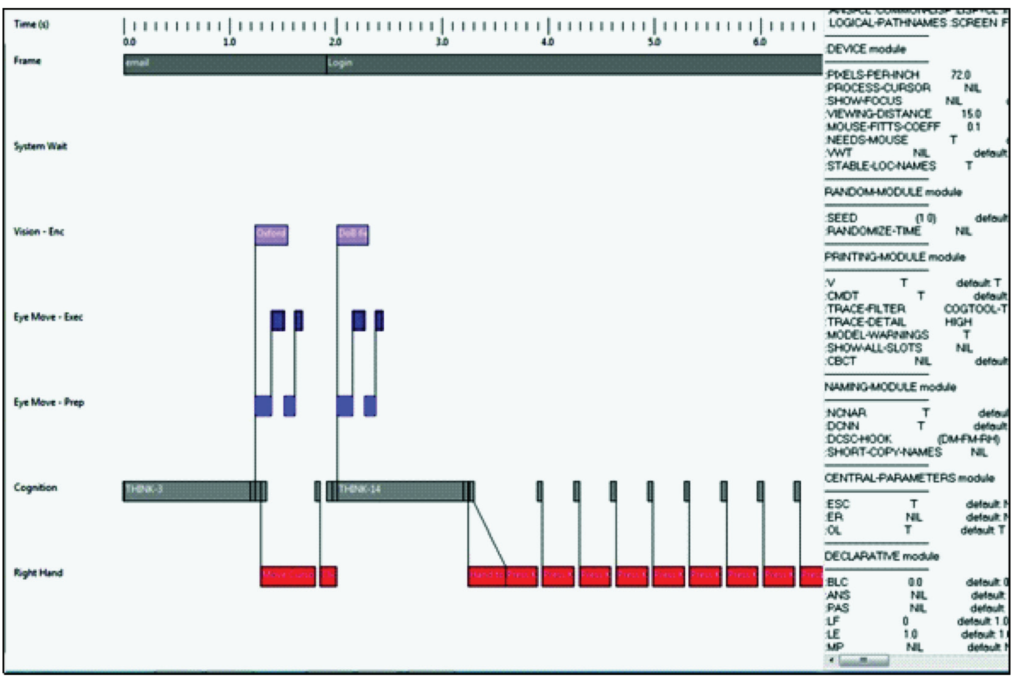

Figure 9. CogTool timeline comparison showing similar patterns in action steps to perform a task

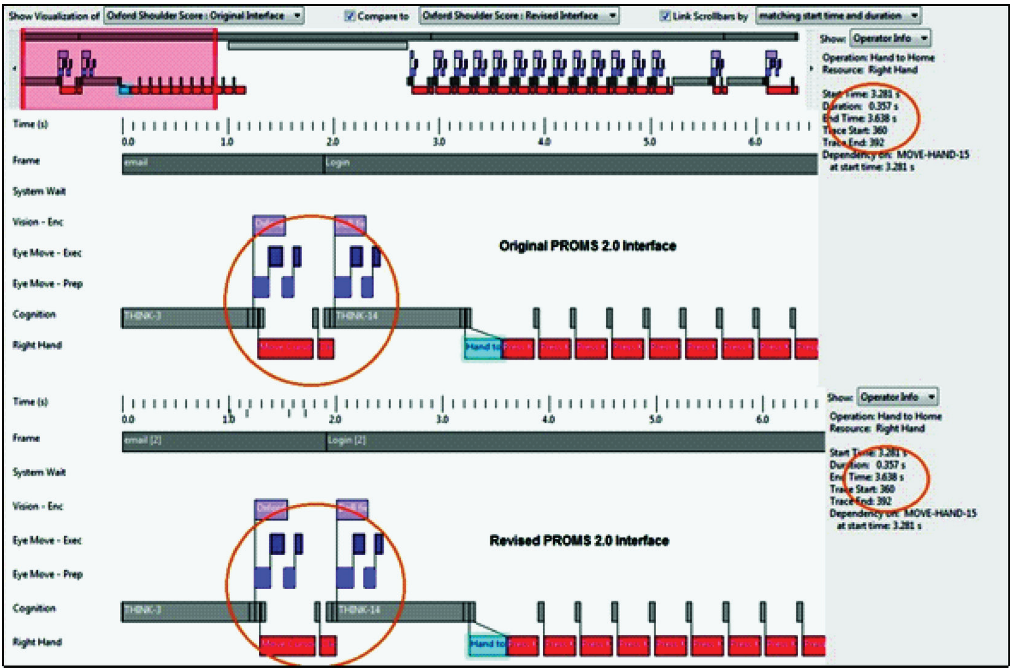

Figure 10. CogTool timeline comparison showing similar patterns in action steps to perform a task

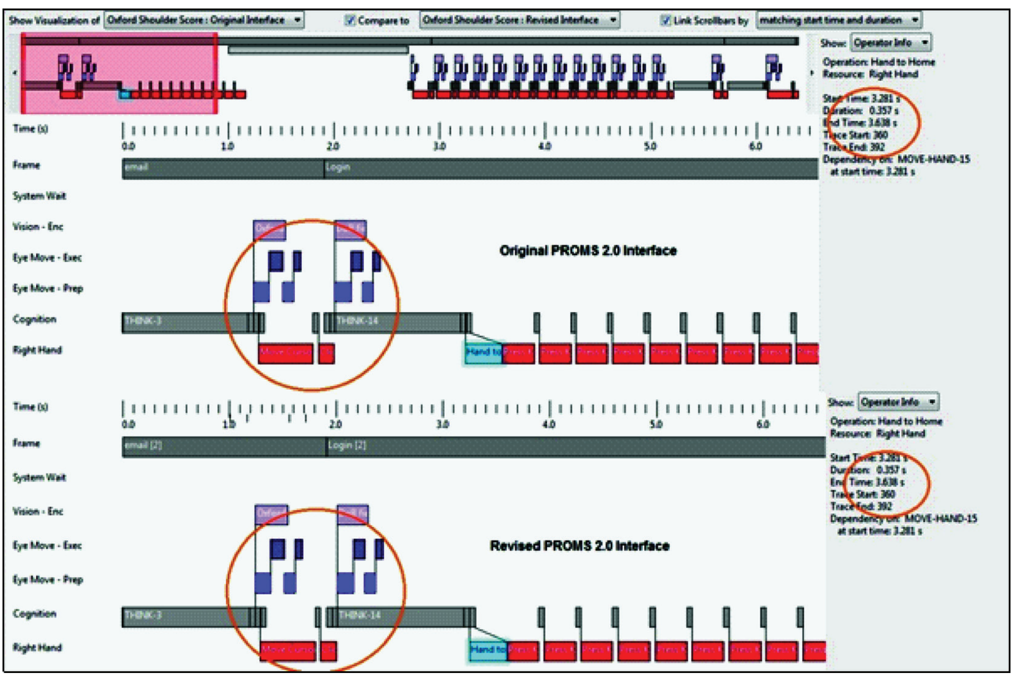

Figure 11. CogTool timeline comparison showing variations in action steps to perform a task

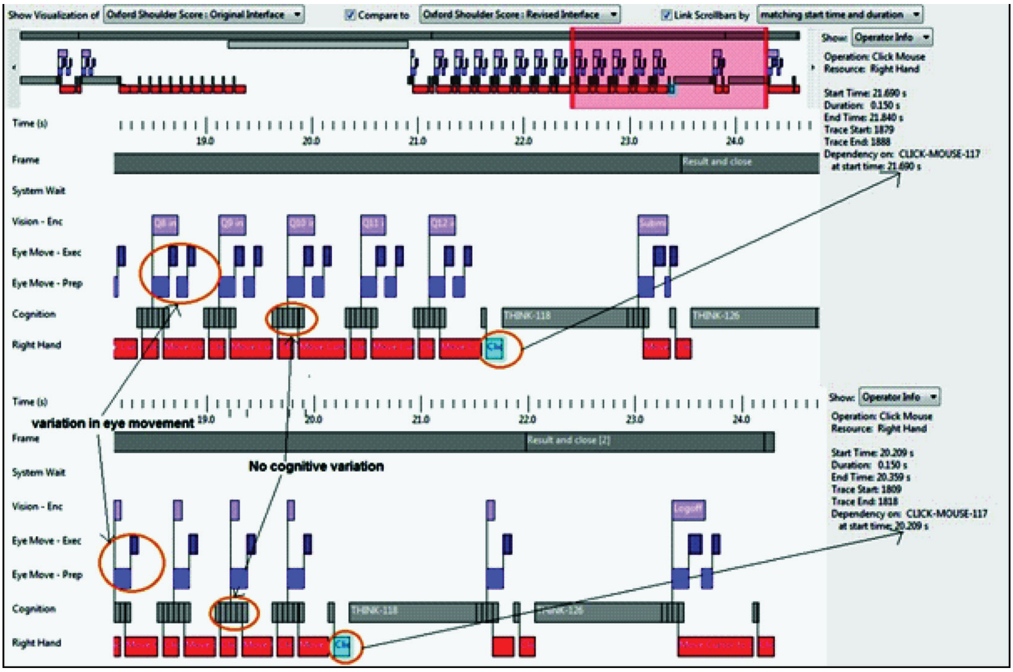

Figure 12. Nielsen and Molich's nine heuristics (source – (Card et al., 1983))

1. **Simple and natural dialog** - Simple means no irrelevant or rarely used information. Natural means an order that matches the task.
2. **Speak the user's language** - Use words and concepts from the user's world. Don't use system-specific engineering terms.
3. **Minimize user memory load** - Don't make the user remember things from one action to the next. Leave information on the screen until it's not needed.
4. **Be consistent** - Users should be able to learn an action sequence in one part of the system and apply it again to get similar results in other places.
5. **Provide feedback** - Let users know what effect their actions have on the system.
6. **Provide clearly marked exits** - If users get into part of the system that doesn't interest them, they should always be able to get out quickly without damaging anything.
7. **Provide shortcuts** - Shortcuts can help experienced users avoid lengthy dialogs and informational messages that they don't need.
8. **Good error messages** - Good error messages let the user know what the problem is and how to correct it.
9. **Prevent errors** - Whenever you write an error message you should also ask, can this error be avoided?

Figure 13. Example heuristic analysis of PROMS 2.0 patient user interface

1. **Simple and natural dialog** – This is OK. The idea of this design seems to be that a user enters his date of birth in order to log into the system, and then complete the questionnaire by choosing applicable options before submitting to view results. We understand there is need for user login.
2. **Speak the user's language** – I can see an effort to do this. They have called the system 'PROMS 2.0' which is very similar to its services. The use of the actual questionnaire names (e.g., Oxford Shoulder Score) within the assessments is also a wise option but there is need to distinguish between pre-operative and post-operative forms.
3. **Minimize user memory load** – The interface is a very simple one and there is nothing the user has to notice in one step and remember one or more steps later. Everything stays visible here, so the memory load is low.
4. **Be consistent** – There was inconsistency in the interface after completing the assessment. The result screen does not include the header element which was clearly visible in the login and assessment pages.
5. **Provide feedback** – Design seems good because something happens whenever an action is performed. The login button produces the questionnaire and the radio buttons highlight once clicked. However, the result after submitting assessment opens in what looks like a box within the same window, with no trace of the previous window elements i.e., the header. Of course, this would lead to usability problem because user would be wondering how to properly exit the system. There is no evidence of action after closing the result window. The box just goes away.
6. **Provide clearly marked exits** – As explained above, the result box has a 'close box' in the upper right. Users would expect a 'Logout' button in a system they had to logon for access. There is need for 'Logout' button on the page header region and this has to be consistent across the system.
7. **Provide shortcuts** – There is no need for shortcuts here. The tasks are very straightforward.
8. **Good error messages** – Current design exhibits good error handling. For instance an error message is displayed when a user selects more than one option per question or tries to submit incomplete assessment. However, there is no error message for incorrect authentication data entry (i.e., date of birth). I guess this is because there isn't a database yet on which the system relies on for authentication. It will be a good idea to add a help link on the login page.
9. **Prevent errors** – Same comments as for error messages.

Summary

Based on the heuristic analysis, We would like to see some changes. There is a need to distinguish between pre-operative and post-operative assessments. There is need to explain what a user needs to do in case of failed authentication. Consistency is required across all the pages and more importantly a 'Logout' button is needed to guide users towards the right exit.