A holistic approach to design: Using experience to develop a vision of potential users of a robotic rehabilitation technology

Background

It is notable that there is a need for upper limb rehabilitation especially in the early stages following stroke. Research into motor relearning and processes of cortical reorganization after stroke has demonstrated that regular repetitive exercise supports restoration of arm function [1,2]. However, the exercises should be meaningful, personalised and goal-directed [3]. Robotic technology has the potential to provide people with stroke with the opportunity to independently perform intensive and repetitive exercises [4,5]. One of the major advantages of technology-supported rehabilitation interventions such as those provided through robotics is that the technology enables users to perform exercises in their own homes thereby assisting them to have more active roles in their care. Facilitation of self-directed exercising provides opportunities for distributed practice sessions and variations within practice which are deemed to be more beneficial for the improvement of arm function [6]. Moreover, people with stroke are free to choose the number and length of practice sessions at their own convenience which is more likely to result in enhancement of performance and retention of tasks [7]. Although the significance of home-based rehabilitation technology has been underscored in the literature, the challenges of creating appropriate applications for the home environment are yet to be adequately addressed. Most commercially available rehabilitation robotics systems are bulky, large and expensive and are for use in clinical rather than home settings.

The challenges faced by technology developers in creating home based rehabilitation robotic systems mirrors the failure of most technology initiatives during the implementation phase in real situations [8] and is attributed to many factors including technical, behavioural, economical, organisational, policy and legislation [9]. There are still practical problems with translating a technology concept into real practice. Determinants that influence the implementation of technology applications vary with the type of technology under consideration. However, involvement of end users and professionals as potential users of technology in the design process is crucial in determining how the resultant device is perceived and fits into people's lives [9].This emphasis upon how users' perspectives can be

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used to develop and evaluate the feasibility and effectiveness of novel technologies has been accompanied by interdisciplinary and pragmatic research, where users are partners in the design and development process. Rather than focusing on functional dimensions, user-driven approaches focus on how people make sense of their experiences including their experiences of using technologies in everyday life and hence supports the importance of deep and meaningful dialogue with users [10]. This user driven knowledge provides researchers with new conceptual tools for understanding complex conditions such as stroke and the potential role that technologies might play in the management of these conditions [10]. This approach also argues for the value of participatory approaches in which the whole person behind 'the user' is actively engaged with designers in the co-design of systems as differently placed experts who envision possible solutions and make creative choices [10] .

This approach continues to command the attention of researchers within health and social sciences as well as technology and design fields. For example, the potential of new technology has been previously used to design and develop stroke rehabilitation prototypes [11.12]. A recent review of users' perspectives about virtual reality games for stroke rehabilitation showed the importance of incorporating user experiences into the design process [13].

The aims of the study

This paper reports the findings of the first phase of an interdisciplinary project called the Supervised Care and Rehabilitation Involving Personal Tele-robotics SCRIPT funded partially by the European commission and involves researchers from several European countries. The first phase of the study examined the outcome of initial engagement with the potential users of a to-be-designed robotic technology for home-based rehabilitation of the hand and wrist following stroke. The aims of this first phase of the study were twofold: 1) to understand users' experience of living with stroke and with technology in their home, 2) to envision their relationships with their social and physical environment and with the to-be-designed technology. The findings would inform identification of user requirements.

Participants

The target group for participation were people six months post stroke aged between 18and 80 years old. Other inclusion criteria were having hand function to some extent, with no cognitive or other psychological or physical impairments that would hinder them from giving

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informed consent or participating in the proposed research activities. Participants were required to live in the community, with a family or friend closely involved in their care. They also needed adequate language skills in order to understand and express themselves verbally. Carers were recruited once the person they cared for had agreed to participate in the study and were identified by the person with stroke. In total ten households in the UK, the NL and the Italy were visited (Table 1).

Insert Table 1 here.

Table 1: Characteristics of the participants took part in the home visits

Home visits
Participants who expressed interest in the study were visited in their homes on two successive occasions. The aim of the visits was to better understand the physical, personal and social aspects of participants' lives and the context in which could envision using the proposed technology. The data from these visits would enable us to identify the user needs and abilities.

We designed technology biographies [14] to understand the use of everyday objects and situations for the purpose of reaching an empathic understanding with the users. Use of this approach in this study allowed participants to express their thoughts and feelings about past technological development, their current use of technologies and associated concerns or problems, and to draw out hopes and fears regarding future technological development. Cultural probes [15,16] promote motivational and creative responses and provide clues about participants' lives and thoughts. Cultural probing allows researchers to observe participants' behaviour over a certain period of time [17].

Materials provided in the Cultural probe pack in this study included a personal diary, and a disposable camera (Figure 1) and participants were given the option to select one or both of these items to record their views and perceptions between visits.

Participants were presented with a guide leaflet to prompt them how to use the materials. The guide read:

This pack is designed for you so you can give your views about your daily coping routines, your rehabilitation and what you think about using technology particularly for assisting you with your rehabilitation. The pack includes:
- A diary

The diary includes some fun activities including close and open-ended questions and a drawing.
- A disposable camera

You can use the camera by following the instruction printed on the camera and as explained to you to take Photos number 1 & 2, which have assigned topics: 1) something you want to get rid of, 2) your favourite place at home. The remaining pictures could be photos of places, objects or any other things that you think would tell researchers your experience of stroke and technology use.

A diary was also included in the pack which prompted the participants to talk about themselves, their families, friends, to imagine a perfect day, to come up with perfect solutions that assist them to maintain or improve their relationships, to help them achieve their life goals, to support them with their rehabilitation at home and finally to encourage them to use their imaginations to draw a device that could help them with their exercises.

On the first visit, we conducted technology biography interviews [15] and introduced the participants to cultural probes which were to be left with them for three weeks [16,17]. On the second visit, three weeks later the content of the completed probe packs were discussed with the goal of establishing further empathy with the participants. The content of the probe packs were used as prompt to conduct in-depth interviews with people with stroke and carers. We used narrative method in which context and interaction play significant roles in creation of meaning [18].

Insert Figure 1 here

Figure 1: Cultural probes kit

Analysis

We systematically analysed the data by immersing in participants stories, diaries and photos. The analysis process involved categorizing using qualitative data analysis methods [19] and narrative analysis [20] to understand the uniqueness of personal experiences of stroke and technology over time. Through this analysis we developed an in-depth understanding of the challenges participants encountered and their life goals. Life goals are meaningful and challenging activities that the person with stroke is trying to achieve or regain after stroke

[21]. We also obtained details of their capabilities and attitudes towards technology in the home including how new home-based rehabilitation technology might fit into their life style.

Findings

As described above, we applied a variety of ethnography techniques during two successive home visit with each participant to open up new ways of capturing users' views and perspectives.

Home visit 1

Technology biography:

Participants identified a number of domestic technologies as their first used technology such as vacuum cleaners, washing machines, dish washers, microwave ovens, radio and televisions. They referred to current use of telephones, mobile phones, DVD players, internet, touch screen smart phones, wireless, digital cameras, computers and laptops. However, all participants said that they found it difficult to operate technologies such as computers, mobile phones and cameras following their stroke even they had good information technology (IT) experience before the stroke. Those who participated expressed a range of attitudes towards new technologies as it is shown in the following extracts:

> Since my stroke I couldn't use computer anymore, very difficult ... too difficult to push the buttons ... we only have one mobile phone for an emergency, when I'm going away alone, e.g. with my mobility scooter. (NL-HV1-PP2: Lore)It's a bit scary until you know what you are doing. It's like anything it's easy when you know how, but it's a bit daunting until you're ok with it. I think younger ones are more ok with it but it's more difficult when you're older. (UK-HV1-CP2: Laura)

> It is very important, but I do not really trust in new technologies and I don't get easily familiar with technologies. I think that I will never use the computer. I use a mobile phone, but just for phone calls, I am not able to write or read sms. (IT-HV1-PP4: Beatrix)

> I am in favour of technology, even if I don't really know much about new technologies and I don't get easily familiar with them. I just use a mobile phone, but just for calling. Technology is for me like a monster. (IT-HV1-PP5: Cristina)

> I have a problem with the computer in the sense that before the stroke I used it with two hands, with 10 fingers. I can use only one hand now. Moreover, I have some visual problems, because everything is written very small. (IT-HV-PP1: Alberto)

They expressed how technology can be used to assist with the rehabilitation of stroke. In the context of how technology could be engaging and motivating, one participant suggested that technology should be personalised for users and said:

> Make it musical for us, if that thing is individual to people you can put a tune to it so that they can listen to their favourite tune or anything to motivate people and then you might have a switch to choose a different tune. … and the more colourful they are the more upbeat you are going to be like music. (UK-HV1-PP1: David)

Another participant suggested:

> Maybe it's an option to use voice-activated functions in more devices in future. That would be really nice for patients who cannot use their arms/hands that well, because you have to do fewer actions. (NL-HV1-CP1: Ava)

Easy to use and simplicity of technology was reiterated by participants as it is evident in the rhetoric of one participant who responded to the interviewer's question of "What do you expect of these technologies?"

> Simpler and to make things easier, easy to use and make things easier and make your life easier in theory, if it's difficult you tend to give up unless you're particularly inclined but generally people would not bother unless it's fairly simple and easy. (UK-HV1-CP2: Laura)

Their expectations, hopes and fears from future technological development were explored as it is exemplified in the following excerptions

> Given the progress that we have now with the technology, well, what amazes me is the fax, the fax is an extraordinary thing for me and I use it sometimes when I need it, I consider it a sensational discovery. I wish that research on cancer makes progresses, because there are many people who suffer for this. (IT-HV1-PP2: Antonio)

> No hopes or fears. We are facing what is coming in future and we will then decided if we do something with it or not. (NL-HV1-PP2: Lore)

Participants talked about how they managed to regain their previous goals such as playing music and playing sport or are trying to regain or develop new goals based on their current situations following the stroke.

Two participants from the UK and Italy explained the motivational impact of having a meaningful goal, respectively:

I couldn't get out of the wheelchair or move my arm. I am left handed and my guitar has made me get this hand back. If you have nothing to really aim for then you are just going to lay back. … It's coming on slowly, I played in a band back in the 60's and I have always played a band back in the 60's I have always had a guitar. (UK-HV1-PP1: David)

I have never practised any sports, but I like Formula One. I loved to drive the car, this is somehow part of me. I was a police man and I always drove around. I had a car, which I gave away, because I couldn't drive anymore. I also loved to go to the sea, because I was born in a place at the seaside. (IT-HV1-PP2: Antonio)

Another participant explained how he pursued other goals in his life and how he created new hobbies after his stroke:

"I love going in my garden, my son has altered it all for me. He cuts my hedges he does everything but *** (his wife) bought *** my granddaughter a little table, its ideal for me it's the right height. She gets me my pots and compost and puts them on the table, I manage to plant them up I love it. (UK-HV1-PP1: David)

A UK-based participant linked the themes motivation and technology to group education:

I think sometimes if you have a small group for this gadget, and if one person can see its doing him good then other people may think I am interested in that, such as demonstrating it.
I know that but once people have learnt how to use it within a group, such as group therapy. I think just to dump it (technology) on someone isn't the way forward. … All I am saying that some people have no motivation, the same as if you have got a mentor you could have class of 10 people with stroke. But if you put me in front of those people I would make them do it. You don't just sit there, you have to get people in the frame of mind. (UK-HV1-PP1: David)

David also had a different interpretation of feedback:

You get it (feedback) from elation, if you were a runner and you did 200 yards instead of 100. Well I get that feeling of elation. That's the same with your hand, I get it every step of the way, trying to move my shoulder, it's elation. (UK-HV1-PP1: David)

Home visit 2

Cultural probes and In-depth interviews
All participants from the UK, the NL and Italy chose to use both diary and photography activities in the probe packs but some of them did not complete all the activities involved. Participants took a variety of photos, which were then put in a photo album by the researcher to discuss with the participant. . The photos reflected different aspects of their lives. For example, some photos told us about their relationships (e.g. photos of partners and other members of family), their home environment (e.g. photos of gardens, kitchen, bathroom,

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living room, furniture, mobility devices, and used technologies), their hobbies (e.g. wood works, cooking and playing guitar), and their social activities (e.g. visiting family and friends).

When looking at Steven's photo album there was a picture of his wheelchair that he wanted to get rid of and a few pictures of his living room where he spends most of his time watching television. This opened up a discussion between Steven and his wife Laura in the presence of the researcher about motivation and the significant role that it plays following the stroke:

> Well he (Steven) can use the email but you don't, well I don't know, there is no motivation to sort of thinking well I'm going and check them every day, we sort of talked about it to get to the habit of doing it again. It's not the matter of easiness, well it takes 5-10 minutes to get you there, but once you're there it's the lack of well do you want to go there, oh nooo not really (laughs), well do you disagree (asking her husband)? (UK-HV-CP2: Laura)
> PP2: (Steven) No I found it frustrating.
> CP2: You found it frustrating, why what is it you found frustrating?
> PP2: I can't do it as quickly as before.

Similarly, Alberto expressed his dislike of his exercise bicycle because he is not able to use it anymore and Beatrix and Sem wanted to get rid of their wheelchair and computer, respectively. This activity led participants to reflect on their stroke as a relative experience and used comparison to compare their situations with the past [22]. The following excerpts show how two persons with stroke and a carer participant used this strategy in their narrative accounts:

> It just came out of the blue totally, life changing. … We both worked, that's gone for both of us, the option would've been, he's a people person he likes to be out, it's a bit stressful, he enjoyed meeting people and going out, really really he did. He just misses it and he's not used to it even now. It changes your life in every respect, even if you want to pop out it needs to be a bit more planned, going to places that are accessible and you just need to work your way round, he used to love driving and do all the driving. (UK-HV-CP2: Laura)

> I spent a lot of time sailing, I was very active and very curious. At the sailing club I used to repair boats, and I was always very busy trying to come up with the improvement of a manoeuvre on the boat, so that it could be smoother and faster. (IT-HV-PP1: Alberto))

> I did almost everything, I was very active, I cooked and I sewed, I was a tailor when I was younger. Now I cannot do anything because my hand doesn't work anymore. This makes me really angry, also to stay all day long doing nothing. I can't stand it, because I was really active. I also used to go for long walks. Even going out is

difficult now, because my wheelchair doesn't fit in the elevator. You need to take off the wheels every time and this is very inconvenient. (IT-HV-PP4: Beatrix)

Antonio only took one photo of his exercise bicycle as an object he wanted to get rid of and did not take any photos of a comfortable place in his home. He also did not complete the unassigned photography activity. While reviewing his photo album, he was encouraged to compare his present situation with past times before stroke:

> It has been tremendous. When I had the stroke, I did not understand what happened, I got the first explanation when I was already in the hospital, because I noticed that I couldn't move my arm and my leg anymore. It was terrible, because I considered myself useless, worthless compared to the person I was before. It (my life) changed because I lost the relationships with the people I had known and I had cared for. This happened because I felt invalid and unable to keep these relationships. So, it was even my fault. (IT-HV-PP2: Antonio)

The unassigned photos provided further insight into the participants' experiences of stroke. Lore's album included a range of photos of her going shopping with her mobility scooter, doing gardening and relaxing on a chair in the garden. For another participant, Sem, photos of her partner as his main support, his bike, his chair, and his brainteasers depicted his story of stroke. David took a number of photos that showed the importance of wood work, gardening and playing guitar for him after stroke. Cristina took photos of herself while performing rehabilitation exercises and doing her make-up. She took photos of bedroom and living room as comfortable places in her home. When reviewing the photos, she was asked why she had taken all the photos of herself, and she responded that she had developed an appreciation of how everything has changed since she had a stroke:

> Everything changed, even my living conditions. I live in my house, but I could not stay alone, so my daughter and my son-in-law have moved here. For me it was a big change because I love to stay alone. (IT-HV-PP5: Cristina)

In addition, for participants the diary in the probe pack acted as a tool for better communication with the researchers and complemented our interview data. The heterogeneity of responses provided us with a multifaceted picture of potential users of technology who have a range of attitudes and expectations. For example, in the diary participants described a perfect or dream day in different ways. While David would play guitar and go for a walk with his grandchildren, a dream day for Sem would be a day free from planning and thinking about which obstacles he might face during the day. Cycling, going out, having fun, car

driving and going on holiday are the features of Lore's dream day and Nick and Silvio described their dream days as follow:

> "I would go out in the country side and enjoy a good long walk. I wouldn't care where I walked at all but in truth Scotland would be the best place". (UK-HV-PP3: Nick)

> "Having a normal life, doing things like driving the car, taking the train, listening to music, to be able to have and follow a conversation, be able to walk and to make plans for the future. (IT-HV-PP3: Silvio)

In the diary participants were asked to describe a gift or gifts they wish to receive from friends and family. Some of these imagined gifts were practical like Lore who wanted to receive flowers or Sem who wanted a macro-lens for his photo camera to use it for close-up photos of plants, and or Nick who wanted to receive an IPad as it is simpler to use than a laptop. However, others envisioned the practical values of imaginary technologies. For example, David wished for a pair of shoes to enable him to walk with his family and friends.

The diaries provided insight into participants' relationships with others. For example, Steven wished for a disabled driving course to be able to drive again. This prompted his wife, Laura, to tell us a story that showed the impact of stroke on her role in their relationships:

> … we did manage to get on holiday, we used to go down south a couple of times a year, and two years ago we first went, I was never driven out of *** then, but it was a case either I did it or we didn't and I did it, it was a very big challenge and that was something different. And I was making fuss, checking tyres and everything and he (Steven) said to me it's only down the road well it isn't to me. We had a week in ***, we got there and we got back and a week after I suddenly got exhausted and it must've been the strain and it suddenly hit me. (UK-HV-PC2: Laura)

David wished for a pair of shoes to enable him to walk and help his wife. This small clue created a narrative interaction between David and his wife, Janet, and illustrated how stroke influenced their relationships:

> "Everyone is different with a stroke. It does devastate your social life". (UK-HV-CP1: Janet)

> Devastating, it's not me it's my wife she has run herself ragged. I have always been a dominant husband but the stroke has made me that, she only has to clang a plate and it sets me off. If anyone comes up behind me it startles me. (UK-HV-PP1: David)

> "You just have to get on with it". (UK-HV-CP1: Janet)

We have been very near to blows because of the stroke. I push her and she pushes me, I don't mean literally but I have a stick and I have been very near to using it out of frustration. But the same goes for her, she is frustrated because I am like this, I can't move without her. (UK-HV-PP1: David)

Sem wished for "appreciation and respect" as perfect gift from families and friends. The significance of having a meaningful relationship was stressed in Sem's diary to the extent that he linked his relationships to receiving feedback on progress and recovery from stroke:

"Confirmation of family and friends, therapists and fellow stroke sufferers, that they say you are on a good way or you are doing well". (NL-HV-PP1: Sem)

Lore wished for everyone to act normally around her. The following quotes show how Alberto and his wife describe their favourite gifts:

"A car with an automatic drive to be more autonomous and three cartons of cigarettes so that I could smoke in freedom". (IT-HV-PP1: Alberto)

"More involvement in everyday life, even a phone call to escape from the routine. I don't care for something material, because the presence of people who care for you represents already a gift". (IT-HV-CP1: Sofia)

The following excerpt demonstrates how stroke could affect relationships in many different ways:

"Your life just suddenly changes, suddenly he wasn't independent anymore. … He changed personality, but in a good way. He is now more cheerful, has to laugh about things more, and makes more jokes. He really enjoys life now". (NL-HV-CP1: Ava)

Participants provided additional information that could improve their relationships with others including being normal again without a stroke, ability to walk and talk fast.

Participants envisioned perfect solutions that could assist them to achieve their goals. One participant from the UK, David, wants to have every machine at home at his disposal. Similarly, Sem believes assistive devices with the capacity to provide feedback on progress could be a perfect solution to support his home-based rehabilitation. The following excerpt shows Alberto's idea of a solution to support home-based rehabilitation:

An efficient device, which can improve my condition without provoking terrible pain and that I can handle by myself, without the help of somebody else. (IT-HV-PP1: Alberto)

Envisioning rehabilitation solutions led to discussion about relearning activities with some participants as follows:

> He needed to learn some things again, which were normal to do before such as cycling and travelling with public transport … and more problems in preparing and planning trips". (NL-HV-CP1: Ava)

> Gardening, shortly after her stroke, she couldn't do it anymore, but now she can do some again but she has to do it slowly and she has to take care of things she cannot do anymore". (NL-HV-CP2: Hendrik)

> I do not feel very sure of myself yet, of my potential, that's the reason why I don't like doing so many things, like going too far from home when I go out, you know. I set myself some distance points, like 'tomorrow I'll do 500 meters', then 600, then 700 and see how I feel. If I notice that it costs to me too much effort, the next day I repeat the same distance with confidence. This way I feel safe. (IT-HV-PP2: Antonio)

In general, Dutch participants were willing to use any kind of technology to improve their conditions after stroke. However, British participants expressed some reservations and emphasised on specific aspects of technology and the context of use. For example, while the home space did not seem to be a problem to accommodate a home-based technology for Dutch participants, small living rooms were the most commonly problems that British participants would face to house a home-based technology. The following statements provided by two Dutch participants show their attitude toward using technology for the rehabilitation of their stroke:

> If it's needed we really like to train at home. It is no problem to offer some space to place an extra device for training. ... If it's needed of course you would do that. If you like to make your life better you will do everything you can. (NL-HV1-PP1: Sem)

> It is very good to use technologies for rehabilitation. It's more fun to train with a device, so that's very good. ... It's no problem to place extra devices in the living room, even for a longer time. You want to do everything to have more arm and hand function and I think this also concerns all other patients after stroke. (NL-HV1-PP2: Lore)

Nevertheless, while a British participant welcomed the idea of having a home-based rehabilitation system he stressed the practicality of using such technology:

> Presuming that everybody can work with a laptop or computer and I would go on to say that I don't know but at a guess I would think a lot of stroke people haven't got a clue. ... so you've got to find a way of saying how can we get people interested in using that system and you've got to get them interested because if the interest isn't there then they won't take it on, will they? (UK-HV1-PP1: David)

Discussion

Qualitative and user-centred design methods such as cultural probes have been used to develop home-based rehabilitation technologies for stroke [21]. These methods provide researchers with insights into the subjectivity of patients' experiences of stroke and of technology and yield detailed empirical knowledge grounded in their personal and social contexts. The purpose of this study was to understand the user not only as an individual with plans and goals but also to address their whole experiences including the emotional aspect of user's experience and to provide technology developers with insight into the user's values, thoughts and feeling. In other words, the paper examines the applicability of affective models of design [23,24]. Norman [23] identifies three different levels of cognitive and emotional processing as visceral, behavioural and reflective. In line with this model, our aim was to elicit participants' emotional responses as well as to examine their behaviours, and to understand their goals and motivations in relation to their experiences of stroke and technology use.

All the individual data gathered during the study was summarised to generate a series of personas and scenarios as the representatives of target users. Based on a persona-based scenario methodology [25], these user models and their activities helped us understand the potential users of the to-be-designed technology, their goals, their network of relationships, and the context in which the technology is meant to operate. In other words, user characteristics as well as contextual characteristics were identified which would play into the process of design and development. Each persona-based scenario represents a person with stroke and describes their experience of stroke, their goals and their relationship with technology in their homes. Three scenarios were created based on the experiences and behaviours of real people by each participating country as descriptive models to represent a diverse range of target users. The scenarios were goal-directed, that is the personas involved had goals and intended to achieve their goals. Following Cooper and colleagues [25], we were interested in identifying three types of goals which corresponds to Norman's visceral, behavioural and reflective levels and includes experience goals: how a user wants to feel, end goals: what a user wants to do and life goals: who a user wants to be. Persona-based scenarios provide a framework to understand users' behaviours and in particular goals are the driving force behind those behaviours [25].

In addition, Desmet [24] showed that in their interactions with products people can experience different positive emotions such as respect, love, joy, hope, courage, relaxation, relief and satisfaction. Similarly, products can induce positive emotions in various ways. For example, emotions are experienced by the product's quality, the meaning attached to the product, the interaction with the product, the function facilitated by the product and the impact of product on ourselves and the effects of other people's reactions to the product. Emotions shown by the users are also believed to have different effects on behaviour [24].

Here we illustrate the applicability of affective models of design to one of our persona-based scenarios.

Edward is a 65 year old gentleman who lives in the UK, Sheffield in a large detached house with his wife Jane. Edward had a stroke five years ago which left him with a left-sided hemiplegia. He has some activities in his shoulder and can move his arm slowly in front of his body if supported. He has some hand grasp and release but poor fine movements of hand. He enjoys private physiotherapy sessions every week. He used to work as a university lecturer and Jane is a retired nurse. She has to give up her job five years ago to look after her husband as his main carer. Edward is an experienced IT user, he uses computer, internet and email, IPod, mobile phones, camcorder, printer, satellite, wireless, and digital camera. Hence, he experiences positive emotion of confidence and pride when using different technologies. He also experiences joy, relaxation and love when he plays computer games with his grandchildren. Edward is close to his family including his younger brother who lives nearby and visits Edward and Jane regularly. He walks with assistance but uses an electric scooter for outdoor mobility. He has a disable car equipped with a hoist, an electric garage door and the lighting with movement sensor, which give him feelings of relief and satisfaction. These emotions have positive effects on Edward's behaviour. He is motivated to use all these technologies to give him a measure of independency and even has developed new hobbies including gardening and wood work. Edward's main hobby was playing guitar and he is trying to regain his ability to play guitar again.

In addition to inducing positive emotions, technology products can generate various negative emotions. Fokkinga and Desmet [26] developed a framework that explains how people's negative experiences of technology products can be enjoyable. In this framework the negative emotions such as frustration, fear, and anger evoked by, for example a piece of technology, have physical and mental effects, which holistically transform the individual's perception of

the situation and his or her attitude toward the situation. However, what makes a negative emotion pleasant and enjoyable is a psychological gap that people create between themselves and the technology product, which in Apter's words is called "protective frame" [27]. Fokkinga and Demet [26] modified Apter's original "protective frame" model and proposed an additional frame named "perspective frame" in which the individual creates new meaning of the negative emotion by considering the wider positive implications of the situation. "Perspective frame" can be used to explain how negative emotions created by technology following stroke can also be enjoyable. Our next persona, David, illustrates the applicability of this frame:

David is a 60 year old who lives with his wife Tessa in a terraced house in Hengelo, the NL. He used to work in a large retail chain before he had a stroke six years ago, which left him with a left-sided hemiplegia. He has some return of function in his affected shoulder and elbow but has real difficulty with hand control, grasping and releasing. He cannot walk independently and uses a wheelchair. After the stroke, he no longer drives and Tessa does all the driving. This makes David angry and Tessa feels that she has to take more responsibility. Tessa resigned from her job several months after David's stroke to look after him as his main carer. David mainly enjoyed cycling, photography, and going out into the countryside. He used to use computers particularly for sending emails. After he had a stroke he does not use computers often because he is not as quick as before and he finds it frustrating. He uses mobile phones and text messaging and likes touch screens such as I Pad. He has a Wii but he does not use it. Tessa believes her husband has no motivation to use technology and David believes that after his stroke nothing is easy anymore. Although, David's attitude toward technology is shaped by the negative experiences of frustration following stroke he is willing to rethink what it means to be concerned about using technologies once he considers the broader and long-term benefits of using technology for the rehabilitation of his stroke. "The perspective frame" maintains a connection between David's negative feelings and the need to be aware of improving the functional abilities. He even envisions a compact and simple technology to help him get back to a normal way of working and assist him with cycling. However, the question of whether or not people with different background use "the protective frame" is central to the current discussion in terms of the issues raised in relation to negative experiences. For example, the findings of the study suggests that Dutch participants are more likely to use "the protective frame" meaning that they are willing to try different technologies to improve their functional abilities after stroke.

The findings further suggests that the person with stroke is involved in a network of relationships and his/her decision to use a home-based rehabilitation system is influenced by those who are part of this network such as friends, family, health professionals, and peer groups. Hence, the experience of stroke and technology use could be a process that the person with stroke and the carer create new identities in relation to self and others. Being entangled in the network of relationships, would create a complex, dynamic, changing and adaptive situation [28] that requires continuing meaningful dialogue with the user to encourage participation and engagement.

Conclusion

The findings of this study helped technology developers to detect a number of issues cluster around what is commonly referred to as user requirements. The identified user requirements were mainly concerned with the issue of usability. For example, it was suggested that the to-be-designed technology should be compact, simple to operate and robust. It should also look and behave in a humanistic manner, be usable without any assistance, be easy to clean, and transportable. Nevertheless, our interest in people's experiences encouraged us to transcend the limits of user requirements and to think the big picture. Studies open to new forms of inquiry for technology design as was illustrated in this paper potentially hold promise for developing new understanding of the process of design. Drawing on Dewey's principle of continuity [29], "in which experiences are a continuous interchange between present and past and between personal and socio-cultural" [10, p.140], people's experience of a technology starts when they first hear about it from others [10]. For instance, we examined the experiences of our participants of a new robotic device by talking about the device and its related issues. The idea was to design not only a device that could be engaging and therapeutic but to have the potential to transform the way people with stroke, their carers and stroke professionals perceive stroke home-based rehabilitation.

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