Designing a Social Machine for the Heart Manual Service

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Abstract: Social machines are emerging as a focus of research within the field of informatics as they begin to become the central administrator of our everyday communications. The difficulty of applying such systems to specialised contexts, such as healthcare, calls for guidelines on how to design them, so that they become truly useful. In collaboration with the Heart Manual Department, this project is an attempt at finding suitable methods for designing social machines in a healthcare context. It suggests that adopting a participatory approach where stakeholders are active, equal participants throughout the design process leads to a more usable, likeable, and thus more successful social machine. We describe the process of designing a social machine for the Heart Manual service, in which requirements were elicited through various participatory design methods and a proof of concept evaluation was carried out with a prototype. The prototype was received largely positively and scored highly on the System Usability Scale, indicating the success of the proposed methodology.

1 INTRODUCTION

The Heart Manual (The Heart Manual Department, 2016) is the UK's leading home-based supported self-management programme for individuals recovering from acute myocardial infarction and/or revascularisation. With the help of a team of facilitators (typically nurses, psychologists or general practitioners), who are based in different locations nationally and internationally, it guides patients through a series of sessions which empower them to improve their lifestyle. Apart from the initial training that facilitators receive, there is no infrastructure for community building, and knowledge exchange takes place in an ad-hoc fashion, with individual facilitators contacting the Heart Manual (HM) team to clarify their questions.

Social machines (Hendler and Berners-Lee, 2010) can provide an appropriate infrastructure for such interactions. Through a closer interaction between humans and machines, such systems can support communication and the sharing of experience, and contribute to a sense of community. Despite recent research interest in this topic, there are still no best practices for designing successful social machines.

In this paper, we propose a participatory approach to the design of healthcare social machines. We posit that the involvement of users throughout the design process can address usability and likeability aspects, which are key success factors for health technologies. In particular, we describe our experience in employing participatory design methods to develop a social machine for the HM facilitators. Background information is provided in Section 2 and our methodology is introduced in Section 3, followed by an account of requirement elicitation in Section 4. We next present a first prototype created to collect quick feedback (Section 5) and how this was further adapted and evaluated by HM facilitators (Section 6). We conclude with an overview of lessons learnt and future work.

2 BACKGROUND

The Heart Manual (The Heart Manual Department, 2016) is a home based cardiac rehabilitation programme, supported by trained facilitators and evidenced by three randomized control trials (Clark et al., 2011). It consists of six weekly sessions that include education, exercise, relaxation and stress management. The programme was digitised in 2015

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(Deighan et al., 2015), and there is now the opportunity to extend it with recent advances in large and distributed open systems, such as social machines.

Social machines are technology-enabled social systems, seen as computational entities governed by both computational and social processes (Hendler and Berners-Lee, 2010). They are defined as "Web-based socio-technical systems in which the human and technological elements play the role of participant machinery with respect to the mechanistic realization of system-level processes" (Smart et al., 2014). Social machines are a recent research theme, with related work focusing mostly on analysing existing examples, such as Facebook, Wikipedia and Stack Overflow (Shadbolt et al., 2013; Smart et al., 2014). Literature on designing social machines is relatively sparse. Donath (Donath, 2014) approaches this topic in terms of conceptualising communities and strengthening ties, while Murray-Rust and Robertson (Murray-Rust and Robertson, 2015) suggest using existing social machines that bring together designers and developers to generate new social machines. Both approaches push for an understanding of the users and a close tailoring of the social machine to its participants. Yet we are still lacking guidelines for practical requirement elicitation for new social machines.

In healthcare, a number of social machines aim to bring patients together to help them live healthier lives. PatientsLikeMe.com, for instance, connects patients with similar conditions, allowing for peer support and knowledge sharing, while the Fitbit and Nike+ FuelBand online communities operate as behavioural interventions that complement activity trackers. However, the majority of such machines lack a clinical evaluation, and there are concerns around confidentiality and patient self-diagnosis.

Similarly to the proposed HM social machine, other machines connect clinicians rather than patients (e.g. doc2doc.bmj.com). A recent review (Rolls et al., 2016) explores how social media have helped health professionals worldwide create virtual communities where they exchange knowledge and network. However, the paper does not give a comprehensive review of design methodologies. The closest example in this literature were the trials for the Midwifery Forum (Brooks et al., 2004). However, the participatory design mentioned in the paper was limited to prototype evaluation, rather than collaborative design.

3 METHODOLOGY

The lack of guidelines for designing social machines is a considerable gap, especially in the healthcare con-

text, where technology uptake is relatively slow. Including the capabilities of the users in the interface design can have a significant effect on its usability and, thus, the success of a healthcare social machine.

We thus adopt a participatory approach to the design of a social machine for the HM facilitators. Participatory design is a user-centred design methodology, in which the end-user is made a full participant of the design process, typically by interacting with mock-ups, prototypes and other tools that represent developing systems (Schuler and Namioka, 1993; Simonsen and Robertson, 2012). We hypothesise that *participatory design is an effective method for the design of a social machine of health services with respect to system likeability and usability, as measured by a small-scale evaluation of a web-based prototype.*

An iterative development process was followed, consisting of three main phases: requirements elicitation, low-tech paper-based prototype design and high-tech wireframe prototype development. Inspired by the spiral model of software development, each phase included a repetition of steps, namely planning objectives, collecting information from users, analysing their feedback and creating a next level prototype (or list of requirements, in the case of Phase 1).

4 ESTABLISHING REQUIREMENTS

We utilised Shadbolt's constructs for classifying social machines (Shadbolt et al., 2013; Smart et al., 2014) to establish a set of questions which provide a framework for gathering requirements for a social machine. The questions devised cover the tasks and purpose of participation, participants and their roles, as well as motivation and incentives (see Figure 1).

Three main methods were used for establishing requirements, described hereafter:

Training session: We first attended a two-day training session that prepares healthcare professionals to become facilitators of the HM programme. This allowed us to gain a clearer understanding of their role and the challenges they face (e.g. cultural issues that might impede patients from following dietary restrictions). To address such challenges, the session also made apparent the usefulness of a space for facilitators to discuss their opinions and experiences, share good practice and provide peer support, especially in the case of facilitators working in remote areas.

Brainstorming session: This was organised in the form of a "Future Workshop" towards idea generation (Simonsen and Robertson, 2012). Future workshops are common in participatory design and consist

Questions	Answers for HM social machine
Tasks, purpose and context of participation	
What creative content is going to be produced?	sharing of good practice; peer support; updates
How visible is every individual contribution?	individual, named posts
Is there going to be some form of rating of the content?	yes: favourites; contributions marked as helpful; reporting
Will tasks be domain specific?	yes: directly related to or surrounding the HM
Does the machine owner (NHS, HM Programme) benefit from participation? How?	yes: touching base with facilitators; circulating surveys
Are activities pre-defined or participant-defined?	facilitators start discussions; HM team hold chaired live sessions
Is there variation in tasks?	yes, but it should be easy to find and access tasks
What media is used for participation? (Web, desktop, mobile devices…)	desktop computer
Is the participation done in a mobile context or in a physical location relevant to the service (i.e. at work/hospital)? Are the facilitators engaging with this tool during working hours or in their spare time or both?	at work during working hours
Participants and roles	
Who are the participants? How many are expected to join? How many will be active constantly?	HM facilitators (especially isolated ones); 935 currently active; weekly or monthly use
Can users be solely passive?	possibly, but preferably not
How autonomous are they? Or is their participation dependent on others?	activity and interest may depend on other members' activity
Are they anonymous?	yes, if desired, for patient confidentiality purposes
What is the hierarchical structure?	HM team: supervise and mediate; HM facilitators: participate
Are roles clearly separated?	yes: admin have more power
Motivation and incentives	
What is the intrinsic motivation of participants? Gaining/sharing knowledge? Benefiting the Heart Manual? Widening their expertise? Solving problematic situations?	revalidation and understanding how other facilitators work with the manual; ask and answer questions
Will there be extrinsic rewards? (payment, status)	mixed opinions about a badges system
Will the tool also have autotelic elements?	yes: enjoyable aesthetics; feeling part of the community

Figure 1: Questions to guide requirement gathering for a social machine, and answers for the HM social machine.

of three stages: i) critiquing the present, ii) envisioning the future and iii) implementing - moving from present to the future. Four clinicians participated in the workshop: a health psychologist, an assistant psychologist, a specialist nurse who is also an HM facilitator, and the lead of the HM team. Following the Future Workshop structure, we first focused on existing communication between clinicians, and then we discussed the goals of the HM social machine. Based on these goals, the participants were then asked to devise dream solutions, unrestricted by technical knowledge or possibilities. Three examples of social machines were then presented to them: Facebook, doc2doc and Stack Overflow. These were carefully chosen, so as to prompt discussions around different forms of communication, privacy and confidentiality regulations, as well as user reputation, respectively. This presentation initiated a new discussion about the dream solutions, leading to a jointly ordered list of requirements.

Telephone interviews: Three semi-structured interviews with additional facilitators were organised so as to verify some of the ideas collected previously, as well as to clarify points where participants had differing opinions. For example, participants gave their opinion about the motivation for a social machine and the associated concerns, the need for private groups or private messaging, anonymous posting, etc.

The brainstorming session and telephone interviews were recorded (with the written consent of the participants), transcribed and analysed following top-down thematic analysis, as guided by the questions in Figure 1. Outputs included explicit answers to these questions (presented in the same figure), leading to a list of functional and non-functional requirements. Among functional requirements, we distinguish the following elements: discussion forum, quizzes, surveys, blogs, events and notepad. Posting anonymously and tagging content as helpful were deemed desirable, but setting up groups or private messaging were not. The list of non-functional requirements included high levels of security and privacy, low maintainability and the option to report forum abuse.

5 FIRST PROTOTYPE AND ITS EVALUATION

Following best practices in participatory design (Simonsen and Robertson, 2012) and based on the requirements gathered, we created a low-fidelity, paper-based website prototype, so as to quickly obtain feedback and generate ideas at an early stage of the design process, before committing to design decisions that would be harder to change later on. A set of pages were designed to capture the main functionality of the website: i) homepage, ii) discussions, iii) submitting a discussion (see Figure 2) and iv) user profile.

A **prototyping session** was organised to collect feedback, with the partaking of the four participants from the brainstorming session. Each participant was questioned individually around two activities. In the first activity, they were given a set of cut out items (e.g. buttons and taskbars) which they could arrange
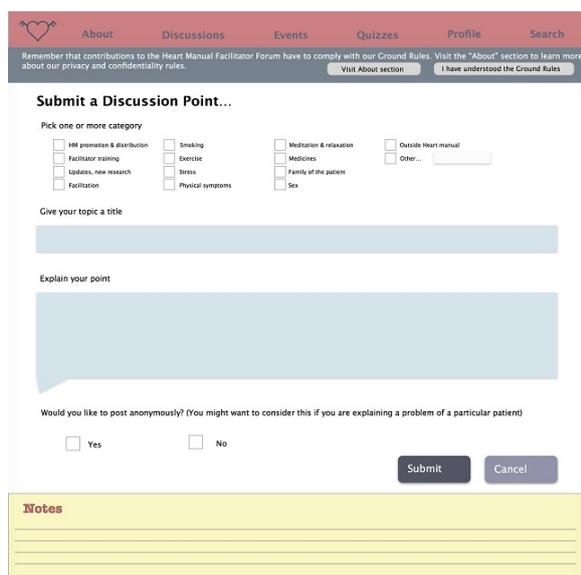
Figure 2: Paper-based prototype for submitting a discussion.

Figure 3: The home page in the final prototype.

on a sheet of paper to reflect their idea of the homepage. In the second activity, they were presented suggestions for the design of the screens to elicit opinions and given screen print-outs to annotate. Topics discussed included the notes facility and the presentation of ground rules for participating in the discussions, so as to avoid misinformation and breach of confidentiality. The prototyping session was audio-recorded, handwritten notes were taken and any visual material created was documented with photographs. These resources were analysed qualitatively using a combination of top-down and bottom-up thematic analysis. In general, it was found that participants were pleased with the layout that was presented to them. Opinions were evenly split on the presentation of the ground rules and on a simple versus busy look of the homepage. A pop-up window and a busy feel, respectively, were chosen by the designer for the next version of the prototype, which would be further evaluated, thus reducing the associated risk.

6 FINAL PROTOTYPE AND ITS EVALUATION

A hi-fi web-based prototype was developed by adapting the first prototype given the feedback gathered. It was presented on a browser and made from linked screens to generate a feel of the interactions that would take place (see Figure 3). Its main difference to the first prototype was that users could interact with the system and see its dynamics in operation. The pro-

totype was not fully functional, but a proof of concept. It was designed to work for certain scenarios that were set up for the evaluation: 1) starting a discussion, 2) entering a discussion point, 3) marking a contribution as helpful, 4) reporting a contribution as harmful, 5) entering an event, 6) adding items to favourites, and 7) accessing favourites.

The prototype was tested with seven potential users (five members of the HM team and two facilitators) for usability and likeability. Three of the HM team members had participated in the first prototyping session, while the remaining two had not been involved in any of the prior activities. The two additional facilitators had been interviewed for establishing requirements. The evaluation was divided in two main activities (i.e. think aloud and questionnaire), while a survey was set up for carrying it out remotely.

Think Aloud and Short Structured Interviews: For this part of the evaluation, participants were presented with the prototype on a laptop. They were given four sets of tasks: i) submit a new discussion, ii) find a discussion, mark it as a favourite, mark and report a contribution, iii) find an event and mark it as a favourite and iv) revisit favourites. The participants were asked to "think aloud" while completing these tasks, i.e. explain their thought process, so as to make explicit where they were stuck and why, what they were looking for, what their expectations were, etc. Following their think aloud, participants gave their opinion about the presented features and their intuitiveness.

Questionnaire: Participants were next presented with a questionnaire around usability and likeability, which included three sets of questions: i) SUS scale (Brooke, 2013), ii) how often (in a scale from 1,
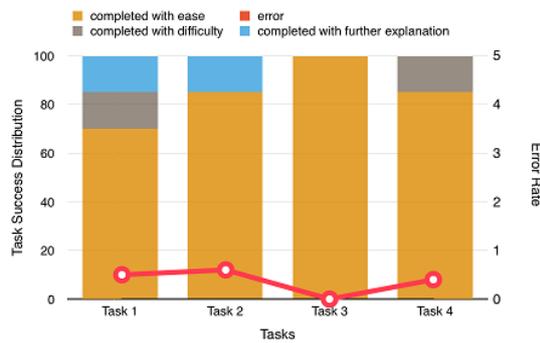
Figure 4: Accuracy and completeness in Think Aloud tasks.

i.e. never, to 5, i.e. very often) participants thought they would use certain features and iii) whether they thought certain aspects were particularly enjoyable, unenjoyable or concerning and why.

Survey: Participants who performed the evaluation remotely were emailed an online survey containing the same questionnaire and Think Aloud tasks, and a link to the prototype. They were also asked to put remarks in comments if they were stuck at any point, especially if they were unable to complete the task.

The five participants of the HM team carried out the different evaluation activities in the presence of the researcher. One of the facilitators completed the evaluation using the survey, while the other completed it remotely, with the researcher on the phone and watching the screen navigation in real time.

The Think Aloud sessions and structured interviews were audio recorded (with the participants' permission), transcribed and, together with the survey data, analysed qualitatively using a combination of top-down and bottom-up thematic analysis. Interview or on-line survey replies on intuitiveness were attributed a ranking from 1 to 5. During the Think Aloud session, the time for completing each task was recorded, and notes were taken about whether it was completed successfully and the number of errors. These data were analysed quantitatively with regards to efficiency, task accuracy and completeness. Questionnaires were also analysed quantitatively.

Figure 4 presents the accuracy and completeness measured during the Think Aloud session. All participants were able to complete all tasks independently, except for one participant who required further explanations on two tasks. The errors observed had to do with misunderstanding instructions and with the fact that the search bar lacked functionality at this stage.

Regarding efficiency, the average time in seconds for each of Tasks 1-4 was: 57.4 (SD 57.4), 67.4 (SD 43.5), 21 (SD 8) and 35 (SD 19.4), respectively. Note that the standard deviations here are inevitably large, given the small number of participants recruited.

Based on participant remarks and answers during the Think Aloud session and the short structured interviews, all tasks scored highly on intuitiveness: the average intuitiveness score (on a scale from 1 to 5) for Tasks 1-4 was 4.6, 4.4, 5 and 3.7, respectively.

The average SUS score was 86.4 (SD 18.02), indicating "excellent" satisfaction, according to published grade rankings of SUS scores (Bangor et al., 2009). With the exception of one participant who gave a score of 50 (i.e. "ok"), the rest of the scores ranged from 80 (i.e. "Good") to 100 (i.e. "Best imaginable").

The results to the question of how often participants would use certain features ranged from 3 (i.e. every now and then) to 4.43 (i.e. between regularly and very often). The former was assigned to the use of the notepad for keeping personal notes, while the latter to reading discussions and looking up events.

A variety of features were found to be enjoyable. Discussions, in particular, were mentioned by five out of the seven participants. For instance, a facilitator mentioned: "Starting a discussion. I liked that. And I liked it because if I know I've got a thought in my head and I can put it out there and see what my colleagues and counterparts have. So it can validate the ideas I might have". Three facilitators mentioned that the favourites feature also seemed very useful. No feature was pointed out as unenjoyable or concerning.

7 CONCLUSIONS

Based on the quantitative measures presented in Section 6, the hi-fi prototype was a great success, performing well on both satisfaction and effectiveness. The SUS score was very positive, corresponding to an "excellent" usability grade. Only one user was unable to complete two tasks independently, totalling an overall average of 92% success per user. The overall error rate was low, with no errors on many tasks and less than one error on average for tasks with errors. Some of the errors, such as accessing the search bar (which was not yet functional), are easily resolvable. The efficiency of the tasks can only be compared between each other, as we do not have an absolute measure of how long these should take. A learning effect between Tasks 1 and 3 can be noted, as they take a similar amount of clicks, but the latter is faster.

The system seemed to have a high level of acceptance, as most features were marked to be used between "every now and then" and "very often". This shows that the features proposed in the prototype were in line with the expectations of the participants. This is also demonstrated by the fact that discussions were highlighted as a particularly enjoyable feature.

This interdisciplinary project highlighted several themes which we expect to be recurring when designing social machines for health professionals, given the general characteristics of the domain. Firstly, designing for time constraints is crucial, given that clinicians are very busy. Hence, an easily learnable interface is recommended, where all features are directly accessible on display. Security is another important theme, and access control aspects should be carefully thought out. Furthermore, social machines that support knowledge sharing should allow users to identify misinformation, which is critical in healthcare.

The choice of participatory design allowed us to identify these themes and concerns, which might not have been addressed without input from the users. Our overall experience of using participatory design in healthcare was greatly positive. Participants were very motivated and gave thorough and careful feedback. On the other hand, recruiting participants was the biggest issue, as healthcare professionals are generally very busy and communication channels tend to be controlled. We worked around this issue by ensuring that different types of stakeholders were involved in the study, from experienced to new facilitators and from isolated workplaces to busy hospitals.

The range of participatory design methods used provided us with a wealth of both quantitative and qualitative data and allowed for a good level of user engagement and interaction. The two-hour brainstorming session, which resulted in 26 pages of transcript, allowed participants to exchange and visualise ideas, and thus served as a good basis for establishing requirements. The phone interviews did not provide the same level of idea generation, but carrying them out separately with each facilitator provided a safe space for them to express their personal views on a HM machine. Furthermore, the paper-based prototyping session was found to be very useful, as it allowed us to concretise ideas at an early stage.

The questions presented in Figure 1 were particularly useful for designing the HM social machine. They guided the requirement elicitation process, from structuring the brainstorming session to analysing the qualitative data obtained. We would, hence, recommend their use to other social machine designers.

In the future, we wish to continue using the participatory design methodology and implement the feedback received as part of the current study. In order to create a truly usable social machine for the Heart Manual service, we plan to include more participants and to investigate new topics, such as the moderating role of the HM team. Applying the methodology presented in this paper to the design of other social machines is another exciting avenue for future work.

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