

# User-Centered Design Method for the Design of Assistive Switch Devices to Improve User Experience, Accessibility, and Independence

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**Abstract**

Despite an increasing awareness of user-centered design (UCD), there is limited discussion of how such approaches can be translated into the resource and time constrained environments of medical engineering departments; yet, much of the work in such environments involves the prescription and tailoring of equipment for an individual. This article explores the suitability of adopting a user-centered design approach to understanding the needs of 10 electromyography standalone switch users who have complex disabilities. This feasibility study was conducted in a busy Rehabilitation Engineering Unit of a National Health Service hospital.

A UCD approach was developed and tested using a range of qualitative techniques that included user interviews in the home environment, content analysis, and affinity mapping. This approach enabled clinical engineers to work alongside design researchers to elicit key parameters for future switch designs. A number of themes emerged relating to the day-to-day use of environmental controls by individuals with a limited range of physical lower limb movements. A key finding concerning switch use was the importance that users placed on the ability of a switching device to increase their independence and have control of their activities; conversely, there was also the revelation that in some cases the effort invested in using an assistive technology was not worth the gain to the user. In such cases having a caregiver perform the task instead was preferential.

This paper documents a university-affiliated research team's efforts to guide user-led practice and product insight acquisition with the implementation of a UCD approach.

**Keywords**

design, assistive technology, engineering and technology, technology, user, disability



## Introduction

This feasibility study was the result of a collaboration between Abertawe Bro Morgannwg University (ABMU) Health Board's Rehabilitation Engineering Unit (REU) and PDR, an international center for design and research. It was borne out of discussions with clinical engineers centered around ways in which the needs of assistive switch users can be better understood using design research approaches that center on the end user. The research was funded by Devices for Dignity (D4D) Healthcare Technology Co-operative, which is a national initiative funded by the National Institute for Health Research (NIHR) to drive forward innovative new products, processes, and services to help people living with long term conditions.

The clinical engineers at REU along with their medical electronics colleagues observed a potential gap concerning the design and use of electromyography (EMG) standalone switches, that was, the gap in the UK market for a commercially available standalone EMG switch. EMG switches are muscle activated switches enabling severely disabled users to independently control their environment or access communication with tiny muscle actions, sometimes their only reliable movement.

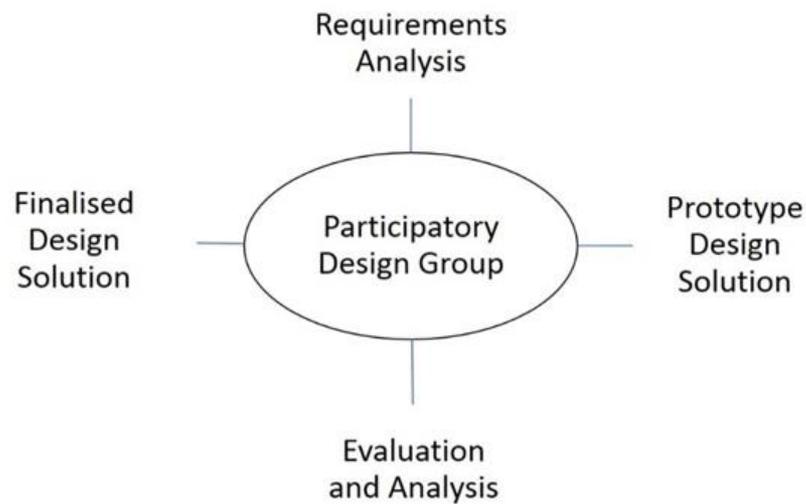
Product designers in industry are typically constrained in terms of time and budget that frequently prevent them from consulting with end users while assessing the ease of use of the products they create (Cardoso & Clarkson, 2012). Arguably this is even more acute for clinical engineers trying to deliver services to increasing numbers of patients with fewer resources. As such, this project presented an opportunity for the REU clinical engineers to work with Cardiff Metropolitan University to see whether a new approach would help them develop improved assistive switches.

The initial goal of the project was to develop a working EMG prototype to establish a clear understanding of the commercial viability of such a switch; the thinking being that it would increase independence for disabled individuals with very limited mobility and muscular function. This project was formed in two parts: first, understand the needs of potential users of an EMG, and second, develop an EMG prototype. This paper covers the first part of this project and explores how user-centered design (UCD) methods can inform the clinical design process. The clinical lead for this project stated that "The group was keen to enter the competition as we saw it as a great opportunity to use a multi-disciplinary approach for the design and development of a device that would improve the lives of disabled individuals."

### **Background to User-Centered Design**

Design approaches have traditionally been alleged to fail when it comes to engaging with the end user (Hansen, Percival, Aldred, Brownsell, & Hawley, 2007). There has been criticism directed toward designers instinctively designing for able-bodied users, being unaware of the needs of users with different capabilities or not knowing how to accommodate their needs within the design cycle (Keates, Clarkson, Harrison, & Robinson, 2000). UCD is a design philosophy that looks to overcome this by placing the needs, wants, and desires of users at the center of the design process, allowing these needs and desires to drive the development of a product, system, or service.

UCD bridges the gap between the differing mental models of a user (i.e., what they develop to explain the operation of any designed system) and a designer (the conceptualization that the designer has in mind). The result is a system image, where the designer "...must ensure that everything about the product is considered with and exemplifies the operation of the proper conceptual model" (Norman, 1988, p. 189–190). UCD places end users and their experience of a product, system, or service at the center of the design process and allows the user to contribute to every stage (Figure 1).



**Figure 1.** UCD placing the user group at the center of the design process. From “Applying User Centred and Participatory Design Approaches to Commercial Product Development” by C. Wilkinson and A. De Angeli, 2014, *Journal of Design Studies*, 35, 614-631. Reprinted with permission.

UCD requires the participation of a multidisciplinary team (Mao, Vredenburg, Smith, & Carey, 2005). Furthermore, it captures the needs of the end users in the context of use (von Hippel, 1986). This increases the relevance and acceptance of the output design and reduces the risks associated with the use of a product (Norman, 1988). In UCD, designers apply a variety of tools to better understand the end user of the product. The detailed understanding of the end user is then incorporated in the design concept. An essential aspect of UCD is that the design is refined through testing in the real world with the intended users (Pratt & Nunes, 2012). However, the reality of UCD in resource constrained environments does make this problematic.

Although the UK is at the forefront of countries contributing to UCD in healthcare research and literature (Ghazali, Ariffin, & Omar, 2014), in terms of user-centered EMG switch control design and development, the literature is relatively scant. There is also the need to understand the resource constrained environment of conducting UCD in a National Health Service (NHS) department. Wilkinson, Walters, and Evans (2015) described the challenges faced when adopting UCD in a commercial setting, whereby companies are reluctant to commit financial resources to a full UCD approach, preferring to opt-in and opt-out of elements of a user-centered approach. Conversely, the constraints within an NHS department similarly are of a financial nature, and our paper aims to explore the issues of applying a UCD approach in an equally limiting context.

The research presented adopts a user-centered approach by actively using a number of current, expert, and of potential users in the specification and development process (Taffe, 2015; von Hippel, 1986). Initial findings from this study were presented at Design 2014 focusing on the analysis of the data that led to a design wish list (specifications) for users of assistive switches (Dorrington & Mihoc, 2014).

The project started from the standpoint that individuals would want to move to EMG switches as soon as their disability worsened and their range of movements (or functions) decreased, hence, the increased need for an EMG switch. However, the adoption of a UCD approach highlighted that not all users were willing to adopt EMG switches; the users had concerns over reliable activation of the switches and the potential to set them off with involuntary muscle movements. Subsequently, as EMG was shown to not always be an appropriate solution, a stronger desire from users to have enhanced day-to-day assistive switches emerged.

Subsequently, we shifted our focus to understanding how existing environmental control switch users currently use their switches, along with their general day-to-day switch requirements. This was then followed up with their overall thoughts on the use of EMG switches. A large amount of data about switches and their use in general was garnered, which was then analyzed to inform future switch designs; the principles for which also apply to EMG switches.

The purpose of this paper is to explore how a UCD method was applied to understand the needs of assistive switch users in a resource and time constrained design context.

## Methods

The following sections discuss the study design, the participants, and the materials and tools used during the study.

### Study Design

A user-centered design approach was developed and followed, incorporating various qualitative research design elements, such as interviewing and inductive coding. Interviewing produces a vast amount of narrative data that is incredibly rich in content but can be unwieldy to order and analyze. As stated by Miles and Huberman, "words are fatter than numbers and usually have multiple meanings. This makes them harder to move around with and work with... numbers are usually less ambiguous and can be processed more economically" (1994, p. 54). However, even though narrative data, words may be more difficult to work with than numbers, we would argue that they render more meaning than numbers when understanding the needs of users with complex disabilities. In order to overcome some of the potential difficulties with such data, the researchers followed a highly structured approach to collection and analyses of data, which can be seen in Table 1.

**Table 1.** An Overview of the Ordering and Analysis Process for the Data

Stage of Research	Activities
Research design	<ul style="list-style-type: none"> <li>• Gain ethical approval</li> <li>• Consider research methods</li> </ul>
Research execution	<ul style="list-style-type: none"> <li>• Develop interview template</li> <li>• Arrange and conduct interviews</li> <li>• Transcribe interviews</li> <li>• Inductive coding of the first two interviews</li> <li>• Harmonization of codes amongst researchers</li> <li>• Continued coding</li> </ul>
Data	<ul style="list-style-type: none"> <li>• Data across interviews from each code printed out and prepared for affinity mapping section</li> <li>• Affinity mapping section</li> </ul>

A semi-structured interviewing approach was used to gather the data from switch users. The following are our methodological reasons along with practical reasons for adopting an in-home interviewing environment as the main research method, rather than using surveys or focus groups:

- Face-to-face interviewing of individuals who may have difficulties in communicating (both orally and in a written form) provides direct answers without any reliance on a third party to complete questionnaires and so on. The answers therefore come directly from the actual switch users.
- Interviewees are in a familiar and comfortable environment which eliminates the need for unnecessary travel that might be logistically difficult.

- Researchers can observe how interviewees effectively interact with the switches in an environment they are familiar with.
- Researchers can gain a deeper understanding of how the switches work through realistic observation rather than selecting a box on a survey questionnaire.
- Researchers can expose new lines of inquiry by asking open questions.
- Researchers have the flexibility to deconstruct any large research questions into smaller sub-questions that are easier for the interviewee to answer. This is particularly important considering any potential reduction in cognitive function that may accompany a user's condition.
- It would be very difficult and not as effective to conduct a focus group or group interviews with the user group concerned in this study.

### **Participants**

Potential users of EMG switches will vary in their functional ability and causes of disability. This paper uses the term *users* interchangeably with *participants*. From discussions with the clinical engineers involved in this project, a sensible selection group to approach were individuals with cervical cord injuries, Duchennes Muscular Dystrophy (DMD), and other conditions affecting the central nervous system such as Cerebral Palsy. Such users have limited mobility (and are likely to be wheelchair users) and were selected because they are already using environmental control switches and may be candidates for EMG switches. All of the users required 24-hour care.

A purposive sampling method was followed in order to gain the most from the interviewees recruited. Purposive sampling refers to the interactive process carried out by a researcher when directing their data generation, analysis, theory, and sampling activities (Mason, 2006). This led to users being selected with a varying level of function (i.e., ability). Table 2 provides anonymized details of research participants. All identifiable characteristics have been removed for the purpose of confidentiality.

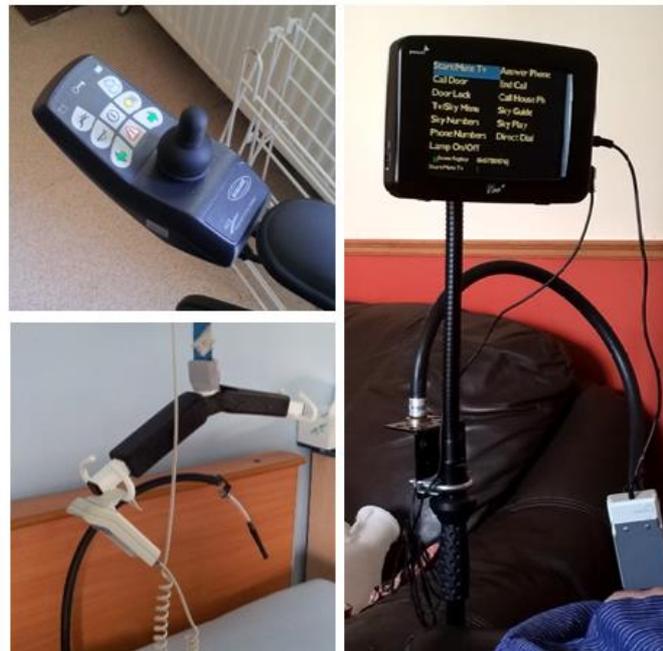
**Table 2.** List of Participants Visited in Their Homes and Interviewed About Switch Use

<b>No.</b>	<b>Diagnosis</b>	<b>Functional Ability</b>	<b>Current Switches</b>	<b>Independence</b>
01	Complete cervical cord injury at C5	No wrist/hand function or tricep use	Suck/blow pipe (ECU) and push switch on desk for operation in the day	Some independence, calls on caregivers throughout the day rather than them being in constant attendance
02	Complete cervical cord injury at C2	Ventilated, difficult and tiring for communication; no control over movements from neck down, unable to move head	Suck/blow to operate power chair; laptop with reflective tracker device	24-hour care, most things done for the participant due to a high level of impairment
03	Complete cervical cord injury at C4	No wrist/hand function or tricep use; adapted mouthpiece and pointer to use mouse devices and computer (including tablet)	Bar mounted joystick and chin switches; bar mounted recreational shooting device	Supported lifestyle, but independent; goes on short outings in their chair; calls on caregivers throughout day rather than them being in constant attendance
04	Duchennes Muscular Dystrophy	Help needed to position arms, but some function; no functional ability in legs; limited hand function, can grip and operate switches placed nearby	Joystick and switch to drive and adjust chair; use of smart phone	Active lifestyle, sport participation, attends college; caregivers always present

No.	Diagnosis	Functional Ability	Current Switches	Independence
05	Duchennes Muscular Dystrophy and acquired scoliosis	Ventilation; help needed to position arms, but some function; some hand function; acquired postural deformities	Joystick and switch to drive and adjust chair; specialist games console switch interface	Goes on short trips on own; likes to remain as independent as possible
06	Motor Neurone Disease	Able to walk; struggles on uneven surfaces; upper limb weakness; unable to grip items; weak gross movements with hands to operate ECU	ECU	Manages to get to stair lift unaided (holds on to furniture) so can get upstairs
07	Motor Neurone Disease	Limited walking; help to rise from seated; upper limb weakness; some control of overall body position, easily lose balance	ECU push switch operated	Uses powered chair for outdoor mobility
08	Motor Neurone Disease	No functional ability in legs; can move using feet; poor trunk control; special seating supports him in a midline position; repositioning by caregivers; some gross movement in upper limbs; can grip and operate switches placed nearby	Bell to call family caregivers; smart phone (issues of getting head in right position to see screen)	Full-time assistance required; attends higher education institution
09	Cerebral Palsy	Ataxic movements limit upper body control; good lower limb movement and moves around house on back	Fine control of left big toe operates trackpack/keyboard for computer; also uses toe to operate chair	Good lower limb movements enabling movement around the house; 24-hour care otherwise
10	Cerebral Palsy with severe spinal scoliosis	Limited upper limb movement; able to grip a joystick to operate power chair	Power chair joystick; iPad	Lives alone supported by sheltered housing; still requires 24-hour care

*Note.* All participants used wheelchairs. ECU = environmental control unit.

Figure 2 shows some of the types of switches used by participants. These devices are referred to in Table 2 as well.



**Figure 2.** A collection of the different switch interfaces used by participants and discussed in Table 2: micro-joystick (top left), puff-blow ECU (bottom left), and push-button linked to a Possum ECU (right).

In order to limit bias, Eisenhardt recommended the use of “numerous and highly knowledgeable informants who view the focal phenomena from diverse perspectives” (2007, p. 28). As such, users were selected with varying degrees of experience in using the switches; that is, a few had conditions that had recently worsened and meant they had only used environmental control units for as little as three months. A number of users were considered *lead users*, having accumulated a large amount of experience over decades (von Hippel, 1986). This multiplicity of perspectives was deliberately sought in order to answer the research problem more effectively and enable the triangulation of data (Poole, Van de Ven, Dooley, & Holmes, 2000).

In terms of widening the applicability of any design solution, the sourcing a representative sample from which to generalize is paramount, and the success of this intention should be verified. The aim would be to utilize participants from a broad spectrum of educational backgrounds, geographical locations, and physical and psychological abilities (Wilkinson, 2015, in press). It is worth noting that, in this example, the intention was to develop a suitable design solution for a specific demographic. However, it is still advantageous to ensure the ultimate solution is applicable to a wider demographic as possible.

In this way, the inclusive and participatory approach outlined can be seen to be of value in obtaining a more accurate picture of user requirements and reactions to prototypical design solutions and, in a wider context, contributes toward the explorative development of assistive technology that is more usable, understandable, and intuitive to a larger market (Wilkinson, Walters, & Evans, 2015).

The institutional ethical procedures for the University and the Hospital Trust were adhered to, and participants were asked for their consent to be interviewed for this research. It was made clear that they could stop participating at any point of the process if they felt uncomfortable or changed their minds. These assurances were delivered by the clinical engineer when approaching participants and organizing interview dates with those wishing to take part. A full participant information sheet was also given to each participant prior to any contact, and finally key aspects of data protection were reiterated at the start of each interview.

Furthermore, qualitative research stresses the importance of direct experience of the social settings (Bryman & Bell, 2003), in this case, the user's home environment. The importance of visiting users in their own environment was extremely helpful to understand how they carry out their day-to-day activities and to see any workarounds they developed to deal with their environment.

### **Materials and Research Tools**

The semi-structured interview method and reasons for its use have been outlined in the Study Design section in this paper. In order to increase the robustness of this approach and repeatability of interview questions posed, an interview template (available in the Appendix) was developed and used during the interviews. This also meant that answers followed a logical sequence for each transcript, enabling a smoother coding process. The questions asked were mainly open in construction in order to discuss a range of issues relating to switch use. One particularly insightful question asked the participants to describe a typical day in terms of when and how they use switches; the time and associated activities were logged accordingly to build up a more in-depth understanding of switch use on their day-to-day activities.

To facilitate efficient data coding and retrieval prior to the affinity mapping procedure, NVivo qualitative analysis software was used.

### **Procedure**

The rich data from the interviews was inductively coded according to emerging themes. Portions of text (a clause, sentence, or paragraph) were selected and assigned to the themes that emerged. From the set of 10 transcripts, the first two transcripts were each coded by two of the researchers. Following this exercise, the rules for assigning codes were discussed and harmonized, to increase coding reliability, prior to the coding of the rest of the interview scripts. Qualitative data analysis software was then used to search each theme and print out each unit of analysis (typically a response from a participant) ready for the affinity mapping process. Essentially this resulted in hard copy printouts of participant responses that had been retrieved and grouped together for each theme.

Affinity mapping or diagramming is a business tool that has been in use since the 1960s for creating a hierarchical overview of key customer issues; furthermore, since the 1990s it has become a standard approach in user interaction and experience design following adaptation by Beyer and Holtzblatt (1998).

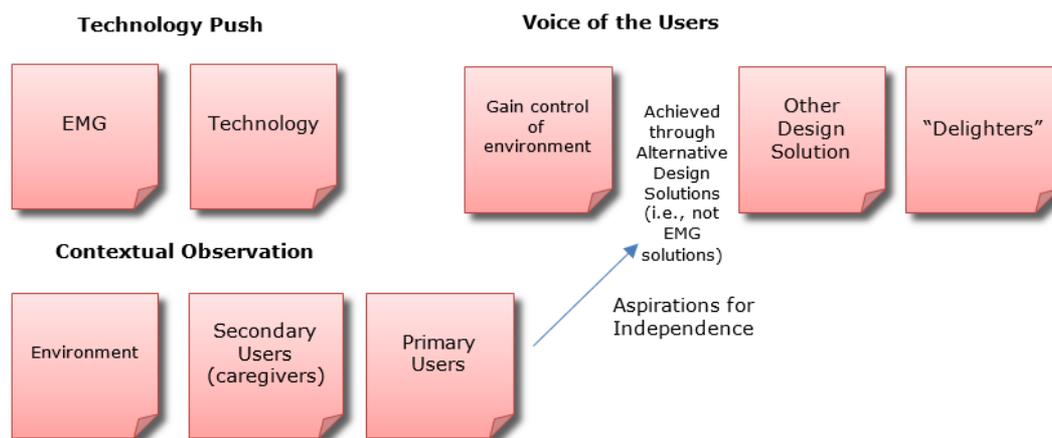
An iterative process of reviewing and clustering the data (the themed extracts from the transcripts) was used to create the Affinity Diagram (see the example in Figure 3).



**Figure 3.** Example of affinity mapping of data to generate key themes.

## Results

The affinity mapping sessions resulted in a range of emergent themes related to the day-to-day use of environmental controls by individuals with a limited range of movements. These themes were ordered according to the over-arching groups that emerged from the final walkthrough of the data: Technology Push, Contextual Observation, and Voices of the Users, as displayed in Figure 4.



**Figure 4.** Final groupings as a result of thematic analysis.

Focusing on the grouping "Contextual Observation" in Figure 4 as one example of the groupings, the reduction process leading to this is illustrated in Table 3.

**Table 3.** Clustering According to the High-Level Contextual Observation Group

<b>High-level clustering</b> 	<b>Cluster heading</b> 	<b>User voice "..."</b> 	<b>Affinity notes</b> 
Environment	Internal (home)	I want to access entertainment, news, etc.	Higher reliance on environmental controls when sedentary
	External	I'd rather be out and about than confined inside. I want to travel widely.	Dependency on certain switches Airplane/airports Higher reliance on caregivers when away A new environment (adapting to or lack of usual switches) Weather
Secondary Users	Caregivers	I need 24-hour care.	Caregivers provide backup (when technology fails) Reliance on caregivers Confidence in setting up equipment
Primary Users	Motivation	I am motivated to use environmental controls.	Effort: benefit trade-off Empowering technology (specialist) Empowering technology (standard)
	Degeneration	I still want to use my devices although my condition is getting worse.	Involuntary twitching Hypersensitivity Degeneration -> more technological assistance Degeneration and fatigue (inability to use radio-controlled car controller, a hobby previously enjoyed)
	Independence (inferred)	I want to be independent, but still want caregivers or rely on caregivers.	Motivation driven by the need for "normality" Self-motivation for independence Privacy
	Independence	I want to be independent. I want to be safe inside and outside the house. I do not want to be patronized.	"Killing by helping" (highly motivated, find a way to help) User is left vulnerable if EMG breaks or is stolen Reduced independence linked to lower self-esteem Portability and size of control units (e.g., Possum EMG) Switch use hinders communication (e.g., talk and drive with puff-blow switch)

Note. Data reduction went from right to left.

Rather than discuss the findings from each theme in detail, this paper is concerned with testing the UCD approach in a resource-constrained NHS department. A detailed look at each theme has been published in the conference proceedings for Design 2014 (Dorrington & Mihoc, 2014).

However, for completeness, some of the key themes are now discussed to illustrate the usefulness of the findings this approach can gather.

### **Use of Standard Technology**

The use of readily available standard technologies was common amongst the group interviewed. A user in the early stages of progressive Motor Neurone Disease (MND), who uses a mouse with both hands and clicks the select button with a finger on his right hand, revealed a significant interaction issue: "very often if my finger twitches.. I click something that's not necessarily what I want to click." Those with lower functional capability, for example, a male in his 50s with complete cervical spinal cord injury was only able to operate chin switches and used a stick held in his mouth to push and physically move a mouse. In a number of these cases users had degenerative conditions and were persevering with technologies that they were previously able to use more effectively.

Other examples of standard technology use included one interviewee with Cerebral Palsy who had developed an innovative way of lying down so that she could look at a computer monitor while operating a keyboard with her feet. Additionally, she had an integrated trackpad on the keyboard that she was able to control with her toe. This participant also demonstrated the use of a pen tablet and stylus to use basic graphics software. By staying on the floor, she was able to negotiate her environment more effectively and make use of a computer. Sitting in a wheelchair prevented her from achieving this interaction.

These findings suggest that methods for interacting with standard technology or switches should be investigated when considering switch design; there may be a more cost-effective way of developing an interface or adaption allowing the use of standard technology—such as popular smartphones—for these users. This was neatly summarized by one interviewee: "I want access to appropriate technology".... "I want this [push switch] to be compatible with smart products."

### **Independence of Users**

One pivotal output of this research were users' emphasis on the effect that a switching device has on their ability to be independent and have control of their activities; this is in agreement with a study conducted by Judge, Robertson, and Hawley (2009). However, there was also the revelation that in some cases maintaining independence was "more than it is worth"; the explanation being that in some circumstances it was preferable for users to compromise their independence and have a caregiver perform tasks for them.

### **Motivation of Switch Use**

The motivation levels of users appeared to vary across the sample. Of note was the finding related to the *effort-to-benefit* trade-off for using technologies; that is, the effort of using an assisted technology is sometimes greater than the benefits for the user when they have somebody else who can do it for them and who can probably do it more efficiently. Like independence, this is juxtaposed to when the user wants more privacy and will be more motivated to spend more time and effort on a task. A number of the younger interviewees found using an iPhone beneficial for just such reasons: "It is quite good with the iPhone, I can have it and I can use it without having to ask anyone to help me."

### **Empowering Technology**

Using environmental controls, with a particular emphasis on being able to use the phone when a caregiver is absent for a brief period, provides users an element of independence. Ubiquitous access to the Internet is clearly a significant enabler, particularly for users who rely on it as part of a communication system or tool, such as email or Skype.

### **Degeneration**

One participant explained that: "I still want to use my devices although my condition is getting worse." A number of users described their frustrations of how as their conditions worsened over time or as fatigue set in during the day they were unable to exert the same force on switches to activate them. If switch designs included a sensitivity setting, this would allow caregivers to adjust devices to accommodate degeneration of strength.

## Discussion: The Application of a UCD Approach in Context

Through a university-hospital collaborative project, a UCD approach was adopted and trialed to understand the needs of 10 assistive switch users with complex disabilities. This approach

- utilized a range of qualitative techniques including user interviews in the home environment, content analysis, and affinity mapping;
- was capable of eliciting key parameters for future switch designs;
- was specifically developed for application within the context of the NHS, as a direct response to the same forces that often constrain the adoption of user-centered design in industrial and commercial contexts, which holds a maximum added-value within an environment of extreme resource limitation.

The interviews with actual users revealed that not all were willing to adopt EMG switches due to concerns over the reliability of their activation and their appropriateness as a situational solution. Subsequently, through content analysis and affinity mapping, the focus shifted from understanding how existing environmental control switches were used to determining what alternative or custom-made solutions would satisfy the needs emerging from this unique discourse with the participatory design group. Arguably without the adoption of such a user-centered design process, there is a risk that the identified gap for an EMG switch may have led to the use of limited resources to develop the wrong solution, that is, the assumed “technology push” solution of developing a new EMG switch.

A number of themes emerged relating to the day-to-day use of environmental controls by individuals with a limited range of movements, as did the revelation that in some cases the effort invested in using an assistive technology was necessarily not worth the gain to the user.

The main disadvantage of using qualitative interviewing was the time required to transcribe, code, and analyze the rich narrative data collected within the limited constraints of this project. It is worthy of note that transcription and coding are often labor-intensive and previous studies by the authors were no exception; in one scenario, the data collection and analysis consisted of thirty 1 hour recordings that were transcribed and coded in their entirety. On average this assumed a 1:3 ratio. One hour of raw material taking 3 hours to transcribe and at a later point in time to code. Such a commitment should be born in mind when designing any experiments or interaction sessions (Wilkinson, 2015, in press).

## Conclusion

This paper presents a research team’s efforts to guide user-led practice and product insight acquisition with the implementation of a UCD approach within the Rehabilitation Engineering Unit of a National Health Service Department. The approach itself was seen to yield substantial results both in terms of physical adaption to existing problems and solutions, but furthermore it provided unique and often surprising insights into solution identification from the perspective of actual service and system users.

The UCD approach applied has the potential to assist designers to rethink the development of assistive technologies by listening to, and focusing upon, the experience and actual lives of everyday users of such technology. It also reinforces that effective user-centered design need not be prohibitively expensive and can be applied across a myriad of product types efficiently and cost effectively.

This research provides a strong evidence base, concurring with literature that appropriately designed assistive technology has the potential to reduce healthcare costs, including costs related to institutional care and in-home nursing, as well as improve the everyday lives and experiences of individuals (Wilkinson & Ghandi, 2015). Furthermore, such developments have the potential to reduce caregiver intervention, as well as reduce the rate of decline in patient capability, if desired.

One of the most considerable barriers on impact to general design practice and the consideration of users is time and cost constraints (Goodman-Deane, Langdon, & Clarkson, 2010), which are highly prevalent in a typical NHS department.

A senior clinical engineer reported that the UCD approach provided “an invaluable insight into the complexities of user’s requirements,” and that “this style of engagement was made feasible through collaboration with a University affiliated design group and was appropriate for a small sample of users which had a minimal impact on NHS resources.”

The findings highlight the range of user needs in this group of individuals with complex disabilities and in some cases the conflicting information provided by the users that indicates that one-fit-all solutions is not applicable in this scenario. The methodology employed in this study is transferable to many design approaches in Rehabilitation Engineering and this experience has demonstrated to the clinical engineers the feasibility of utilizing UCD for future projects. One of the key ingredients to the format of this study was performing the interviews in the user’s environment as this provided the holistic assessment and appreciation of an individual user’s needs and challenges.

### **Tips for Usability Practitioners**

The following are some tips and recommendations garnered from our study:

- When eliciting the needs of users who have complex disabilities, you will gain far more insight into their daily lives if you meet them in their home setting; this is also far more convenient and comfortable for them.
- Qualitative interviewing is time consuming and takes time to transcribe, code, and analyze; therefore, have a plan as to how you will carry out such tasks. One suggestion is to seek a professional transcription service if you have the budget, which gives you and your team more time to carry out the most rewarding and insightful tasks of analysis and insight gathering.
- From a UCD perspective, involving actual users in research optimizes their influence on product and interaction design, and maximizes the output of design insight exercises.
- The UCD approach detailed in this paper shows how user insight activity can drive more effective design research and lead to the development of more user-focused products with a greater likelihood of accessibility, uptake, and adoption.

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## **Appendix: Devices for Dignity—Unmet Needs Project—Assistive Technology User Interview Template**

[Introduction]

Thank you ...

We are ...

We would like to ask you about your experience of assistive switches that you have used or are using currently. How do they help you carry out your day-to-day tasks and control your environment?

[Record the interview to make sure that we do not miss any important issues when we come to review the data.]

Is this okay?

If you feel uncomfortable with any of the questions, or would like to stop at any time, then please let us know ...

Any questions about anything I have said so far?

Are you happy to continue with the interview?

Firstly, I would like to ask you about your current assistive switch devices, and how you use them?

- Can you tell us about the assistive switches that you use?
- Have you had others?

I would like to ask you more about the usability of your switches?

- How easy are they to setup, operate, and use? [Get perspectives from users and caregivers.]
- What do the switches enable you to do that you couldn't otherwise? [Note the type of devices: how they enable the control of the environment and how they are operated.]
- Are they customizable to you as an individual?
- Comfort? [Note where or how the following applies: wearable, discrete, position on body or chair, trailing wires, size of unit, connections to muscle group.]
- Interface with other assistive devices? [Note where or how the following applies: wires, ease-of-connection, and use.]
- Number of outputs for switching devices on/off? How are they triggered (e.g., pectoral muscle)?
- Range of possible outputs (e.g., press and start, press and hold)?
- Power supply (e.g., durable, rechargeable, backup supply, reliable)?
- Mobility (e.g., linked up to other peripherals)?
- Future needs that could be addressed (e.g., more outputs, lightweight, wireless)?

Can you describe your typical day to us, and how and when you use your switches?

- When, where, and how often (e.g., operating environmental controls or operating assistive technologies such as communication devices)?
- How do you use your switches during a non-typical day, for example, in an external environment or change in routine such as when you are on holiday?
- When, where, and how often (e.g., operating environmental controls; operating assistive technologies, e.g., communication devices)?

What additional challenges do you face when outside of your home environment (e.g., mobility of switch equipment, power sources, interfacing with products in environments not built for disabled users)?

- Are there any ways in which assistive switches might help overcome these challenges?
- User's condition?
- Stability of condition or degeneration of condition: how has this affected the way you are able to use your assistive switch?
- Any loss of control?
- Need to re-calibrate the switch? Does this require help from another person?
- Other considerations?
- Frustrations of using assisted switches?

Thank you for your time.