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DESIGN FOR REDUNDANCY IN A PARTICIPATORY ACTION THAT HELPS CALIBRATING HEARING DEVICES

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ABSTRACT

This paper aims at analysing redundancy as a specific aspect of the design activities tied to 3D Tune-In, an innovation action funded by the European Commission. 3D Tune-In is mainly oriented toward (a) implementing software technologies (binaural spatialization engines, hearing loss simulator and hearing aid simulator) and (b) adopting these technologies to create videogames that can be used by people with hearing aids to fine-tune their hearing devices.

The high number of stakeholders involved in the project and their differences (in terms of needs, wants and agendas) motivated a design approach supporting redundancy: rather than orienting all the design and development effort toward a clearly and strictly defined set of functionalities, 3D Tune-In created a wide variety of more or less loosely connected components with their own – at times disjointed - features. This paper intends to explore how this redundancy helped stakeholders in carving their own niche in the project, but, at the same time, increased the design and the development challenges.

INTRODUCTION

According to the World Health Organization's estimates, more than 360 million people suffer from hearing loss (Olusanya et al., 2014). Hearing aid technologies have dramatically advanced in the last 25 years, but people's perception and use of these devices have not changed much. New models of hearing aids have functions that go beyond the simple amplification and equalization operation performed by the traditional analogue devices, but most individuals with hearing aids still use their devices as if they were standard analogue hearing aids, i.e. only for amplification and equalisation features. New functionalities (such as advanced algorithms for noise reduction, compression, directivity) are considered difficult to use and, as such, they are not fully exploited by people with hearing impairment (Hickson and Meyer, 2014). 3D Tune-In – a EU-funded innovation action - relies upon the idea that gamification mechanisms (McGonigal, 2011) can support these subjects in learning how to better use their hearing aids.

3D Tune-In started with an initial set of partners (research centers, hearing associations, videogame companies and a hearing aid manufacturer) and their quite focused idea of creating a coherent and well-defined set of software applications (an open source software toolkit and some connected videogames). Over time and after repeated participatory design processes with the direct involvement of a wide variety of stakeholders (the initial set of partners and external

healthcare providers and audiologists), 3D Tune-In realized about the diversity in terms of needs, wants and languages of these stakeholders. Consequently, the innovation efforts of 3D Tune-In were re-oriented toward the creation of an overarching and loosely connected system articulated into a large number of software components (Levtov et al., 2016). Each of these components (e.g., wrappers for various environments, hearing testing applications, hearing aid diaries) offered additional – either complementary of disjointed – functionalities that could be of interest for a wide variety of diverse stakeholders.

In other words, in 3D Tune-In there was a deliberate and systematic attempt to pursue redundancy in the design and development phases. This pursuit of redundancy came with a price, as it multiplied the design and development efforts and introduced a higher level of complexity in coordination.

This paper will try to explore the fine line between the potential and the challenges of designing for redundancy in a participatory innovation action related to healthcare.

LITERATURE

Various authors have investigated how a design approach and design methods can be used in healthcare. Some studies surveyed best practices in creating environments that enhance the quality of healthcare delivery with perspectives spanning from architecture (Anderzhon et al., 2012), to interior design (Marberry, 1997) and wayfinding (Miller and Lewis, 1998), all the way up to real estate design and design management processes (Zwart, 2014). Studies have also shown how, within healthcare, design thinking and various design methods can support user research (Glasemann and Kanstrup, 2011; Høiseth and Keitsch, 2015), product development (Cheung, 2012) and innovative services (Bessant and Maher, 2009; Koomans and Hilders, 2016). Donetto et al. presented Experience-based Co-design (EBCD) as a participatory research approach that builds upon design tools and ways of thinking to bring healthcare staff and patients together to improve the quality of care (Donetto et al., 2015). Lee examined the design of ambulatory healthcare from a service design perspective (Lee, 2011). A variety of authors specifically focused on how human-centered design can be instrumental in developing information and communication technology for healthcare (Bate and Robert, 2007; Jones, 2013; Wildevuur and Dijk, 2011). These are all important perspectives on the use of design in healthcare and, as such, are currently explored by a few dedicated research groups (Reay et al., 2016).

However, to our knowledge, no contribution in design research specifically focuses on the concept of redundancy. This concept is quite developed in more technical design fields (e.g., engineering, computer science), but remains less explored in relation to design-based participatory innovation in healthcare.

METHODS

The considerations presented in this paper stem from a case study approach (Eisenhardt, 1989; Eisenhardt and Graebner, 2007; Yin, 2009). Case studies allow identifying key insights over time (Paré, 2004), within real-life contexts (Pettigrew, 1990; Yin, 2009) and using multiple sources of evidence. The author was part of the 3D Tune-In consortium and had the chance to gather data during two years, through ethnographically-inspired methods such as participant observation and semi-structured conversations with key project stakeholders. The role of the author in the project was to contribute to the interaction design phases and explore exploitation possibilities for 3D Tune-In.

FINDINGS

PREMORTEM AND THE NEED FOR REDUNDANCY

The initial idea of 3D Tune-In was to develop a single software suite where an engine with some advanced technical functionalities (binaural spatialisation algorithms, hearing loss simulator and hearing aid simulator) could be used to create a set of videogames that would help people with hearing impairment in fine-tuning their hearing devices, either on their own or with the help of an audiologist (Picinali et al., 2015; Simeone et al., 2017).

During the first year of the project, a variety of user testing and participatory design sessions with multiple stakeholders (patients and their relatives, audiologists, hearing aid manufacturers, private companies developing IT solutions for healthcare, academic partners) showed that these stakeholders had quite different needs and wants. These divergences particularly emerged during a specific workshop where the method of premortem was used. This is a method introduced in project management by Klein, who describes it in this way: “Unlike a typical critiquing session, in which project team members are asked what *might* go wrong, the premortem operates on the assumption that the ‘patient’ has died, and so asks what *did* go wrong. The team members’ task is to generate plausible reasons for the project’s failure” (Klein, 2007). During the workshop, the participants were asked to list all the possible reasons why the 3D Tune-In software suite would fail. The results showed that quite diverse reasons for failure could be identified for each stakeholder since their agendas were different. For example, the agenda of the academic partners (i.e., advancing research in sound technologies and releasing it as open source) was quite different from the private companies, which wanted to retain intellectual property to secure competitive advantage. The patients were happy to acquire more independence from the audiologists, while some audiologists were worried that their patients could abandon the proven existing protocol for the fitting process and venture into autonomously calibrating their hearing devices (and possibly making serious mistakes). These divergences

made quite difficult to define a set of coherent and actionable measure to counteract the risks of failure. Rather, the stakeholders were suggesting following quite inhomogeneous development trajectories.

DESIGN FOR REDUNDANCY IN 3D TUNE-IN

To address this challenge, the project decided to pursue what we termed as 'design for redundancy', i.e., to implement a design and implementation strategy leaning toward redundancy. The participatory design sessions, the user experience design (early-stage wireframes and visual mockups) and the user testing processes were reoriented in a way to foster divergences among the stakeholders and invite them in suggesting multiple development trajectories. The resulting development strategy broke up the initial coherent software suite into multiple components. Rather than just focusing on a single technological outcome, 3D Tune-In worked on a set of software components that could be used by a third party either simultaneously or independently (high-level code components, multiple wrappers for several development frameworks, various simulators for hearing aids, hearing loss and HRTF, hearing testing application, etc.). Rather than having a single software application that could work only when all its components were operating as an interlocked and unified system, 3D Tune-In focused on a variety of interlinked but also partially autonomous components, providing additional or duplicate functionalities that could function in case some other components or parts of the system would fail or would not be appreciated or deemed interesting by external stakeholders. For example, rather than having a single set of functions for the preliminary fitting of the virtual hearing aid, 3D Tune-In uses three parallel systems with various scales to measure hearing loss for each ear of user. Each user (or developer or stakeholder) can choose which of the duplicated function or component to activate for this preliminary fitting. Or, as another example of redundancy, audiologists can have their own dedicated videogame environment for fitting. This environment builds upon the same principles of the other videogames released for end users, but it is implemented in a way to work at a more granular level and to fully valorize the expertise of the audiologists. Some visual documentation on these applications can be viewed at the link http://3d-tune-in.eu/.

DISCUSSION

3D Tune-In is at a stage where most of these software components have been already developed and validated through both expert heuristic evaluations and usability tests. Results show that this redundancy helped in creating various components that were either already targeted to the specific needs of various stakeholders or that could be easily assembled and customised by every stakeholder in relation to their own needs and wants. This redundancy was also further supported by a quite plastic and varied strategy in relation to intellectual property, which further multiplied exploitation opportunities by defining a quite nuanced dual licensing where key software components were concurrently released commercially and as open source.

This redundancy was an important element for an exploitation strategy that aimed at addressing the divergences of the stakeholders. However, too much redundancy can come with a price. It multiplies design and development efforts. It multiplies future maintenance efforts (including bug fixing and updates on documentation). It also increases the complexity of the dissemination and exploitation strategies. Distributing multiple products to multiple target audiences and according to multiple licensing strategies (e.g., launching the same software components as free and open source and as a commercial package) can also be a daunting task especially within the scope of an EU-funded innovation action, which is limited in time and bound to a predefined budget. Marketing a variety of products and services requires specific competences, which might not be easy to find in small companies or academic organizations. This is all further complicated by the specific context of healthcare and the interdependencies among a variety of actors (hearing aid manufacturers, health IT providers, audiologists and other healthcare professionals, hearing impaired and their relatives) and other factors that can profoundly differ from country to country, e.g., specific regulatory issues, operational issues (wait times, established protocols) and socio-economic processes (e.g., how much national health institutions can spend per patient).

Within a complex environment such as healthcare and an innovation action bounded to a specific duration and a specific budget, where is the fine line, where is the boundary not to trespass when increasing redundancy and multiplying developing trajectories to respond to a multiplicity of stakeholders' wants and needs?

This question points, one more time (Buchanan, 2011; Cooper et al., 2011; Holmlid, 2006), to the need of considering the organizational, economic and financial elements of the design process. Within healthcare, these competences need to be further complemented by a specific expertise in regulatory and legal issue and by a patient-centered care perspective (Jones, 2013). In 3D-Tune In, such considerations pushed in reconsidering once again the number of software components to release. A second premortem exercise recently performed showed how the project stakeholders are now worried that the search for redundancy might have reached a level that becomes difficult to manage. The challenge is now to simplify, streamline, group all the software components already developed into a limited number of package, it is to reduce redundancy to a level that is deemed compatible with the available resources.

CONCLUSION

In its current form and since the 3D Tune-In project is still ongoing, this paper cannot provide any definitive conclusion. However, this preliminary examination of the case showed how a systematic search for

redundancy affected the design and development activities of an innovation action, which saw the participation of a variety of different stakeholders in the complex context of healthcare. At various times during the project, the method of premortem acted as a trigger that pushed toward redundancy and, later, restrained from it. Future studies will look more closely at how the concept of redundancy and the method of premortem can be more systematically conceptualized, also within existing design models.

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