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USER CENTRED DESIGN OF AN ELECTROMYOGRAPHY SWITCH TO IMPROVE USER EXPERIENCE, ACCESSIBILITY AND INDEPENDENCE

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1. Introduction

Electromyography (EMG) stand alone switches are muscle action switches enabling severely disabled users to independently control their environment or access communication with tiny muscle actions, sometimes their only reliable movement. Usually these switches require powerful computers, but a collaboration between Morriston Rehabilitation Engineering Unit (REU) and The National Centre for Product Design and Development Research (PDR) set out to investigate whether a more viable solution was possible.

This paper describes the structured approach followed to understand the needs of a group of assistive disabled switch users and develop an informed Product Design Specification (PDS) for assistive switch devices. This refined PDS is then able to support the designers when developing suitable switch solutions. In order to further understand the knowledge in the 'heads' of the specific user group, and understand the environment (world) they live in, a user centred design (UCD) approach was adopted. UCD bridges the gap between the differing mental models of the user (i.e. what they develop to explain the operation of any designed system) and the designer (the conceptualisation that the designer has in mind). The result is the 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]. UCD places the end-user of a product, service or experience at the centre of the design process. It requires the participation of a multidisciplinary team [Mao et al. 2005], that captures the needs of the end-users [Von Hippel 1986] in the context of use. 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 are applying a variety of tools to best understand the end-user of the product. The detailed understating 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 and Nunes 2012]. Following the requirements for UCD, a combination of researchers, clinicians and users were brought together in this study to examine, analyse, interpret and synthesise the user needs into a product design specification to inform a designer's mental model when developing future EMG switches.

In order to fully understand the needs of potential EMG switch adopters, ten interviews were carried out and analysed in total with users of environmental control systems. '*Environmental control systems were initially developed in the 1960's to enable people who had suffered a spinal cord injury to control equipment in their immediate environment: for example switching on and off lights, operating the television etc.*' [Judge et al. 2009].

An essential part of this research was to understand how existing environmental control switch users currently use their switches, along with their general day-to-day switch requirements. These users

have conditions which may degenerate in the future requiring the need for EMG switches, hence including them and understanding their overall thoughts on the use of EMG switches.

A large amount of rich qualitative data about switch use in general was collected in the analysis, and will be a fundamental part of any EMG switch(es) developed in the future part of the project.

2. Research methodology

2.1 Data collection

A semi-structured interviewing approach was used to gather data from switch users. There were a number of methodological and practical reasons for this, including:

- Access to individuals who may have communication difficulties (orally and/or in their writing ability); through face-to-face interviews direct answers can be solicited without any reliance on a third party to complete questionnaires etc. The answers therefore come directly from the actual switch users;
- Facilitation of interviews in a familiar and comfortable environment for the interviewee; no need for unnecessarily travel (difficult for this user group);
- Observation of interviewees using their switches, and how they are able (or unable) to interact with the environment they are in the most (their 'world'); the importance of focusing on understanding users within the context of their daily lives and aspirations [Coleman 2011];
- Open questions can expose new lines of inquiry;
- The ability to deconstruct large research questions into smaller sub-questions which are easier for the interviewee to answer; particularly important considering any reduced cognitive function which may accompany a user's condition.

Potential users of EMG switches, and the target participants for this study, will vary in their functional ability and causes of disability. Through discussions with the Clinical Engineers, a purposive sampling method [Mason 2006] was followed, ensuring that the sample group reflected this variety. The sample group was comprised of ten individuals with: cervical cord injuries; Duchennes Muscular Distrophy (DMD); and other conditions affecting the central nervous system (e.g. Cerebral Palsy). Such users have limited mobility (likely wheelchair bound), are already using environmental control switches, and may be candidates for EMG switches. The sample size reflects the considerations made in this research study in terms of access, time, cost [Bryman and Bell 2011, p.187] and the adoption of UCD. Typically within a commercial environment, the development team would aim to access 8 to 12 end-users for needs identification. This has been shown to provide a good balance of information when considering the cost of collecting it. Accessing the end-users was the most difficult factor due to the reluctance of individuals wishing to discuss their personal condition with a stranger; requirements for 24 hours care; and availability to interview. Acknowledging these constraints, a sample of ten participants was deemed acceptable for this study.

A number of standard switch interfaces were demonstrated during interviews, all of which controlled the environment in some way. The variety of switches observed ranged from: simple household doorbells (used to alert carers); standard 'push' button switches; micro-joysticks; through to the higher-end puff/blow switches linked to environmental control systems, e.g. brands such as 'Possum'/ 'Steeper' units.

In order to limit bias Eisenhardt recommends the use of '*numerous and highly knowledgeable informants who view the focal phenomena from diverse perspectives*' [Eisenhardt 2007, p.28]. As such, users were selected with varying degrees of experience in using 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. Other users were considered 'lead users' [Von Hippel 1986], having accumulated a large amount of experience over decades. This multiplicity of perspectives was deliberately sought in order to answer the research problem more effectively and enable the triangulation of data [Poole et al. 2000].

Furthermore, qualitative research stresses the importance of direct experience of the social settings [Bryman and Bell 2011, p.615]; in this case the user's home environment. The importance of visiting

the user in their own environment was extremely helpful to understand how they carry out their day-to-day activities, and the 'workarounds' they develop to deal with their environment.

2.2 Carrying out interviews

An interview template was created enabling the interviewer to be consistent when asking questions from one interview to the next. However, due to the communication issues prevalent amongst such a user group, this was used in a semi-structured way allowing for the rephrasing of questions, and clarification of key issues. Interviews took place in the home environment with a researcher from PDR and a clinical rehabilitation engineer. Involving a rehabilitation engineer was important to put the user at ease (i.e. familiar clinical face) and to help explain any technical queries that arose.

2.3 Analysis of data – method

Interviewing produces a vast amount of narrative data that is incredibly rich in content, but can be unwieldy to order and analyse. A rigorous approach was followed to work with and analyse the data.

2.4 Data analysis

A number of data analysis techniques were brought together for this study. The interview data was transcribed and coded inductively using well-established methods of coding and consolidation with other researchers (see: [Miles and Huberman 1994]). The codes used were: *EMG; changes in routine; comfort; condition; proximity; current enabler; current specialist technology; setup and use; current standard technology; general notes; frustrations; important functions* and *indepedence*.

Qualifiers for apportioning coding text to each of these codes were developed amongst the research team. Having coded the data up into these 14 larger analytical 'buckets', a rapid contextual design process was adopted using the techniques outlined by Holtzblatt et al. [2005]. This is a group approach that helps organise the raw user data in order to drive design understanding and thinking.

The affinity mapping sessions resulted in the generation and organisation of over one hundred affinity notes; these were then divided into 22 segments, and duplications removed. These segments were then given a descriptor. A 'voice of the user' statement was also written; that is, if the user were to summarise the affinity notes in the group, this is what they might say. For example: '*Enabler*' grouped together a common set of affinity notes which fit with the user statement: '*I want to interact with my environment*'. The team then walked along the data wall and reviewed the findings. This resulted in further clustering of the segment notes into 3 common themes presented in Figure 1.
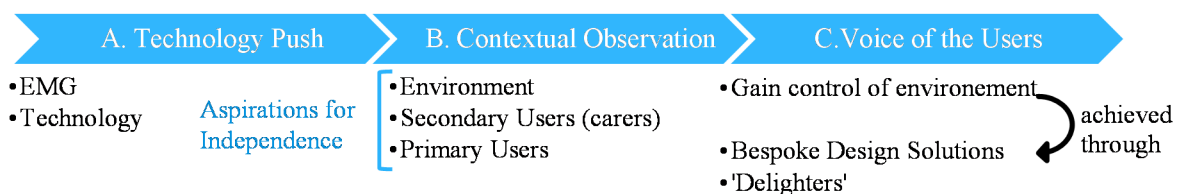

Figure 1. Final groupings

3. 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 severely limited range of movements. The results of the analysis are described below, ordered according to the over-arching groups that emerged from the final walking of the data: Technology Push, Contextual Observation and Voices of the Users.

3.1 Technology push

The 'Technology Push' group captures all user issues relating to the idea that solutions have been created from a 'technology-push' angle; there are two-sub groups: 'EMG' and 'Technology'. The term

'Technology-Push' has been used in terms of technologies being developed for users, but not necessarily fully understanding the needs of those users; hence the need for the 'Contextual Observation' in group 2 and 'Voice of the Users' in group 3. EMG has been included in this section, as the project was built around the unmet need for EMG switches, and understanding how they might enable disabled users to engage with their environment.

3.1.1 EMG

EMG Positive - '*I can see the benefits of using an EMG switch*' (voice of the user)
For those who were managing well with their existing switches an EMG switch might be a useful auxiliary switch to their existing environmental control switches. For example, EMG switches might provide 'quick access' to important functions such as answering a phone before it connected to the answer machine, rather than them having to try and reach physical switches or scroll through menus on an environmental control unit (particularly advantageous when in bed).

EMG Negative -'*I have some concerns with the use of an EMG switch*'
- Interference with day-to-day activities - '*Electrodes interfering with day-to-day activities*' (toilet, sleeping, being dressed);
- Comfort – [carer, mother] said: '*you'd be frightened to death if you had them on*';
- Comfort – [user]: sometimes unaware if raising eyebrow (i.e. triggering a twitch) and subsequently described a preference for buttons which are physically pressed;
- Involuntary switching - '*I think I can see a muscle switch being useful, but it's whether I could guarantee that I wouldn't twitch… inadvertently, you know*'.
- Allergies to EMG pads – '*mine just pop off.. I don't like anything on my body'; 'I'm allergic to those*'; issues of sweating causing them to come off.

EMG Design - '*It would be great if the switches could do this..*'
When discussing the potential use of EMG switches a number of initial design requirements relating to activation were highlighted; for example: '*does the user have a suitable muscle that can trigger the switch and is it reliable and repeatable?*' and '*if they were startled or excited would this accidentally activate the EMG switch?*' The latter implying that there should be a threshold setting or failsafe setting on the EMG switch, and the ability to trigger the switch might vary amongst the target group.
Switch outputs might overcome this, in terms of single twitch, double twitch, dwell/ long twitch. Also questions of how fast or slow the switches should be. The ability for the user to adjust the sensitivity themselves would be advantageous.
Another request was that EMG switches should be compatible with a standard devices 'hub' which links to standard devices (e.g. smart phones). This was also a requirement raised for existing switches, as summarised by one user: '*I'd like to work the mobile phone… it would be handy if you could get an application that you could download or make an application that you download on the phone and then your switch is plugged into it and so you can use your switch for the phone that would be really handy'. It's all about 'get[ting] to the point where these switches interface with something like an iPhone or the technologies that come in.. about making it easier for you to access*'.

3.1.2 Technology

Technology – Standard Technology- '*I want to use standard technology*'
For many of the users there was a desire to use standard off-the-shelf technologies as they are (again smartphones), although a number of difficulties were observed when using such technologies:
- Positioning of devices – a number of users had limited mobility in their spines, so the position of a phone to accommodate a comfortable view was difficult. For example, one user had rods quite high in his back, limiting his movement: '*it's difficult because.. it's like touch screen so it's a bit awkward if you are trying to press the keys and you can't really see them properly.. pressing all the wrong keys*'.
- Manual dexterity when interacting with the touchscreens: one user could use an iPhone, but unable to use the iPad due to the shape and limited movement in his hands; difficulty of actions such as 'swipe' on a screen.

The use of readily available standard technologies was common amongst the group interviewed. One example being that of a standard computer mouse: a user in the early stages of progressive MND was using a mouse with both hands, and clicking the button with a finger on his right hand: '*very often if my finger twitches.. I click something that's not necessarily what I want to click*'.

Those with lower function, e.g. a 51 year old male with complete cervical spinal cord injury – only able to operate chin switches – used a stick held in his mouth to push and physically move a mouse. In a number of these cases users had illnesses that were degenerating over time, so it is likely that they were persevering with technologies that they used to be 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, whilst operating a keyboard with her feet. She had an integrated trackpad on the keyboard, which she was able to use with her toe as well. She 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 rather than sitting in her chair, which would have prevented her from this. Also included under this category was the **inappropriate use of technologies**. On a number of occasions standard technologies were being used, or had been referred for use by external assessors which were not really suitable for the individual. For example: wireless doorbells – for calling carers, which are very basic and provide no way of communicating verbally with carers (unlike dedicated intercoms); baby alarms/ monitors – for calling carers; these were suggested for a number of users in their late teens or early 20s, who, understandably were embarrassed to be using baby monitors, particularly when their friends were visiting; and turning the volume on a TV up or microphone volume on a computer to call carers.

Technology – Specialist Technology - '*I want you to adapt technologies to fit my needs*'
Examples included bar mounts made from a standard camera mounts, specialist console gaming interfaces and voice recognition. The latter often proving problematic due to incorrect set-up, poor recognition of voice due to being on a ventilator, or having a quiet voice.

Technology – General
A number of general issues were raised when discussing technology in general, such as, its appropriate use, e.g. putting buttons within reach; the use of buttons that are easy to press (i.e. not membrane switches as often used on standard wheelchair controllers); and standardised connectors, i.e. being able to link specialist switches with standard technologies, as summed up by one interviewee: '*I want access to appropriate technology'.... 'I want this to be compatible with smart products'*.

3.2 Contextual observation

The 'Contextual Observation' group captures the deeper understanding of the users (primary and secondary) and their environment. Three sub-groups were drawn from the data: 'Environment', 'Primary Users' and 'Secondary Users'.

3.2.1 Environment

Internal (home) environment - '*I want to access entertainment/ news etc.*'
One carer described how her dependant was '*lost without*' his environmental control unit when out of his house environment. Users reported a higher reliance on their environmental controls when sedentary (often in the home environment):'*I don't miss my Possum when I'm out really, I only miss it when I come home*'.

This individual used to be in the Army and was – in his words – '*an addict*' for the news, so the environmental controls enabled him to access the outside World when home. The importance of accessing entertainment when home is highlighted in the 'Important Functions' section.

External Environment - '*I'd rather be out and about than confined in the home.. I want to travel*'
The majority of those interviewed discussed how important it was for them to be able to go out of their home environment. However for all of them, when out of their home environment they have a higher reliance on their carers. As one interviewee said when asked about having portable EMG/wireless sockets to run devices when away from home: '*I think across the board people would find that useful because it's having to rely on people all the time and that's the problem you have you can't always get*

the help for people to rely on and whatever help you need you have to pay for as well, so anything you can do independently is a bonus really'.

Conversely some users describe how they would not take any environmental units on holiday because of the fact they would have increased care anyway, and because the units are bulky and need configuring to new electrical equipment. '*I wouldn't take that.. didn't take it last time..I wouldn't go on holiday by myself so it would be with [my wife], I mean [she] came and our eldest daughter. So really anything that needed doing, they were able to do'.*

Being in an external environment often means a <u>new</u> environment. This brings with it the problems associated with adapting to this new environment and the lack of usual switches:'*when I was on holiday quite a few years ago.. my first few nights there were a nightmare because I kept waking up to touch the mouthpiece with my mouth to either turn the fan on or the fan off and I didn't have it there. So it was having .. my mum or my carer, or my friend who was with us on holiday to turn the fan on because I was warm'..*

New environments may also bring issues of new climates, and weather: '*During the winter.. go out somewhere, can't stay out for long, because hands get too cold, and won't be able to drive wheelchair at all'* – this is an example where an EMG switch might be highly beneficial; conversely:'*I've found when speaking to other people who are tetraplegic, the weather can play havoc with your muscles.. and how tense you get as well'.* So this would need careful consideration.

3.2.2 Secondary users & carers -'*I need 24 hour care. I always have someone in the house with me'*

The sample interviewed was made up of individuals requiring 24 hour care. Carers in all cases were responsible for setting up the technologies or positioning them on the user (e.g. wireless headsets for phones, chin switch bars). With this come challenges in the confidence of the carers in setting them up: '*They're terrified, they won't even touch my.. Companion..[environmental control unit] They pick it up, plug it in and put it down. And then.. as they are about to pick it up I set it off! 'Oh!' [they say] .. [and]put it down. 'What have you done now?', I say, 'Oh God knows what you've done now!, make them feel guilty as usual!'*

In all cases carers provide backup when technologies fail: '*[do you find it frustrating then that you can't use the Possum?] Well I don't find it frustrating as such, because there's always people around'.*

3.2.3 Primary users

Motivation -'*I am motivated to use environmental controls'*

The motivation levels of users appeared to vary from our sample. However, one interesting finding was related to the 'effort-to-benefit' trade-off for using technologies; that is, *the effort of using an assisted technology is sometimes more than it is worth for the user when they have somebody there who can do something for them, who can probably do it quicker.* An example of where the effort may be more beneficial is when the user wants more privacy/ independence and will therefore be more motivated to spend more time and effort on a task. A number of the younger interviewees found using an iPhone beneficial for these 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 – The use of environmental controls enabling an element of independence; with a particular emphasis on being able to use the phone when a carer is out for a brief period. The internet is clearly a massive enabler particularly for a number of users using it for communication (email, Skype).

Degeneration - '*I still want to use my devices although my condition is getting worse'*

A number of users had conditions such as MND, and were prone to <u>involuntary twitching</u>. One user described how: '*it works around various muscles and it started off with my legs ..They don't twitch all the time but sometimes, as I was explaining using the mouse, sometimes my finger will twitch and I click on the wrong thing'.*

In addition some conditions leave the individual <u>hypersensitive</u>. One interviewee who was injured leaving him tetraplegic described how he had no feeling from the pectoral region and down, so everything else was hypersensitive. So he said any EMG switch interfaces would need to be as small

as possible. Tiredness was reported for tasks such as using a computer for a long time (e.g. typing with a splint for an hour).

Independence - *'I want to be independent but still want carers/ rely on carers'; 'I want to be independent'; 'I want to be safe inside and outside the house (including travelling)'; 'I do not want to be patronised'.*

There was evidence of motivation driven by the need for 'normality' from a number of interviewees. A mother of one of the interviewee's explained that she thinks '*it is better to have less equipment… [at home].. it ceases to be a home*'. Another example was the 19 year old adult with MND who didn't want to have 'straps' holding him in position on his chair.

Privacy – the use of wireless headsets as part of telephone units enabled individuals to have private conversations.

A number of those interviewed described their need for independence in terms of being able to travel outside of their home on their own. When asked if they would like to take their existing (or future) technology with them, they described how they would feel vulnerable. There are issues of the technology breaking leaving the user stranded, or worries concerning expensive technologies being stolen if the user is outside on their own. A couple of users said they would be concerned that technology such as a tablet PC or other device could be stolen from them if on display.

Independence and self-esteem was described as being reduced when individuals are 'tied into a World of Care', according to the mother of the 19 year old with MND:'*It's … because we're here you see, you know… so he always has to ask… It's always.. a question of you have to ask somebody to do it. You can't just go to the toilet, you can't just phone somebody. You always have to [ask] can you do this for me? And I think .. [he] finds that quite difficult*'.

For one user the incorporation of his puff/blow switch to enable him to independently drive his wheelchair led to the problem of him not being able to talk whilst driving:'*I can't talk with the sucking pipes, the suck and puff mouthpiece and that, it stopped me from talking so much*'.

3.3 Voice of the users

The 'Voice of the Users' group hones in on the issues affecting the design of any assisted switch technology, which feeds directly into the design specifications/ recommendations for EMG switch design. The sub-categories include: 'Users gaining control of their environment'; the requirements for a 'bespoke design solution' and the issues that 'make the difference' (in terms of 'delighters', i.e. they are more likely to be a 'delight' to the user rather than fulfilling a standard need).

3.3.1 The user gaining control of their environment

Important Functions - '*I want to be safe'; 'I do not want to be bored'; 'I want access to the outside World*'

As expected, the top desirable function to be activated by an EMG switch was that of an emergency contact. Second it was the phone in general; third was interesting, as it was entertainment. This reflects the observations made concerning switches in the home environment, and the importance of being entertained when more sedentary at home. Finally the adaptation of standard technology was described. This refers to previous observations made in the EMG Design section.

User control (of kit)- '*I want to be able to reach and use technology consistently*'

Discussion of existing assistive switch technologies demonstrated the importance of repeatable positions of switches. Unreliable positioning led to inoperable activation. One suggestion was that EMG switches could be used as an auxiliary switch to drive locating devices like a chin bar mount back to a 'home' positions if knocked out of position. Furthermore the ability to personalise/ adjust specialist kit was seen as a benefit; for example: one engineer programmed their own voice on a standard environmental control unit. Another example was an iPhone Application used as a communication aid, where the healthcare engineer programmed in a number of statements that were played when the buttons were pressed. There did not appear to be a way for the user or the carer to add additional buttons.

Customising switches – The clinical engineers described how they always have a choice of switches that they might like to put in: '*always a tricky one trying to find the right position. Everyone is*

individual'. A number of users said they would benefit from switches that could have the activation force altered to make them easier to press as their conditions worsened.

Enabler - '*I want to interact with my environment*'

Users interacted with their environments in a number of ways in addition to environmental control units. One surprising observation was the prevalence of what will be called '*Heath Robinson*' enablers. These were examples where either the carers of the individuals or the allied healthcare workers adapted equipment to enable individuals to interact with their environment. For example, one interviewee who used his chin to activate switches, had a device which essentially comprised a mouthpiece with an attached stick on the end that the user could then use to push a standard computer mouse around. The end of the stick had velcro attached, which affixed to a velcro pad on the mouse for traction; he was also able to operate an iPad using this stick device;

Additional enablers were seen in the form of 'software enablers' for example on-screen dwell keyboards.

3.3.2 Bespoke design solution

Design of Switch - '*I want to be able to activate it*'

Surprisingly a number of standard switches were described/ demonstrated as being difficult for the user to press. For example:

- Standard switches on adjustable beds are too hard to press, similar to those on the standard wheelchair function units;
- '*Some more difficult to press. If they could be easier to press. If he has to reach a bit [he] find[s] it harder to press*'. A number of users struggled to press the buttons;
- One user had to lift his hand with his thumb, so that he could then use the switches;
- Lack of comfort – leading to discomfort in using the technology. Examples were given with the puff/blow switch boxes that are a pager-type and belt worn. They were described as 'indiscrete' and haven't changed in the last 20 years. Any switch boxes or ancillary housings for an EMG switch must bear in mind the comfort of the user. One user said that if he's not comfortable with the switch set-up then he 'just sort of relax[es] and won't use the controls';
- Customisation of switch operation – The ability to adapt switches in terms of how they operate came across as important; so being able to activate different functions using a variety of activations offers the users more control (long dwell, short dwell etc. for an EMG switch).

Position of Switch - '*I want to have constant and comfortable access to my switch*'

Users require:

- Consistent access to their switch(es) – positioning of user's hand/arm – a key issue for interviewees was the need to be able to access their switches comfortably and consistently;
- A number of users describe how they have to be positioned in order to be able to reach their switches, and when they move out of reach. This leads to another issue of 'inconsistent positioning of switches' by different carers. Once in position, it is difficult for users to access other things: 'Yes it is. He can't really move his arms away from that position';
- An EMG might overcome this issue. However a number of users described how they move a lot when asleep; a limitation for any EMG switches in bed potentially?
- Switches can also move out of position during use, e.g. wheelchairs going over bumps and switch mounts moving;
- Improved grip made a big difference for some users, e.g. on the suck/blow pipes. A few users required help correctly positioning their hands; it would be highly advantageous if there was a way to help them adjust the switch position. Again, EMG switches may overcome this need.

3.3.3 Making the difference ('Delighters')

This collection of issues describes what we have termed the 'delighters' in terms of use. This term is used to describe those unmet needs that are not necessarily essential to an environmental switch design, but would make the users 'delighted'; they can be seen as a 'bonus' to basic requirements.

Communication - '*I want to be able to communicate inside and <u>outside my</u> home*'

- Communication
- Emergency contact – Linking the EMG switch to a phone/ auto-dial on a mobile speaker-phone.

The 'delighters' part here is being able to communicate outside of the home; for example, the 19 year old with DMD and his mother were told that a walkie-talkie might fulfil this need. Clearly this would not be appropriate for a user with limited hand control, and the range would not be enough for him to travel far.

Risk - '*I do not want to be left vulnerable*'

Current environmental control units are large and bulky in comparison to, say, modern tablet computers. There is the risk of breaking them and then being without the environmental control units. This ties into the comments about transferable units/ mounts. A number of users didn't want them on their chairs because they are quite bulky. One user described how '*sometimes your carers can walk into [it] or you can drive into a door frame. I didn't fancy smashing it up really*'; so this user positioned his unit on a worktop with a switch, so he could drive over to it. He did not want to risk breaking the unit and then being without it overnight or for a few days. Another user didn't want it on the chair because they go out a lot, and they didn't want to risk wear and tear on the unit as it's taken off and on the chair.

- Safety – a number of users describe their desire for independence, however this needs to be coupled with a feeling of safety. If they have an expensive-looking electronic device on their chair/ lap when out and about then they would worry about it being stolen.
- Occasional illness– The 43 year old cervical cord-injured user described how he had had*: '..an ear infection a couple of weeks ago .. and I've not walked round for like twenty-one years.. you feel when you have an ear infection when you lean can't you. And I was driving my chair the other day and .. I thought I'd had a stroke, I thought something was really wrong*'…. So an EMG switch help when the user's position changes due to illness. The switches they usually use may not be as easily accessible as usual.
- Any EMG switch would need to prevent against accidental switching – Users gave examples of pets setting off units, control boards falling to the floor etc.
- Aeroplanes/ airports – although less related to specific switch use, users reported problems when travelling with expensive and large wheelchairs, which can have associated environmental control units on. There is the risk that if they did have environmental controls mounted on their chairs there would be the fear that they would be damaged in transit: '*..dad has to then think… take all sorts of bits and pieces off the chair because . and he's go that and, you know, to try and get somebody to do that and take them in to the plane with him because some things can't be left on the chair because they'd just get smashed*'.So although many users enjoy travelling, the whole airport experience was reported as very difficult in terms of the assistive technologies they use.

Aesthetics- '*I don't want to look disabled*'

A number of the users – mainly those in their late teens / early 20s commented on the aesthetics of the environmental switches they are using. One example was a young man on constant ventilation, who had large black straps holding the nasal pillows in position. As his mother said in relation to the colour of the switch: '*sometimes you want it 'flesh-coloured, not stand out.. otherwise might as well have a flashing light on the head*'.

Another young guy declined the use of strapping to keep him in a position, which would have looked like restraints.

Environmental control unit size – refers to being able to use a smart device which would be far smaller than using the standard environmental control units. Easier to travel around with etc. An EMG switch could be used to run a 'cross-hatch' over a screen.

4. Discussion and impact

This study has demonstrated a user-centred methodology for understanding and analysing the requirements of the user needs of a specialist assistive user group. The output of these findings have been developed into a product design specification built around the user perceptions of environmental

controls and how they might adopt EMG switches should their condition worsen. The PDS forms the basis of the design blueprint for the development of a working EMG prototype.

The data is limited to a sample of ten assistive switch users (including a number of carers). In order to provide a reasonably representative sample and a range of user experiences, they were selected according their functional ability and use of switches (i.e. some were new users to the use of switches, others had used them for many years). To overcome professional participant bias, the lead interviewer was from a non-clinical background, and the second interviewer mainly provided reassurance and support for the interviewee.

This report has discussed the method used to gather and analyse data from ten highly disabled assistive switch users. An analysis of the data has been provided, and this data has been used to revise the initial Product Design Specification (PDS) to include user input. The final PDS is being used to inform the development of the final EMG switch for this project.

Key findings of this research were users' emphasis on the importance 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 et al. [2009]. However, there was also the revelation that in some cases the effort of using an assisted technology was '*more than it is worth*' in terms of the benefit they gained; the explanation being that it was just as easy to have a carer there who can do it for.

Furthermore this research has shed more light on the actual appetite for EMG switches amongst potential users; the majority of users seemed more interested in being able to access 'smart' technologies from their everyday switches. Without the UCD approach adopted in this research and resultant findings, the clinical department would have continued to priorities the development of EMG switches, producing devices with a limited uptake of users. This is very important in terms of the department allocating scarce resources to the most beneficial areas for patients.

A structured approach to data gathering using qualitative research methods has provided rich information into users' perceptions of their assistive switch needs, which will inform the design of early EMG switches in a clinical environment.

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