Tangible Interaction for Stroke Survivors: Design Recommendations

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Abstract
In this paper we outline the initial stages of a human centered design process aimed at the design of novel technology (tangible interactive objects) for stroke survivors. We found it useful to support standard methods, such as interviews and focus groups, with a video prototype in order to make the concept of tangible interaction, which was novel to our users, more clear. In addition we carried out a co-design workshop together with stroke survivors. Based on these activities, we present a set of preliminary design guidelines for tangible interaction for stroke survivors.

Author Keywords
User studies; stroke; activity; tangible interaction; co-design; participatory design.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
Stroke is a significant societal and public health challenge, and the third highest factor of morbidity and mortality worldwide. Much of the rehabilitation occurs at home, through performing different types of exercises and activities. It is the goal of the project ActivABLES to investigate how tangible interaction can

Video sketch

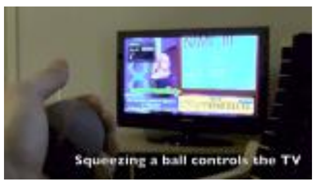


Figure 1. Snapshots of the video illustrating the project

be used to better support the continuation of rehabilitation at home.

Technology for Stroke Rehabilitation

Existing techniques to support rehabilitation, although shown to improve patient independence, suffer from problems that degrade their effectiveness. Uzor and Baillie [14] found exergames to be successful in overcoming lack of interest and commitment to fall rehabilitation. A similar approach has been proposed, but not evaluated, for Stroke rehabilitation [6]. Whilst exergaming can provide improved adherence to rehabilitation programmes it is not without issue. Axelrod et al. [1] looked at the practices around home rehabilitation. They identified that areas that would be most suitable for home rehabilitation were often kept for relaxation. This is in contrast to [14] and other work that uses interactive visualization for training [10], which need to interface to a television to present visual feedback to the user. But items such as televisions are often used by several persons in a household, reducing the opportunities for exercising. Bagalkot, Sokoler and Shaikh [2] extends on this, by arguing that rehabilitation must also consider the wider social context of the rehabilitee life. Fitzpatrick et al. [7] also note that is it is important to remember the context of rehabilitation, in particular the emotional and physical support network of friends, and that caregivers must also be considered. A balance should be struck between rehabilitation practice and what the individual stroke survivor wants, finds fun and motivating.

Tangible interaction offers significant potential benefits, creating interfaces that are easy to handle for persons with cognitive or motor impairments [11], can be small and portable, to overcome the issues raised by Axelrod et al [1] and Fitzpatrick, Balaam, & Egglestone [7] of exergames and TV visualizations, and naturally supporting ADL exercises through their physical design. However, there is little study of their use with stroke survivors. Vandermaesen et al. [15] developed a tangible table top game to support lifting and left/right movement skills. However, they evaluated only with stroke rehabilitation nurses and not with stroke survivors themselves.

Co-design with stroke survivors

Current work on co-design has largely involved able-bodied people. Björkquist, Ramsdal et al. [4] found that it can be difficult to involve older senior users in focus groups due to lack of information about different services. There is also the challenge of adapting activities to suit the prospective users. The physical and cognitive ailments of ageing can add several challenges to a co-design process [9]. Technology to be tested needs to be either very robust – or the activity well supported by persons able to cover up technology prototype imperfections [12]. Hendriks et. al. [8] identified seven challenges for doing co-design with people with dementia. These challenges seem to come down to 3 fundamental concerns that can apply also to co-design with stroke survivors: 1) the lack of approach for co-designing with these users 2) the over appreciation of the visual and the verbal and 3) the perception of participatory design/co-design – which normally assumes that partners of (relatively) equal cognitive and physical abilities participate in the design process. An example from [16] showed comic like strips useful in focus groups with persons who had had a stroke, and physical objects and props have been found to be a useful tool when involving persons with speech impairments in a design process [16].

Tangible lo-fi prototypes

1 2 3

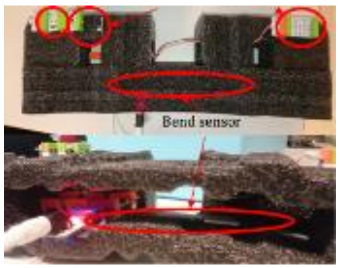
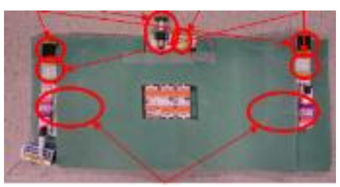


Figure 2. Flex charging massager prototype (1 active indicator, 2 vibrator, 3 charge indicator)

1 2 3



pressure sensors

Figure 3. Balance board prototype (1 buzzers, 2 balance indicator, 3 bar-graphs)

Project ActivABLES – Initial User Studies

The initial user studies in ActivABLES consisted of interviews and focus groups involving 2 specialist physicians, 5 speech/language therapists, 6 occupational therapists, 8 physical therapists, 1 neuropsychologist and 3 nurses were carried out in Sweden, Finland and Iceland. We carried out three focus groups with in total 16 stroke survivors (4 women, 12 men) in Sweden and Iceland, and one focus group with 5 family members (4 women, one man). To support the discussions, a video sketch/video prototype was developed (Figure 1). Tangible interaction may be well known within the research community, but is not a concept known to the general public. Thus, it was deemed necessary to have an initial illustration of what the kind of technology to be developed within the project might be like.

In addition we carried out a co-design workshop at a Rehabilitation Center in Reykjavik, Iceland. 5 researchers of the ActivABLES project, 5 stroke survivors, 2 of their relatives, and one health care professional participated in the workshop. The participating stroke survivors were affected by a range of different and very individual challenges like motion, balance, verbal communication, etc., but all of them were active in the workshop. To introduce some possible designs, the video prototype (Figure 1) was shown. Two different demonstration Lo-Fi interactive prototypes created with littleBits® (http://littlebits.cc) were also demonstrated. The first prototype symbolized a "Flex-charging massager" (Figure 2). It contains a bend-sensor, which detects how much the prototype is being bent around the middle. By flexing down the object using both hands repeatedly, the charging indicator started to fill-up. Once the "charge-indicator" is full, the "active- indicator" turns on and the prototype starts to vibrate. The massager discharges slowly over time, to keep it working one has to repeatedly flex it from time to time. If the "charge-indicator" gets empty, the "active-indicator" turns off and the vibrator stops. The second prototype was a balance board (Figure 3). It contained two pressure sensors one could step on. The pressure difference between the sensors is monitored and indicated visually and audibly. Indication is made on the side that had more weight on, via a bar-graph and a buzzer (speaker). If the pressure difference between the sensors is small enough, the "balanced-indicator" is turned on and a small DC-motor starts rotating. After the prototypes were demoed, participants were divided into 3 mixed groups in separate rooms. Each group started with a brainstorming session of around 30 minutes. After the brainstorming session, each group was instructed to spend about 20 minutes to choose one or two ideas and prepare a presentation of these the whole group. Then, participants were brought into the same room and each group was instructed to explain and demonstrate their chosen idea(s) to the rest of the participants. Each group had 5 minutes for the demonstration. The workshop concluded with a short discussion of the ideas and on the project.

The above activities were recoded and later transcribed, and analyzed qualitatively in order to identify common themes.

Discussion

Participants in our activities have been stroke survivors, but also family members and health care professionals. The mix has been important, since different stakeholders have different perspectives. This became

Design principles 1

Support the user in keeping a good balance between activity and rest.

Exercises need to have a purpose/meaning, and should be embedded in activities.

Safety & security needs to be considered

The system should provide reminders, and support the user remembering and getting started.

Activity goals should preferably be broken down into subgoals, to allow the stroke survivor to "win many small victories".

Feedback and awareness on activity and progress should be provided.

Provide a sense of accomplishment and empowerment.

Designs should be easy to use, but not childish.

particularly apparent when one compared the comments from stroke survivors with the comments made by family members. It is quite clear that anyone designing for stroke survivors need to involve persons at least from both these groups. If the technology is intended to be used also in a health care setting, health care professionals should also be involved in the design process.

Even though there is a risk of restricting the design potential of the workshop by presenting design alternatives on video and demonstration prototypes, we believe that both the video (Figure 1), and the physical examples (Figure 2) and (Figure 3) were very useful. Tangible technology may be standard fare for interaction designers, but for people in general it is something unfamiliar and unknown. The video served as a way to familiarize users with the technology, as well as a way to provide concrete examples that could be commented on. The prototypes developed as examples for the workshop had a similar function, but had the added advantage of being concrete and possible to test hands-on. Thus the video prototypes worked as expected [18] also in the present context. An advantage of the video prototype was that it was possible to reasonably quickly generate a fairly wide range of ideas. As for the workshop example, although fast prototyping tools like littleBits® were used, it still takes some time and effort to produce working physical prototypes. By using both approaches we were able to get the benefits of both a wide range of visualized ideas, and a few more concrete examples – something that can be particularly important when also involving users who are unfamiliar with the technology and may have cognitive difficulties [4,5].

For the co-design workshop it turned out to be important both that several of the participants had been "primed" [13] by taking part in earlier focus groups, and that persons who were used to design work (two design researchers) were present. Coming up with design ideas is not trivial, and by having experienced persons around we were able to support the participants in the process. A potential risk with this approach is that the experts might influence the designs too much, and we tried to deal with this by having two groups that were only monitored by a design researcher. In the groups where a design researcher participated the researcher helped elaborate ideas from the stroke survivors, and tried to avoid making new suggestions. While bodystorming together with stroke survivors during the co-design workshop, "empathy" has been a defining characteristic of the relationship between the design researchers, stroke survivors and healthcare professionals [17].

We found that activities involving balancing, standing up/sitting down, walking and activating the less good side of the body would allow us to reach a wide range of stroke survivors. Training of cognitive skills such as concentration, memory, planning, coordination and language/speech may be useful to add into the design. Analyzing the different user activities we arrived at a set of design principles for the technology to be developed – see Design principles 1 and 2.

Inspired by Balaam et al [3] we have designed materials and activities (video, prototypes, discussions and design activities) intended to help persons articulate what motivates them, and what they feel is important. Compared to [3] we have taken a more generic, toolkit oriented approach as the starting point

Design principles 2
Social use and the social context should be considered.

The technology should support patient – family - professional communication

Motivation is key; designs need to be either useful and/or fun

Indoor and outdoor use should be considered.

Designs need to support different speeds and should be adjustable, personalizable and multimodal to allow use by persons with different sensory abilities.

Avoid excluding users with aphasia.

Designs should be flexible, easy to move and allow users to reappropriate the technology.

To support different skill levels, it needs to be possible to adjust a suitable level of challenge.

for our design. We have involved not only stroke survivors and their families, but also health care professionals. Although our results with regards motivation generally agree with the lessons presented by Balaam et al [3], we also find a subtle difference: Not only is balance between work, duty and fun important, but also balance between activity and rest. Additionally, we present concrete guidelines for the interaction design of tangible interactive objects intended to support activity after a stroke.

Although we state that the system should provide reminders, it is important to note that a tangible object can be said to be a reminder in itself [19], which is yet another argument for the development of these kinds of devices.

In the interviews with health care professionals, it was pointed out that co-location of interaction and feedback can be important, since it can put additional strain on both attention and cognition to focus on the interaction while monitoring what is happening elsewhere. This recommendation is in line with what was found in [5], that co-location of interaction and feedback can be quite crucial when designing for persons with cognitive disabilities.

Future work will include further co-design activities and prototype development making use of the identified design principles. We also plan an extended analysis of the materials gathered from our initial activities.

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