

Universal Design and Technology for Older People

A Survey Tool for Assessing Technology Design for Older People, in-situ, in an Irish Context

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EXECUTIVE SUMMARY

Purpose

The purpose of this study was to develop and test a Universal Design Survey Tool for assessing older people's use of everyday technologies in Ireland. In particular the researchers wanted to incorporate cognitive and memory abilities of the user into the Tool as these aspects have not been considered extensively to date in the existing tools in the literature.

Scope

The tool developed was applied in the homes of 30 older people in the Liberties Area in Dublin 8. All were over 65 years of age and most live alone. The cohort chosen are users of a "pendant alarm" system: a button worn on a pendant that can be pressed to call for help in the event of an emergency or need for assistance. In each home visit, the Universal Design Survey Tool developed was used to assess the pendant alarm technology and one additional technology identified as difficult to use. Difficult technologies were mainly IT, communications or entertainment devices such as laptops, mobile phones, radios/cd players, DVD player, TVs and set-top boxes but also included gas fires and cookers.

Study Context

The Irish Longitudinal Study on Ageing (TILDA) is the first longitudinal study in Ireland and has collected representative data on older people in Ireland including cognition and memory impairment, anxiety and depression, disease prevalence, and proximity to family members - amongst other information. All these aspects of ageing have a potential bearing on technology use. There are a number of studies taking place in Ireland on technology usage by older people, primarily in the health domain. A significant area of investigation relates to connected health including chronic disease management in the home (e.g. diabetes, Chronic Obstructive Pulmonary Disease (COPD), Chronic Heart Failure, etc) Older people are more likely to be users of such services. Technology deployed to support "ageing in place" needs to be designed appropriately for older people to use.

There appears to be a significant technology 'knowledge gap' between older and younger people. The degree to which this gap is directly due to the ageing process isn't entirely clear. It's possible that the evolution of older people's exposure to technology is also a factor. Younger people have an advantage in terms of more continual exposure to the rapidly developing lexicon of technological symbols and usage models. Certainly, in this study we noted older users had little exposure to technology in their working lives or that they had worked at home their whole lives. Some older people in the study had used the same technology such as a radio for years without knowing many of the functions of the device. They were able to "make do" with what they

knew and this may have led to the finding that the older people tended not to be forthcoming with a technology they found difficult to use.

Background and UD Survey Tool Design

A literature review on the capabilities of the older person was carried out with an emphasis on cognition and ageing. A number of design considerations are made to address, for example, decline in the speed of information processing and a reduced capacity for working memory. A number of questionnaires exist in the literature which are based on the Universal Design principles and guidelines. It was found that no single off-the-shelf tool was suitable for this study and that a hybrid of over 5 tools was needed. In particular, the design aspects for this tool included the following:

1. The questions are aligned along a task sequence – from pre-use (e.g. reach) of the device, to its use (e.g. pushing a button), to post-use (e.g. satisfaction). This was done to facilitate ease of navigation by the interviewer and allow for a natural progression between different subtasks of the main task. It considered the user's approach in coming into contact with the technology and their implementation of the task and how they reflect on the experience afterwards;
2. Rephrasing of questions in the existing questionnaires since some of the existing questions were found to be hard to understand;
3. A combination of questions in the existing literature – questions were taken from multiple tools to incorporate the different phases of product use;
4. Questions were included which addressed the abilities of the user;
5. Inclusion of user experience and impression questions which may affect future use of the product;
6. A grid design of the questions for ease of navigation. The researchers also created a Survey Tool Pack (given in Appendix A) for ease of use and re-use of the tool.

Pilots and Tool Adjustments

While a theoretical approach was used to design the first prototype of the UD Survey Tool, three pilots tests were implemented to improve the design of the tool and to allow the researchers to determine which questions should be included, removed or rephrased. The pilots also helped the researchers to reorder the questions, consider alternative ranking scales (settling on a 3-point scale), and redesign the tool for collecting data from the interviewees with ease. Two options for this data collection were given – a long format for detailed responses or a shorter format on a single page for quicker navigation. Both were found to be useful. A number of questions were added at this stage

to gather demographic data on the user's experience with technology and contextual data for each specific technology. Contextual questions were included which, for example, assessed the motivation the older people had in purchasing the technology and where and when they used it. This informed the observation process for the researcher while watching the user perform his/her task with the device – e.g. sending a text message on a mobile phone. From the experience in the pilots another significant adjustment to the tool was the replacement of many of the direct questions related to the use of the device with observations made by the researcher. The user's responses in the pilots to direct questions were sometimes found to be unreliable with significant self-reporting bias. It was found in some instances that answers to direct questions did not align clearly observable experience or conversational responses. For example, one user who had responded that they were not embarrassed when using the pendant alarm made a clear reference later in the interview that they would not be seen wearing it. Direct questions were however employed during the use phase (alongside observations by the researcher) to maximise the data that could be captured from the user performing the task.

Assessment – Main Issues facing Older People in using Technology

The Tool as designed was found to be suitable for use by both a usability expert and an engineer with design experience.

The tool was able to generate some quantitative scoring of the relative difficulties the users had, and the qualitative data captured uncovered many design issues that the users struggled with – such as buttons being the same colour as the device casing. Contextual use of the device was also found to be an issue for the older users; for example, where reduced mobility and dexterity made it difficult to reach down to and operate a DVD player placed at a low level relative to the ground. A number of possible developments of the Survey Tool are suggested to incorporate this context of use into the questions where perhaps “reach” would not only apply to the device's features and functions relative to each other but relative to the user's normal posture and position when attempting to use the device.

One major finding from the pendant alarm technology was that the older people assessed were mostly unsure or unaware of what steps would occur after they had pressed the alarm button. While most were sure that contact would be made by an Agent from the monitoring station to their house firstly via the central base unit of the pendant alarm system and then via their landline phone; they did not know what would happen if they couldn't get to the base unit or phone to answer the call. Some mentioned they would have to drag themselves somehow to the phone or perhaps if they couldn't then they would be “left to die”. In reality there are a sequence of other steps performed by the pendant system such as contacting neighbours and An

Garda Síochána. These steps were largely unknown and opaque to the user who had no understandable feedback from the system as to what was occurring. A number of design suggestions were given by the users such as to have a microphone in the wrist worn pendant so they could speak to the Agent from anywhere in the home and not just when in close range to it.

It was found that many of the designs that older users struggled with in their “difficult technology” made no allowance for user’s lack of technical knowledge or exposure. Some of the designs were found to be extremely poor and it is likely that other user groups would also have had difficulty with the technology. For example, some devices lacked labelling or feedback which are violations to basic usability principles.

Recommendations

The authors have suggested a number of follow-on projects to address the accessibility and acceptability of the Universal Design principles and guidelines to product developers such as designers and engineers. These are:

- 1) A large national study on technology use in Ireland by older people in their homes and considering how these technologies meet or don’t meet the Universal Design principles and guidelines;
- 2) An extension to the Universal Design Survey Tool (Universal Design Pre-Fabrication Tool, (UD-PFT)) to address and assess designers of products for older people and to investigate if the extended tool could be useful for designers in developing products to be more easily understood and used.
- 3) Development of an adapted tool and process for linking product features to Universal Design principles and guidelines to make designers aware of the potential impact of each component of their design on Universal Design. In this development, the Universal Design principles and guidelines would be intrinsically linked to product features and these features would have different weightings (relative impact on the overall design) which would be informative to the designer. If, for example, the designer wants to change a certain feature such as the colour of a button, they could look up (in a table) the relative impact of that design change on Universal Design. This tool would allow designers to implement Universal Design principles and guidelines via “weightings” of the product features which they would be more familiar with. Potentially, this approach could increase the accessibility and acceptability of Universal Design principles and guidelines for product developers and improve Universal Design in product development as a whole.

CHAPTER I: INTRODUCTION, STUDY PURPOSE AND MOTIVATION

This study investigates the use of technology by older people and how Universal Design (UD) can help in accommodating the older person's design needs. The main qualities of UD products are ease of access, understanding and use. With a globally ageing demographic, a deeper understanding is needed of the role and application of UD in improving older people's experiences of technology.

It may be argued that general design guidelines for developing technology for older people are reasonably well developed with respect to accommodating for decline in visual ability, hearing and haptics. The decline of cognitive abilities receives less consideration when providing design solutions for older people. Universal Design principles and guidelines do provide guidance on cognitive aspects of use and as such may help a designer to improve and optimize designs not only for visual, hearing and haptic impairments but also for decreasing cognitive ability for older people interacting with technology.

As part of this study, a UD questionnaire was developed and piloted with older people in their own homes. The tool is intended to allow researchers explore the extent and quality of UD present in a technology used by an older person. The study built on existing tools from the literature for assessing Universal Design in consumer products, but also addresses a number of shortcomings in these approaches.

The tool was piloted with a cohort of older people in the Liberties Area of Dublin 8. All participants have received home technology packages through SICCD (South Inner City Community Development Association), a local community organisation. Users are eligible for the technology packages if they are >65yrs old, living alone (or with someone also eligible), and deemed unable to afford the devices themselves. The packages are intended to provide peace of mind and to help facilitate independent living, as the majority of the users live alone. The packages all incorporate a pendant alarm system. If the pendant button is pushed, a 24-hr remote monitoring service is alerted.

The survey tool is used to discover the extent and quality of UD present in the pendant system. Furthermore, the same tool is used to assess general consumer products that the older users self-select as being "difficult to use". The tool is also used in a qualitative exploration of the older people's experience in using the products in their homes. This will uncover vulnerable periods of use of the products and perhaps uncover aspects of use at different times or contextual situations.

Outline

In this report, the **“Study Context”** is addressed in the following (second) section – that is, the specific context of older people and technology utilisation in Ireland. In addition the value of technology to older people is considered.

A literature review is reported in the (third) section **“Literature Review”**. As will be described, the review considers both UD survey tools and cognition changes in the older person. The latter element is required since the Universal Design survey tool developed here will have an emphasis on the cognitive domain of older people. This is an aspect which has not been considered extensively in the existing UD survey tools in the literature. It will be seen that no single off-the-shelf Universal Design survey tool was appropriate for the current study's purpose and so a hybrid of available tools was developed. The main pros and cons of the existing tools are outlined and the rationale for adopting elements of these tools for inclusion in the final survey tool for this study is presented. Movement and sensory abilities of older people are also briefly considered to help address how decline of such abilities with age may affect their use of technology.

The actual tool design for the current study is described in the (fourth) section entitled: **“Current Study Approach – Survey Tool Design and Methodology”**. In addition to cognition, the tool expands on current tools by incorporating an additional category of product use to address user perceptions and user experience. This aspect of the tool considers if UD principles alone are sufficient to motivate the user to use the product. The tool includes questions which assess the pre-use phase of “Perception of” and “Understanding” a product. This section also reports on the need for some experimentation by pilot studies in the homes of older users, as a means of validating the approach and final tool design. Finally, the methodology for using the tool is described.

As will be described later, there were three pilot studies to be carried out to test the pilot test survey tool. This allowed the researchers to adjust the design and incorporate new dimensions and style of questionnaire layout. The changes made after the pilots are described in the (fifth) section - **“Survey Tool Pack Changes to the Pilot Test Tool”**.

Mixed methods data analysis is considered in the (sixth) section: **“Mixed Methods Data Analysis”**. This is followed by the (seventh) section **“Discussions & Conclusions”**. The final **“Survey Tool Pack”** used by the researchers in this project in the real-trials is given in **“Appendix A”**.

CHAPTER 2: STUDY CONTEXT

Study Context – Older People and Technology in Ireland

The current study assesses the interaction of a specific group of older Irish people with technology. As such, it is important to consider the Irish context in relation to older people and relevant studies in Ireland considering technology use in-situ.

Research on Older People in Ireland – A longitudinal perspective

The Irish Longitudinal Study on Ageing (TILDA) is the first longitudinal study on ageing in Ireland. It is a representative study of people aged over 50. Participants in TILDA are followed longitudinally over a ten year period, allowing their health and social circumstances to be tracked. More than 8500 people participated in the 1st wave of TILDA. TILDA involves an extensive face-to-face interview and questionnaire, with participants taking part in a health assessment session either in their own homes or at dedicated centres. While TILDA is not directly concerned with the use of technology by older people, it does provide a wealth of data relevant to the context of technology use. For example, industry or researchers in the connected health and assistive living space can draw on TILDA data to better understand the broader concerns and perspectives of older users. Findings from TILDA [1] of particular relevance to this study are summarised here.

TILDA reports that 75% of all adults over 50 live in close proximity to at least one of their children. Potentially, this support network may enable the older person to learn about and discover new technologies through their children. However, it may also be the case that this network may lead older people to rely on their children to operate or set up technology rather than attempting to read manuals or “have a go” themselves.

Discrepancies between self-reporting and objective measures of health were found in the study. For example, 58% of men and 49% of women with objective evidence of hypertension are undiagnosed. This shortcoming could be addressed by technology in the home where for example, daily blood pressure measurements could be taken and forwarded to a health monitoring station which could flag dangerous static or dynamic changes in blood pressure. Such technology and solutions do exist [2] but they have not received widespread acceptability. Nevertheless, chronic disease management (such as monitoring of blood pressure or diabetes) has been suggested by some marketing experts as having the most potential in terms of market uptake of connected health solutions. [3].

One in five adults in Ireland over 50 take five or more medications. A significant proportion of older people are then regarded as ‘polypharmacy’

users, with an unquantified but potentially negative impact on their cognitive and physical interaction with technology.

TILDA has provided both self-reported and objective measures of cognitive function on the cohort of the over 50's. Cognitive impairment rises sharply with age with 35% of the over 80's being cognitively impaired compared to only 4% for the 50-64 age group. Memory impairment was also an issue, with 42% of the adults over 80 years old, forgetting an action they were asked to perform earlier in the assessment. Such cognitive deficits have implications for learning to use technology and are of particular concern with respect to technologies designed to support independent living, such as the pendant alarm considered in this study. Typically the engineers who install these devices only give the user a single explanatory session on how the pendant works. With memory impairment the user may not retain this information and not actually know how to use the device. In addition, there is potential for user confusion in carrying out the steps necessary to successfully activate an alarm and contact a call centre.

TILDA also found evidence of under-reported and untreated depression, with 78% of those with objective measures of depression, not reporting a corresponding medical diagnosis. A similar picture was found for anxiety where 85% of those with objective measures of anxiety not reporting a medical diagnosis of same. These mental health issues may have an impact on the older person's perspective on technology.

The prevalence of disabilities of those over 75 is nearly at 30% compared to less than 10% for those 50-64 years old and may have a negative impact on technology usability in older age.

Financial constraints are likely to have an impact on older people's uptake of technology and their perception of technology as a luxury or necessity. TILDA reported that the average weekly household disposable income is 767 Euros for over 50's but around 50% live on less than 400 Euros per week. In addition, over a quarter of older adults rely on state transfers as their only source of income. Financial status has been shown to correlate to education level.

Health assessment data from TILDA has identified some areas where home based technology may be of benefit in reducing risks for older people in the community. For example, undiagnosed heart arrhythmias have been shown in TILDA to be relatively common in the older population. These arrhythmias are known to be related to an elevated risk of stroke. Simple technology deployed in the home or community to uncover these risks, or other risks such as elevated blood pressure, may have a positive health impact. Such systems for use in the home will need to be designed for the older person or designed for all if they are to be accepted by the older user.

Technology and Older People in Ireland

A work [4] was commissioned by Enterprise Ireland in 2010 to document the academics, clinicians, and businesses involved in connected health. Connected health describes the use of all information and communication technologies (ICT) in the field of healthcare to improve quality of care and health outcomes [4]. The report was updated in 2011 and illustrates the extensive network of stakeholders involved in connected health across the entire island of Ireland.

The report notes several studies where technology has been deployed in the home to support older people to live independently. These include systems which monitor vital signs and other biomarkers for signs of disease or degradation of health. For example, blood pressure, heart rate, respiration rate, body temperature, weight, blood sugar, blood oxygen saturation, and activity patterns (using PIR sensors in the home) can and are being monitored in the home and uploaded to central monitoring centres which can have automated systems in place to flag abnormalities or undesirable changes in levels for a particular older person.

Chronic disease management (such as diabetes) is expected to be a significant area of investment in the coming years. Therefore, it is important that systems designed for in home (in-situ) adhere to principles that cater for all – that is that they are universally designed. The tool being developed in this research would potentially allow the developer (with usability expertise) to assess the design from the point of view of the 7 universal design principles.

There are a number of groups and studies listed in the Connected Health report [4]. Three significant studies relevant to technology in the home include TRIL, CASALA/The Netwell Center and VHI HomeCare.

TRIL (Technology Research for Independent Living) was set-up to iteratively develop culturally appropriate technologies that enable older people to live independently at home by including ethnographers in their research team [4]. CASALA (Centre for Affective Solutions for Ambient Living Awareness) has an installation of 16 smarthomes fitted with sensors and ambient assisted living technologies to support independent living and collect data from residents they have living there. Their founding Centre, the Netwell Centre, implemented a telehealth initiative in the homes of older people with a system which provides information and motivation for health management of chronic diseases such as diabetes. The installation provided data to be sent to a 24-hr monitoring centre with triage staff to monitor the health status of the resident [5]. Finally, VHI is a health insurance provider having the largest proportion of older people as customers in the health insurance market in Ireland. It provides hospital-like in home treatment to patients who have been deemed suitable by their consultant and the VHI team assigned to the individual case. These typically require intravenous therapy and include conditions such as cellulitis, chronic obstructive pulmonary disease (COPD), pneumonia, respiratory tract infection and others [6], [7].

General Technology Focus of the Current Study

While much of the research into technology in the home in Ireland is concerned with assisted living technology, telecare, and telehealth the current study is more focused on general technology in the home that the older people use. This typically includes entertainment devices such as TV, DVD players, radios, and communication devices such as the telephone and mobile phone. Cooking and cleaning devices are also expected to be among the main technologies explored by the user in their home as being “difficult to use”.

Study Context - The value of technology in the older population

Loneliness and associated conditions such as depression and anxiety are very prevalent in the older population and decrease the older person’s quality of life. While depression and anxiety is common in older people, TILDA identified that 78% of those older people, who showing signs of depression, nevertheless go undiagnosed. In addition, the number of undiagnosed cases of anxiety is even higher at 85% (for those showing signs of anxiety). Lehto and Tekniikka (in [8]) found that technology, by providing new stimuli in the older person’s life, provides an opportunity to prevent isolation of older people and has the potential to enable them to be more independent and would have a positive impact on depression and anxiety. Technology also has a positive effect on increasing social interaction and provides older persons with a sense or feeling of pride [9], self-esteem [10], life satisfaction [11], and perceived autonomy [12].

Technology for the older population demonstrates a wealth of advantages. It has the potential to counteract loneliness, isolation, depression and anxiety by potentially enabling older people to communicate and keep in touch with friends and relatives using, for example, e-mail and computer applications like Skype. It also can give a sense of safety and security by providing home health-monitoring systems which can alert relatives, caregivers or a doctor when something is wrong with the older person. Technology can also intervene when the older person has forgotten to turn gas, provide carbon monoxide monitoring detectors, and can help prevent falls by providing systems which provide better home illumination etc. ([13] in [8]). However while technology may be seen as enabling for the older generation it also can provide an enormous barrier.

The Technology Barrier

Mobile phones are frequently used by older people and the number of older people owning a computer is over 40% for the US population over 65. Yet, despite these reported numbers, it still remains challenging for the product developer, the designer or engineer to develop products which can be easily accessed, understood and used by older people.

First and foremost many older people experience a decline in functions, which may impact and negatively affect their use of technology in an effective and efficient manner. The prevalence of disabilities of those over 75 is nearly at 30% compared to less than 10% for those 50-64 years old. Impairments of the visual system include reduced visual acuity, contrast sensitivity, peripheral vision, motion perception, colour perception and experience of glare. Decline in hearing affects absolute sensitivity, frequency and intensity discrimination, sound localization and speech recognition. Touch and movement and cognition are also negatively affected.

Physical, perceptual and cognitive abilities are involved in engaging in product use - from preparing to use the product or service - to the actual use of and interaction with a product or service. Consequently, systems which are designed for the older population will need to be designed to be easily accessed, used and understood, to demonstrate the described benefit and to be accepted by the older user.

While product developers have begun to address the physical functional limitations of the older persons (such as visual decline and loss of hearing) cognition has not been sufficiently addressed in products and services intended to be used by all. While it is thought to be common knowledge that older persons have poor memory and a decline in cognitive functions in general, this is little considered when designing for the older population. The barrier for older people using technology may be considered as the gap and mismatch between 1) how product developers understand and interpret technology and associated functions in designing new products; and, 2) how older people perceive those products and associated functions in relation to their differing abilities.

While there is undoubtedly a decline in cognitive functions as one gets older, it is nevertheless of interest (for product development) to identify:

1. How much this decline actually does or does not affect the older person's ability to successfully engage and use technology; and,
2. How much impact context of use and environmental factors have in determining an older person's ability to interact and use technology successfully.

Comparison to the Younger Person

Environment and context is primed by the younger generation. Younger generations have grown into the internet and computer/smart phone use. As such, learning how to use a new device or software is a relatively easy task as a younger person will most likely be familiar with, for example, previous software versions or previous mobile phone models. Consequently, a younger person is only required to learn a relatively small amount of new content to be able to operate a new system or software adequately.

When looking at the older population the situation changes. One could for example consider the anecdote of an older person in their mid or late 70's, who decides to buy a laptop computer to communicate and keep in touch with their relatives who live abroad. If they have worked in a job which did not require interaction with a computer they have never had the opportunity to familiarize themselves with the software, the operating system or interaction styles such as icons before. If they had, having retired 15-20 years ago, they may not then be able to update their mental model of how computer software works or appreciate its development in this time period. For an older person starting to use, for example, the latest Microsoft Word version on a laptop may involve learning the package (including the concepts and icon coding MS Word uses) from scratch. Moreover, the person has to comprehend how a computer, an operating system and associated hardware such as a mouse works and can be used to operate such software applications.

This describes a much bigger learning task - one that not only an older person would struggle with but a younger person too.

“Decline” or “Knowledge Gap”

Seeing technology use and challenges of older people to cope with technology from this perspective raises the questions:

1. How much is decline, associated with ageing, actually responsible for older people struggling to use modern technology? and
2. How much actually stems from an older person's gap in knowledge which he/she would have to catch up with in a very short period of time?

Again, overcoming this gap would be an overwhelming task for anyone and not just the older person.

So while, for example, short-term memory tends to be worse in older persons than in the younger, and while research has reported some cognitive decline in ageing – nevertheless, again the question has to be asked: *How much and to what extent is cognitive decline during ageing responsible for the problems older people experience when interacting with new technology?*

Closing

It is this line of thought which will be explored more in depth in the literature review in the next section. A review of the literature related to cognition and ageing, how the different memory systems and how learning is impacted upon by ageing will provide answers to the above questions and provide the basis for researching strategies on how to improve technology for the older people effectively and efficiently, by addressing the right problems.

Once these are understood, some measure of the interaction and design issues older people have with technology is required. This measurement of the interaction of older people and technology has already been considered in

the literature in the field of Universal Design (UD) – which is in essence designing for all people. Nevertheless, available UD survey tools which assess the interaction of older people and technology relate mainly to physical abilities. We wish to also consider other factors such as cognition, memory, and understanding. We will also look at user experience and satisfaction.

CHAPTER 3: LITERATURE REVIEW

Introduction

The literature review considers three elements which are required in order to develop the UD survey tool. These are:

1. Cognition and Ageing;
2. Movement and Sensory Ability and Ageing;
3. Universal Design Survey Tools.

Literature Review – Cognition and Ageing

This part of the review aims to provide the reader with the relevant knowledge to understand and appreciate the older person's challenges when engaging with a product in the use phase. As such this review will concentrate on the cognitive abilities and challenges of older people during the use phase of a product, as the cognitive contribution to design can be seen as having been neglected and appears to be the most challenging for the designer to translate into product features. The review also aims to provide some insight into the ageing person's cognition and how design may accommodate for certain age-related cognitive challenges when using technology.

Literature Review Methodology – Cognition and Ageing

A systematic review of factors associated with cognitive changes in older people and how they to product use is challenging as the topic crosses several disciplines

The literature related to cognition changes does not address specifics of cognition in relation to product use - for example information presented or displayed by a particular product during product use. Cognition is an area of psychology, but intersects with other disciplines such as neuroscience. Publications on product design can be found in various disciplines, such as design, engineering design, as well as marketing. The field of ergonomics provides some linkage between cognition and product design. Ergonomics incorporates and borrows knowledge from many different disciplines in order to understand how users understand and learn new technology and how ageing might impact this process.

Finding the right search terms to locate relevant publications in field of ergonomics (which spans engineering, psychology, physiology, neurology, gerontology, etc.) is challenging. Different disciplines use different terminology when describing the same or related phenomenon. Searching for relevant publications requires some ingenuity and an intuitive expert understanding of search terms, as the same content may be described by different terminologies in different disciplines.

As these publications usually only represent a small niche in bigger disciplines, usually searches in mainstream databases related to medicine, engineering etc. yield few usable results and return an overwhelming amount of material but can miss small niche publications.

An example may serve well here. When the term “usability” is typed into Medline: 4570 research results are returned – many of them not remotely connected to the topic of our interest, all relating to medical fields, such as microbiology, pharmacology etc.

As such, the literature review in this section on “Cognition and Ageing” followed a hybrid strategy which aimed to uncover and detect the greatest number of publications related to changes occurring during the ageing process and how those affect the use of a product or service.

This hybrid approach was done using Google and Google Scholar to uncover and detect search terms which may be used to describe aspects of cognition with an ageing person when engaging in product use.

To be able to find relevant content, dissected and hidden amongst so many different disciplines the literature search was conducted using search terms (shown in the next subsection), selected based on expert opinion, on which factors may possibly contribute to usability challenges of older people using technology effectively, efficiently and with satisfaction.

Search Terms

- Technology use in the older persons
- How older people learn technology
- Attitudes to technology
- Inherent and apparent usability
- Effects of ageing on memory and learning in the elderly

A specific search on the following search terms was also carried out:

- Understanding and cognition with technology in the elderly
- Designing for technology for people of all ages

The following sections are a summary of the literature which was found to be relevant to ageing and cognition in relation to product use.

Main cognitive changes accompanying ageing

The process of ageing, when seen in context of cognitive function, is often accompanied by a decrease in the performance of, and a decline in, memory - specifically short-term memory. Research into the psychology of ageing has looked at cognitive changes, particularly cognitive decline ([14] in [15]). Salthouse [16] in [17]) refers to four important aspects described by the term “psychological ageing”. These are:

1. A decline in speed of information processing,
2. A **lack of resources**,
3. A **reduced capacity of working memory**
4. A **poor capacity for inhibiting irrelevant information**
 ([18] in [19]) and ([20] in [19]).

However, while ageing affects learning, the brain does have ways to compensate for losses by developing compensatory strategies to perform a cognitive task [21] - for instance “by reorganizing the aspects of a problem” [22]. Further, Fisk [23] found that more than 50% of problems experienced by older participants when using technology can be described as usability problems. So while older people experience challenges with technology Fisk reported that 25% of usability problems the older people experience may be solved by improving design, while a further 28% of problems may be solved by providing adequate training.

The impact of ageing on learning

Both short- and long- term memory is involved in learning. Baltes ([24] in [15]) and Horn ([14] in [15]) coined the term “fluid intelligence and crystallized intelligence”. The term “crystallized intelligence” refers to knowledge, including verbal ability and vocabulary, which was accumulated and acquired over the lifespan (e.g. cultural knowledge, linguistic competence). The term “fluid intelligence” describes the process of learning, in which working memory is involved (e.g. problem-solving, distribution of attention on multiple tasks). Baltes ([24] in [15]) refers to the fluid intelligence in terms of “the *mechanics* of cognition”, which can be described as basic information processing while crystallized intelligence can be described as the “*pragmatics* of cognition” (acquired cultural knowledge). According to [19], [25] fluid intelligence (controlled processing of information for example as evident during problem solving activities) declines with age. In particular the ability to retain and integrate new information is affected. The speed of processing decreases with age and effortful processing [25] is affected. Consequently it takes longer to process information [26]. Thus learning new technologies would be impeded by a decline in both performance and memory.

Ageing and Memory

According to [27] both types of memories (short- and long- term) are involved in the three stages of memory function.

The first step describes the **encoding of information**, i.e. learning and training, describes the process of putting things into the memory system. Learning refers to how things can enter the long-term memory and training to the efficiency with which something is retained in memory.

The second stage is **storage**, which refers to the way information is held in long and short term memory, for example mental models are stored in long term memory as well as declarative and procedural knowledge.

The third stage is **retrieval**, which refers to the getting of information out of memory. While sometimes information cannot be retrieved, other times it may be retrieved incorrectly, or steps in a procedure to be retrieved are mixed up due to the ageing process.

Attention and Resources:

Attention is necessary for carrying out a task. This task could, for example, be to solve a problem i.e. to understand how a technology or computer program works. Parasuraman [28] describe attention as a multidimensional construct comprising a variety of processes, which distribute resources amongst the different dimensions. The process of attention and resources used in an attentive task may involve selective and focused attention, divided attention and attentional switch, automatic and voluntary processing, sustained attention and vigilance. Attention can be understood when the **steps involved in an attention task** as well as the **cognitive resources** used in the process are reviewed and it is understood how these work in context.

Selective and Focused Attention:

Selective attention is referred to as the process of selecting certain information to elaborate on and filtering out the irrelevant information. Wickens and Andre [29] for example found that “the most critical variable in predicting performance is the spatial separation of relevant from irrelevant items, not the separation of irrelevant items themselves”. Thus to be able to separate relevant from irrelevant items, one has to differentiate and understand the meaning of the items to be able to select the relevant and ignore the irrelevant.

Ageing processes affect the flexibility during problem solving to select the correct solution, where incorrect solutions are chosen more frequently [30]. This is supported by [31] by suggesting for example that the ability loss in selective attention in older people is task-specific and related to previous experience with the objects used as targets and distracters in the task ([32] in [31]).

Rogers [31] suggests that the loss of ability in older people to use technology successfully is not a functional loss but one caused by the lack of experience, exposure to new content and gap in knowledge of the content to be differentiated, which is presented to the older people. Therefore, Rogers [31] suggests that “age related differences in selective attention can be reduced by increasing familiarity with the items manipulated and with cues that change the attentional need from selective to focused, which does not seem to show age-related deficits”. An example for this is the work of [33], who observed that

when older people were presented with cues about incoming hazards in a driving simulator, the older people's safety behaviour improved.

Divided Attention and Attentional Switch

Divided attention involves the allocation of available processing resources to two or more tasks at the same time, and/or involves the rapid switch between tasks [31]. McDowd and Craik [34] found that the effects of ageing on task performance are more pronounced with increased stimulus complexity, but which nonetheless can be decreased with an increase in the amount of practice of the task (for a brief review see [31]). Strayer [35] for instance, found that older people's reaction time was reduced compared to that of younger people when performing a dual task (talking on the telephone while driving) in a simulator.

Automatic and Voluntary Processing

Rogers [31] states, that automatic processing is not affected by ageing. Voluntary processing requires a certain amount of attentional resources and awareness. As older people are more easily distracted by task-irrelevant information preserved during the task (which may be linked to the increasing unfamiliarity with task objects of the older subjects) this affects voluntary processing with age (like fluid intelligence described earlier).

However, practice can reduce the unfamiliarity arising from a lack of exposure or gap in knowledge in technology, and consequently this can help older people to develop automisation procedures [31]. Older people, as demonstrated above by Strayer [35], are not affected in their ability of automatic processing. Fisk and Rogers [36] and [31] stress that the effectiveness of the older person's automisation routine depends on the kind of task they are engaged in. A visual search task for example requires attention and attentional resources even after long practice. However with adequate training, Jamieson [37] demonstrated that older people show no age-related differences when using a simulated Automatic Teller Machine (ATM).

Sustained Attention and Vigilance

Sustained attention means maintaining focus on the same task under continuous stimulation. Vigilance means keeping the focus on waiting for a rare event. Giambra ([38] in [31]) concluded in his review of past studies that reported results were contradictory with respect to the age-related deficits. Deficits were attributed to task-related functions which were not strictly attentive, such as the ability to discriminate a single stimulation and its duration, requiring working memory effort. Anstey [39] attribute age-related factors affecting driving performance to the reduced ability of sustaining attention, and the mental workload associated with it.

Working Memory

Working memory refers to the short term memory, which can be described as temporary, and holds a limited storage capacity to retain present and active

fragments of information over a relatively short time in order to accomplish a task ([40] in [41]). The processes involved in working memory function are central executive, phonological loop, visio-spatial sketchpad, and episodic buffer [42]. Craik ([43] in [44]) reported that the deterioration of the working memory in older adults is task dependent. The more complex the task is and the more steps required to complete a task successfully - the older people struggle to complete the task correctly. Reynolds [45] suggest that reducing the number of options and giving adequate time to present menu items, will reduce the demand for cognitive resources and information manipulation and thus could assist older people to successfully complete a task.

Long term memory

Long term memory is largely involved in the phenomenon of forgetting, for example when forgetting how to do something. In this respect two different memory types were mentioned in relation to the ageing process in the literature: the semantic and episodic memory. Semantic memory refers to the long term memory which stores general knowledge (meaning of words, concepts, recognizing a location) [46]. Episodic memory is responsible for the recalling of events. Light [47] describes semantic memory as being minimally affected by the normal ageing process and suggests that facilitating semantic memory in learning new technologies could help older people in this learning task. Neale [48] suggests that this semantic-relevant context could be created by metaphors to guide older people in the use of an interface.

Prospective Memory

Prospective memory describes the memory which is responsible for the task of remembering that something in the future needs to be done, for example that an older person has to take his/her medication. Cockburn [49] in [50]) report that prospective memory is affected in old age. Since it affects correct task completion, older people make more errors in a task which is carried out over a timespan or in the future. Einstein ([51] in [52]) suggest that the use of cues helps older people to improve their prospective memory.

Learning and Memory

Memory is affected by ageing [41]. Marquié [53] points out that affective processes, motivation as well as strategic approaches contribute to the ability to learn new things.

Implicit versus Explicit Processes

Procedural and performance related processes (implicit processes) seem to be more or less unaffected by ageing, while declarative and conscious processes (explicit) ones are affected by ageing [54]. As both implicit and explicit processes work together in cognition, the decline in declarative and conscious processes affect both implicit and explicit processing, for example by creating false memories [55]. Mead ([56] in [50]), who investigated the effectiveness of two different training programs for older people learning technology found that action training programs work better than concept training programs for

older people as they mostly draw on the unaffected qualities of older people - namely the procedural and performance related processes. They found that older people made fewer errors using an action training program compared to a concept one on menu navigation tasks.

Implications of research findings in designing for older people

Having considered the challenges and issues older people are faced with in terms of cognition and memory a number of design considerations are given next. Following this, design considerations for compensating for functional decline in other abilities related to the senses and mobility are outlined, i.e., vision, hearing, touch, and movement.

Compensating for Cognitive Decline - Design Considerations

Explicit guidelines are lacking for adapting designs to compensate for the cognitive changes in older people. The following is a summary on how research, which was reviewed above, may help to define design factors to accommodate for such cognitive decline within the ageing population. It is given in order to provide an overview of possibilities for designing in the cognitive domain.

The ability to retain and integrate new information is affected by ageing. The speed of processing decreases with age and effortful processing [25] is also affected. There is also a loss in selective and focused attention in older people. Rogers [31] suggests that this loss of ability is not a functional loss but one caused by *the lack of experience*. Automatic processing is not affected by ageing while voluntary processing is affected. Craik ([43] in [41]) reported that the deterioration of working memory in older adults is task dependent. Burdick and Kwon [50] report that prospective memory is affected in old age as it also affects correct task completion.

Rogers [31] suggests that “age related differences in selective attention can be reduced by **increasing familiarity** with the items manipulated and with cues that change the attentional need from selective to focused, which does not seem to show age-related deficits”.

Practice can reduce the unfamiliarity arising from a lack of exposure or gap in knowledge in technology, and consequently will help the older person to develop automisation procedures [31].

Reynolds [45] suggest that **reducing the number of options** and **giving adequate time** to present menu items, will reduce the demand for cognitive resources and information manipulation, and thus could assist older people to successfully complete a task.

Einstein ([51] in [52]) suggest that the **use of cues** helps in the improving the prospective memory.

Mead ([56] in [50]) suggest that **action training programs** work better than concept training programs for older people as they mostly draw on the unaffected qualities of older people namely the procedural and performance related processes.

Literature Review - Movement and Sensory Ability and Ageing

Introduction

While the main review of the literature for this UD Survey tool is an investigation into cognition and ageing and later the UD survey tools available in the literature, the authors also wish to briefly consider movement and sensory ability in older people. Firstly, dexterity and mobility in the older person is considered as well as how this potentially affects their use of technology.

Dexterity and Mobility in Ageing

In the normal ageing process, movement control is reduced due to changes in the muscles, motor neurons, nerves, sensory functions, and gait - which is accompanied by a decrease in muscle mass and strength. Mainly associated with losses of alpha motor neurons, muscle strength decreases with age. Degenerative conditions such as arthritis and Parkinson's disease increase in prevalence with age which further limits joint mobility and muscle control. Strength is decreased in older adults by 1/3, with a 50% reduction in motor units [57].

With older age the ability to operate controls (e.g. buttons) decreases and manual handling tasks become more challenging. Fine motor skills decrease with age and hence activities which are associated with tasks such as writing, sewing, and typing are affected. This affects the ability to manipulate objects. For older people it is more challenging for example to grasp, push or pull. This decrease in ability may be explained on a physiological level by the number and size of motor units, which decrease with age. The frequency of action potentials, which stimulate the motor unit, may be reduced leading to a general reduction in reaction time and slowing down movement. This also affects force production which is generally impaired in old adults [58].

In general, the ability to perform certain movements which are necessary to manipulate objects is reduced in older age. Coordinated movements of the fingers and whole hand require strength and dexterity in the fingers as well as sensory capability and motor control. Impairment in the ability to perform certain movements in older age is related to three main operations, which are pinch gripping, power grip, and pushing forces. Used mainly to manipulate controls such as sliders and knobs, pinch gripping involves the ability to develop opposable forces between the thumb and fingers of the hand and only requires minimal forces. A power grip as opposed to a pinch grip involves a larger number of muscles and consequently requires less effort.

While manual dexterity decreases there are also changes in locomotion with age which affects the mobility of an older person. Movements, which are associated with walking, getting in and out of vehicles, moving on and off furniture and maintaining balance, are affected. In general, older people tend to take shorter steps and single leg support in the walking movement phases is reduced. Isometric strength and physical cross-sectional area of muscles or muscle groups are reduced [59], while a loss of dynamic torque is also evident in older people [60].

While there is a general reduction in physical abilities associated with the normal ageing process, some reduced abilities may also be associated with certain conditions such as Parkinson's disease, strokes and arthritis. According to the "Clinical Overview and Phenomenology of Movement Disorders" [61] movement disorders can be categorised into Hypokinesias (decreased amplitude, slowness, loss of movement; Parkinsonism is the most common category) and Hyperkinesias (excessive, abnormal, involuntary movements). Most common in age are disorders such as Parkinson's disease, Strokes, or arthritis which impair movement.

Parkinson's disease is a degenerative disease which is associated with a loss of coordination and fine motor skills, symptoms include tremors and rigidity and loss of grip strength. Strokes affect fine motor control caused by paralysis, spasticity (i.e., muscular tightness), and impairment of reflexes, balance and coordination. Osteoarthritis, being the most common forms of arthritis, affects the fine motor skills and affects grip strength and fine motor tasks.

Vision and Hearing – Design Considerations

Design guidelines for older people are more or less well established in the visual and auditory domain. For example, Schieber [62] analysed visual changes and proposed *9 design criteria within a human-factor perspective in order to compensate for age-related deficits in the **visual system***:

- Increasing the illumination of environment or task context
- Increasing the levels of luminance contrast
- Minimizing the need to use a device excessively close to the eyes
- Adapting the font size
- Minimizing glare
- Minimizing the use of peripheral vision
- Adopting marking strategies to enhance motion perception
- Using great colour contrast
- Optimizing the legibility of spatial forms using computer capabilities.

As he did with vision, [62] proposed a further *9 design criteria to adapt design for **deficiencies in hearing***:

- Increasing stimulus intensity
- Controlling background noise
- Avoiding the need to detect/identify high-frequency stimuli
- Avoiding long-term exposure to high levels of noise
- Avoiding signal locations with low frequency sound sources
- Using redundant and semantically well-structured speech materials
- Adapting the rate of words per minute
- Asking for feedback from users to calibrate the devices
- Using the Web to provide verbal communication channels for assistance.

Touch and Movement – Design Considerations

Ageing may be accompanied by problems (arthritis, tremors, particularly for Parkinson’s disease) affecting the manipulation of objects and the perception of sensorial feedback in terms of pressure, vibration, spatial acuity, perception of roughness, length and orientation (for a brief review, see [63]). In particular, older adults have a higher threshold of detecting vibrations ([64] in [63]), which has to be taken into account when devising vibrating alerts. In this vein, Liu [65] realized a system producing a mechanical noise to reduce the vibro-tactile detection thresholds in older adults, patients with stroke, and patients with diabetic neuropathy.

Closing

Now that we can appreciate the issues related to, in particular cognition, but also movement, and other sensory abilities in the older person we need some measure of determining how these abilities are impacted on by the design of technology and products that older people use in their homes.

Universal Design (UD) Principles and Guidelines [66] aim to direct product developers in their quest to ensure devices are fit for use and designed for all. A measure of how well a particular product meets the inherent requirements of the UD Principles and Guidelines could give an indication of whether a particular product or service is designed to a good standard in terms of usability.

As such, a survey tool looking at the extent to which UD is present in a product could facilitate product developers and designers to design products fit for use by the older cohort of users (since UD principles are for all people).

The next section facilitates the development of such a survey tool by a review of the literature of suitable, available, UD survey tools. It begins with a discussion on the 7 Universal Design Principles and 29 Guidelines and how they are related to Usability principles. As reported earlier, the main purpose

of this project is to develop and produce a new UD survey tool for assessing UD of consumer products in situ in Ireland. As such, the review of the literature allows the researchers to develop a hybrid approach to developing such a tool, drawing on the appropriate aspects of each existing tool. The tool is then described in the final section “Current Study Approach – Survey Tool Design and Methodology”.

Literature Review – Universal Design (UD) Survey Tools

In this section, the existing UD survey tools in the literature are explored. Firstly, however, we consider the UD principles and guidelines and their relation to usability.

Introduction – Universal Design

The 7 Universal Design principles describe 29 Guidelines [66] which, in general, aim to give guidance when developing products or services for the broadest possible audience. More specifically, they also provide guidance (to a product developer for instance) on how to consider the perceptual, **cognitive** and physical abilities of a user when designing a product or service. As such, they not only provide guidance on evaluating how well a product fulfils the physical needs of the user but also address the cognitive needs of the user using such products – the user in our case being the older person.

In the following section, the UD principles are introduced and their content and context are explained in relation to the abilities they incorporate. It also gives a brief overview on how UD principles may be explained and interpreted in the framework of User-Centred Design in order to provide users with design features which are adequate for all potential users of a product or service.

UD Principles and User-Centred Design

Most of the content of the 7 UD Principles and associated Guidelines [61] are closely related and in some instances almost identical with the usability principles as introduced by Nielsen [67].

Usability is a **quality attribute** that assesses how easy user interfaces are to use. The word "usability" also refers to methods for improving ease-of-use during the design process. Nielsen's Usability principles - closely related to the universal design guidelines - can be classified into 5 categories. These are:

- **Learnability:** The system should be easily learned, ideally no training would be required and the interface should be self-explanatory
- **Efficiency:** The system should be efficient to use. Once the user has learned or is familiar with the system, there should be minimal errors and a high level of productivity should be possible

- **Memorability:** The system and its operation of use should be easily remembered so that it may still be used efficiently without the need to relearn the system after a period of time of not using it.
- **Errors:** The system should have a low error rate, and if users do make errors they can easily recover from them. There should be no occurrence of catastrophic errors.
- **Satisfaction:** The system should be pleasurable, enjoyable to use, so users like using the system and are subjectively satisfied as opposed to frustrated when using it.

Below (Fig. 1) are the usability guidelines as published by Nielsen in his book “Usability Engineering” [67].

- **Simple and natural dialogue:** Dialogues should not contain information that is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility. All information should appear in a natural and logical order.
- **Speak the users’ language:** The dialogue should be expressed clearly in words, phrases, and concepts familiar to the user, rather than in system-oriented terms.
- **Minimise the users’ memory load:** The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
- **Consistency:** Users should not have to wonder whether different words, situations, or actions mean the same thing.
- **Feedback:** The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
- **Clearly marked exits:** Users often choose system functions by mistake and will need a clearly marked “emergency exit” to leave the unwanted state without having to go through an extended dialogue.
- **Shortcuts:** Accelerators - unseen by the novice user - may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users.

- **Good error messages:** They should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
- **Prevent errors:** Even better than good error messages is a careful design that prevents a problem from occurring in the first place.
- **Help and documentation:** Even though it is better if the system can be used without any documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, be focused on the user's task, list concrete steps to be carried out, and not be too large.

Fig. 1: Usability Guidelines by Nielsen [67].

The following examples help to demonstrate the similarity and close relationship between 'usability principles and guidelines', and 'UD principles and guidelines'. Examples are given linking principles and guidelines between the two in order to demonstrate that while the UD Principles embody usability principles which are important for the "use-phase" of a product; the UD Principles also incorporate guidelines (outside of the typical usability remit) for the "pre-use phase" and "post-use" phases. The importance and relevance of this is described next.

Linking UD and Usability Principles - Some examples

Principle 3: Simple and Intuitive Use: Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.

Associated guidelines:

- 3a. Eliminate unnecessary complexity.
- 3b. Be consistent with user expectations and intuition.
- 3c. Accommodate a wide range of literacy and language skills.
- 3d. Arrange information consistent with its importance.
- 3e. Provide effective prompting and feedback during and after task completion.

UD guideline 3b (Be consistent with user expectations and intuition) for example refers to the content of several Usability guidelines, one being "consistency" – which refers to the fact that users should not have to wonder whether different words, actions or situations mean the same thing. It further refers to Nielsen's guideline "speak the user's language" – "the dialogue should be expressed clearly in words, phrases and concepts familiar to the user, rather than in system orientated terms".

The UD guideline 3d. "Arrange information consistent with its importance" maps onto Nielsen's [67] guideline "simple and natural dialogue", while 3e maps directly onto the Usability principle "Feedback".

This simple comparison exercise shows that there is considerable overlap and similarity between most UD and Usability principles and guidelines.

UD Principles – extending to pre-use and post-use phases

While usability principles and guidelines deal with the use phase of a product (i.e. evaluate, assess and guide, aiming to optimise the steps the user goes through when using a product) UD principles also cover the preparation for use and after/post use.

Preparation for use may be referred to here as the pre-use phase. While the use phase deals with the interaction with a product or service the pre-use phase describes the preparatory phase, which is necessary for a user to go through in order to enable him/her to **prepare and set-up** for the use phase. This may include, setting up the device for use. For example, if someone wants to use an iron to iron clothes, this would require the user to set-up the iron board, plug in the iron and place it on the iron board to be ready for the ironing task. However, the user has not engaged yet in “using the iron” for the intended purpose of ironing clothes. In this pre-use phase physical abilities are determining if the iron can be accessed and used for the intended purpose. The physical ability to lift the iron board, put it up, place the iron onto it and plug the iron in, all require a diversity of physical abilities, such as muscular strength, being able to access the space where the iron is stored, accessing the space where the iron is to be used, and being able to have the dexterity and fine motor control to plug in the iron. The universal design principles deal with these abilities in, for example, guideline 2b: “Accommodate right- or left-handed access and use”.

However most of the guidelines pertaining to physical use are related to UD principles 6 and 7. Where 7 thus can be seen to refer to the pre-use phase before interacting with the device, 6 can be seen as being relevant in the pre-use phase as well as in the use-phase, where physical forces are needed to operate functions which the user needs to navigate and go through when interacting with a product during use.

The examples demonstrate the different abilities relevant in the pre-use phase as well as in the use-phase. While in the pre-use phase physical abilities are predominant in determining the success and extent to which the user may be able to eventually use the product, the use-phase requires predominantly cognitive abilities, while drawing on some physical abilities which are required to complement the execution of a task - such as pressing buttons, keys or turning a dial to enable selecting from a menu choice of options or scrolling between options to make a selection.

Having considered the UD Principles and Guidelines and how they apply to the pre-use, use, and post-use phases the review of the existing UD survey tools is given next, beginning with the review methodology. The various phases of product use will be incorporated into the new survey tool being

developed, as outlined later in the report in the section “Current Study Approach – Survey Tool Design & Methodology”.

Literature Review Methodology – UD Survey Tools

Different disciplines are involved in researching UD, cognitive abilities and resources, which are necessary for an older person to use a product successfully. Literature with reference to UD, UD and questionnaires, and UD and checklists design were reviewed and current opinions, knowledge, trends and research is summarized in this section.

A systematic review of UD survey tool design and factors associated with this is very challenging as it crosses disciplines. Searching for relevant publications requires some ingenuity and an intuitive expert understanding of search terms was required since the same content may be described by different terminologies in different disciplines such as engineering, psychology, medicine, marketing, social sciences, business and management etc.

As such the literature review followed a hybrid strategy (see literature research methodology above on older people and cognition for details), which aimed to uncover and detect the greatest number of publications related to UD survey design. The following search terms were decided on, based on expert opinion.

Search Terms

- Usability,
- Universal Design,
- Universal design questionnaires,
- Universal design checklists,
- UD product and service assessment.

The results of this review and how it pertains to UD survey tool design are discussed next.

Approaches to UD Survey Design

Three main approaches to UD survey design may be differentiated as found in the Literature. These approaches all facilitate the original wording of the UD principles and guidelines (The Center for Universal Design, 1997) [66] in some way and aim to differentiate between user’s abilities and product features. They do this by envisioning the questionnaires being used to assess usability in a usability task.

Approach I:

Approach I to UD survey design facilitates the UD principles and guidelines by using more or less the exact wording of the 7 UD principles and guidelines for its questions as well as maintaining **the order of the**

principles and guidelines. Therefore, questions would be presented to the user in the same order as the 1-7 UD principles and guidelines.

Center for Universal Design, N.C. State University, 2000

This approach (Approach 1) is utilised in “The Guide for Evaluating the Universal Design Performance of Products” [68] which was developed in 2000 by the Center for Universal Design, N.C. State University. This guide is intended to assist in the development of more universally-usable products. Again, the “Performance Measures” follow the structure and content of the UD principles and guidelines and maintain the same order. Nevertheless, the authors of the guide mention and advise that “Depending on the nature of the product, some Principles *may not apply*, and it may sometimes be more effective to *apply them out of order*” [68]. It should also be mentioned that the “Performance Measures” in this guide are not intended to be used as a “score sheet” to derive overall totals or averages to measure a product’s usability. Rather, this tool is “useful for:

- Identifying potential areas for improvement for a product;
- Comparing relative strengths of similar products;
- Identifying particular strengths of a product such as for marketing purposes.” [68]

Since this tool uses the UD principles and guidelines in the exact sequence as they are presented in the UD principles the wording is manifest in a **passive form**. For example, guideline 2c of the UD Principles [66] reads: “*This product facilitates (or does not require) user accuracy and precision.*” A sample question from the guide is shown in Fig. 2 below.

PRINCIPLE ONE	EQUITABLE USE	Not Applicable	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Comments
1A.	All potential users could use this product in essentially the same way, regardless of differences in their abilities.							

Fig. 2: Sample question from “The Guide for Evaluating the Universal Design Performance of Products”[68]

Center for Universal Design, N.C. State University, 2002

In 2002 the same Center published a reworked version of the previous tool, which is more geared towards the user and is called “the Product Evaluation Countdown” [69]. Their “Product Evaluation Countdown” guide attempts to address the issue of the passive form of the questions of the first tool by implementing an **active form** - making the guide **specific to the user** who is using the product. This tool is described by the authors as a checklist aiming to help the user of a product think about their own needs and those of other potential users when selecting products.

So while “The Guide for Evaluating the Universal Design Performance of Products” is intended to help a product developer to identify issues with the design - the “Product Evaluation Countdown” is aimed at users using the product. For this, the questions were reformulated to make them easier to understand by **rephrasing the questions** from the passive form to an *active form*. The **order was also reversed** where principle 7 is addressed first in the questionnaire and principle 1 is addressed last. A sample question from the guide is shown in Fig. 3. The questions can be seen as addressing the user directly for example, in another question, by asking “*This product is as usable for me as it is for everyone else*” rather than asking “*All potential users could use this product in essentially the same way, regardless of differences in their abilities*”.

PRINCIPLE 7. Size and Space for Approach and Use

7A. It's easy for me to see all the important elements of this product from any position (such as standing or seated). Not Important Strongly Disagree Disagree Neutral Agree Strongly Agree

Comments:

Fig. 3: Sample question from the “Product Evaluation Countdown” guide [6 9].

Approach 2:

Approach 2 is based on using the “Universal Design Performance Measures for Products” by Story et al., 2000, 2001 [70], [71] and other usability metrics such as Consumers’ Product Evaluation Survey (The Center for Universal Design, 1999). New questions are formed which use very similar wording to the previous approach but they also make an attempt to **reduce the number of questions**.

Lenker 2001

Lenker’s (2011) approach [72] condensed the UD questions to 12 questions and added some questions relating to product usability such as items dealing with setting up a product for use and cleaning it away.

This is interesting as it demonstrates that Lenker obviously thought about the sequence of performing a task when developing this questionnaire, trying to provide questions for all steps necessary to perform a task. Lenker’s tool [72] was specifically developed for “rapid assessment of product usability and universal design”. They identified that existing tools/resources for assessing UD in products have the following shortcomings:

1. UD resources do not consistently define their target audience or its needs;
2. The terminology used for accessible and universal design is imprecise;
3. There are no accepted standards for measurement and compliance;

4. Standards and guidelines are not enforceable because of their ambiguity; and
5. The usability of the UD resources is compromised” [72].

Thus Lenker was aiming to “create a succinct, psychometrically sound tool that:

1. Embodies traditional usability principles, as well as UD principles;
2. Lends itself to a continuum of consumer products;
3. Is amenable to a diversity of user populations, including older adults and persons with disability;
4. Differentiates products having different usability strengths and weaknesses; and,
5. Reveals product features requiring re-design” [72].

Lenker further elaborates that:

1. “(a) the product types and models being tested are typically identified by the investigator and may have little relevance and meaning for some participants and
2. (b) products are often tested using contrived tasks chosen by the investigator to exemplify ‘typical product usage’, which may or may not reflect the task cycles that participants enact in their daily lives;
3. (c) products are tested in settings that are unfamiliar to participants and lack the affordances present in participants ‘everyday environments; and,
4. (d) participants are asked to provide usability ratings based on a relatively short interval of product exposure” [72].

Lenker's 12 item questionnaire was given to participants of a focus group to rate different products. Lenker [72] (similar to Beecher who developed a survey instrument for UD of consumer products [73]) reported that participants struggled to understand and answer some items in the questionnaire, in particular item #7 - “*I get the information I need to use the product efficiently*”. Several items were reported to be non-applicable such as “*set-up, clean-up and storage, information, safety, draws unwanted attention, and embarrassment*”. Again, similar to Beecher, Lenker draws the conclusion that this non-applicability was related to **the particular type of product being rated** and thus some items in the questionnaire were not particularly relevant to the user in judging the product on usability. Nevertheless, one item that was of particular relevance (in describing bad usability) across all user groups irrespective of their ability was item #8 (“*takes more time than it should*”).

Beecher 2005

Beecher et al developed a survey instrument for Universal Design of consumer products [73]. Initially, Beecher reported a preliminary questionnaire design whereby he used variations of questions from the “Universal Design Performance Measures for Products”. The initial survey was largely based on the Consumers’ Product Evaluation Survey (The Center for Universal Design, 1999) and the Universal Design Performance Measures for Products version 1 (Center for Universal Design, 2000) (see Story et al in [70], [71]).

The initial scales were able to differentiate product design features, different abilities of different user groups, and different levels of task difficulty. However when the initial questions were subjected to a factor analysis, the original UD principles were split into multiple factors. This provides evidence that the original UD principles may contain more than one design principle within each UD principle. This is illustrated well in principle 1 “Equitable Use” and principle 2 “Flexibility in Use”. Some of the items that were originally categorized by Story [70], [71] under “Flexibility in Use” and “Equitable Use” were exchanged between these factors. Beecher further reported that “Perceptible Information”, “Secure, Safe and Private Use” and “Tolerance for Error” were not strongly correlated with the ratings of task difficulty. This may be explained by the fact that the products did not have requirements for use that were cognitively demanding for the user group. Further, none of the products seemed to be threatening to a person’s security except possibly the pliers .[70], [71].

However, key here is that **no evidence** was found to suggest that Beecher **aligned the questions along a task sequence** (i.e. the steps taken by the user to use the product).

Storey 2001

Finally Storey [71] described in 2001 the development of the UD performance measures and associated challenges.

Storey [71] describes the development and testing of two sets of questionnaires, which utilize the Universal design principles and guidelines and are intended to be easier to apply compared to previous UD questionnaires. The aim was twofold: one - to develop a method of evaluating products to determine their universal usability; and two - to develop an evaluation service for industry based on this evaluation method. The approach to develop two dedicated questionnaires for the two user groups, designers and consumers, was chosen as it became apparent that consumers are “concerned only with issues that relate to their personal needs, while designers should address the needs of the widest diversity of users concurrently”.

For this purpose two versions of the questionnaire were developed, to offer both groups, product designers developing new products and individuals assessing products before purchase, a suitable tool to do so. Both

questionnaires comprised of 29 statements, corresponding to the 29 guidelines associated with the 7 Principles of Universal Design. After five iterations (versions) of the Performance Measures (which were reviewed by 28 consumers with disabilities, 18 professional product designers, and 12 marketing managers from across the United States) they tested the two final versions with a diverse group of 60 consumer households and 18 professional product designers using four common household products for a number of weeks. Afterwards they were asked to fill out the questionnaires (which they called “Universal Design Performance Measures”) for each product and some basic demographic information in order to describe their past experiences using these types of products and to evaluate the Performance Measures themselves.

Analysing the responses the following shortcomings of the tool became evident:

- “The higher the level of knowledge of universal design, the more useful the designer believed the Performance Measures to be”. Usability and disability issues which are expressed by the questions thus may not be easily recognised by a novice user.
- The generic wording makes it sometimes difficult for respondents to interpret/understand the intended use of the questions.
- The respondents are required to apply the measures separately to each phase of use of the product which is not obvious to the user
- The designer version of the Universal Design Performance Measures require the designer to imagine the diverse usage by different groups of people, for example, closing your eyes to play the part of a blind user. However, as was reported, closing your eyes is not the same as being blind.

Approach 3:

Approach 3 describes the use of the UD principles as they are relevant **in product evaluation**.

The British standard BSI 7000-6:2005 refers in B.9.4 to a 7 – level model for “countering design exclusion”. This model refers explicitly to the product development process from the idea stage, user testing to the user owning the product and as such describes most elements of the product life cycle from design to use. The 7 steps provide a good guideline for product developers and where to consider the different abilities of the product or service users. In this respect the inclusive design cube is mentioned, which refers to B.9.3 in the BSI 7000-6:2005, by providing a useful visualisation tool to the product developer illustrating the “capability” demanded by the product and its inclusivity of the product. As such BSI 7000-6:2005 in its clause B. 9.3. and B9.4 provides the basis for the approaches described in this section. All approaches have a common attribute, that is, that the questionnaires are

somewhat aligned along the sequential process following product development as described in the 7 steps in the BSI 7000-6:2005.

One approach to product concept evaluation to be used in the early design phases is described in the “Usability screening techniques” (see Law [74], [75]). They are designed to identify major usability problems that people who have functional limitations might experience when using a product. Administered by designers using themselves or their colleagues as users the techniques are intended to discover whether the product can be used without different abilities such as vision, hearing, haptic feedback etc and hence to “screen” for major usability problems.

The screening techniques can be used on in the pre-prototype or prototype stages of a product's development and may be integrated as part of design walkthroughs, heuristic reviews, formal and informal usability testing.

While these screening techniques are useful to uncover design problems early on in the design phase, it requires some imagination of the experimenter on how to re-inact different abilities. However it is more useful to do an evaluation with real users, which can be done in later stages of the design process. In this respect two sub-approaches were found in the Literature in which the UD principles were **reordered in a way which facilitated the human interaction with the product** and thus supported the sequence of use steps carried out. By following the sequence of use steps each step may be evaluated individually and its impact on the overall usability. For example, if one step in a sequence cannot be carried out, it is very unlikely that subsequent steps will be successful. These approaches are useful in estimating enabling or disabling steps in a product user interaction.

Approach 3-1

Approach 3-1 describes a tool developed by Bell in 1995, called “Universal Design Filters” [76],[77].

Ellen Francik (Human Factors Engineering, Pacific Bell) developed this grid tool which was termed “Universal design filters”. It was developed to make telephone products and services more accessible. In this tool the UD principles were grouped into different abilities necessary for the user to use the product and as such it groups and reorders the principles and guidelines into categories of mobility, vision, speech, hearing and cognition. This approach thus makes an attempt to reorder the principles according to a scheme. Lenker also used a scheme to categorise UD principles and guidelines into use phases of “setting up for use, using and cleaning away after use”.

As such, both approaches (Lenker and Francik/Bell) made an attempt to provide a structure, either in temporal form (Lenker); or according to categories of ability (Francik/Bell) to enable the Experimenter to relate and

assess the task with the aid of such categories (which the UD principles and guidelines were grouped into). Both tools did not therefore retain the numbering (order) of the UD principles and guidelines in their original sequence (principles 1-7). Where Francik's does differ to Lenker's however is that it **describes the abilities** (which were mobility, hearing, vision, speech and cognition) and also provides examples of each to help the product developers to identify the problem areas. For example, under the ability "*mobility*" 5 examples were stated as follows:

- Difficulty moving, reaching, pressing, grasping, or lifting, as might be due to ageing, arthritis, or injury.
- Being in an environment where one's hands are busy, such as while driving.
- Difficulty in going through narrow spaces or over obstructions, as might happen to someone in a wheelchair.
- Difficulty in reaching items at a given height, as might be the case for wheelchair riders, short adults, or children.
- Difficulty in responding quickly to information or pressing buttons rapidly, as may be due to ageing or injury.

These examples can be essentially seen expressed in the UD principles and guidelines. For example, the above examples for mobility would equate to UD guideline 7B: "It's easy for me to reach all the important elements of this product from any position (such as standing or seated)" in the "Product Evaluation Countdown" [70], [71].

In recognition of the importance of Universal Design, Pacific Telesis (one of the seven Regional Bell Operating Companies) has committed itself to incorporate UD into its product development processes. As stated earlier, Pacific Bell itself has created UD filters [77], which can be described as checklists that help product teams anticipate potential barriers to product use even within the early stages of product development. Two filters were developed, one for telephone-based products [77] and another for computer- or screen-based products [76]. According to Francik "Each filter describes the most common interactions that people will have with that type of product, and lists barriers that people with different disabilities may encounter".

The filters are organized like a grid (see Fig. 4), where columns represent typical customer interactions or tasks while the rows represent the differing abilities and circumstances that may affect the task.

- The term "Tasks" describe all aspects of a product including ordering, installing, daily use, documentation, and help.
- The term "Circumstances" describes situations that a user may be in which may affect their ability to perform the task. For

example, someone who usually has no problem seeing may have difficulties in a dimly lit environment or, someone who usually has no mobility problems may have trouble picking up and using equipment if their hands are busy carrying items or while driving their car.

The layout of Pacific Bell's UD Filter is shown in Fig. 4. In the grid cells the evaluator notes down issues for each of the five categories as stated in the columns. Issues will thus be listed in each cell for a combination of task and ability/circumstance. Utilising this layout helps to identify areas in the design which need attention. The chart entries, which are made by the evaluator, thus highlight areas that may be deficient in UD design.

	Task 1	Task 2	Task 3	...	Task n
Mobility	=====	=====		////	=====
Hearing		=====		////	=====
Vision	=====	=====	=====	////	=====
Speech	=====			////	=====
Cognition		=====		////	=====

Fig. 4: Pacific Bell's UD Filter Grid layout. Issues are listed within the grid cells for that combination of task and disability / circumstance. Where available, solutions are also listed.

According to Francik “Product teams can use the filters to refine their early product descriptions and to identify issues that need to be solved during product development”.

Approach 3-2

Approach 3-2, was developed for the Irish Swift standard for UD of energy suppliers [78]. It was developed for energy providers to guide assessment of their products and services for UD implementation in 2011 which has been published in the Swift 9 “Universal design for energy suppliers” [78]. While it aids energy providers to assess their products, it has tables that are designed to be interpretive, i.e, are similar in wording to the original Universal design performance measures, for example guideline 2c “Facilitate the user's accuracy and precision.” was represented by two questions (as also shown in Table 1)

- I. Is the content presented in a clear, concise and well-structured way?

2. Does the way the content is presented make it easy for your customer to understand and use it in the way it was designed?

These questions were developed aiming to make it easier for a non-expert in UD to identify possible problems with the product or service. All questions were formulated with input from a plain English expert, who helped express the questions in plain English to facilitate understanding. How this tool differs from the “Universal Design Performance Measures for Products” [68] is that the UD principles and guidelines were **reordered in accordance with how someone would interact with a product**, i.e. the individual steps, someone would go through to interact and use a product. Thus UD principles were reordered in the order of: “perceiving content” (which represented UD principle 4), followed by “customer finding relevant information”, (principle 2), “understanding” (principle 3) and “use of information” (principle 5). As these tables were developed for energy suppliers some UD principles were not relevant and as such were omitted in the Swift 9 tool.

Table 1: Sample of how the Swift 9 Standard Questionnaire maps onto the UD principles and guidelines.

Guidelines for Principle 2	Do your product or service features enable your customers to find information easily?
2a. Provide choice in methods of use.	Does your product or service offer different routes (audio and visual) to find and identify content that enables effective use of the product or service?
2c. Facilitate the user's accuracy and precision.	Is the content presented in a clear, concise and well-structured way? Does the way the content is presented make it easy for your customer to understand and use it in the way it was designed?
2d. Provide adaptability to the user's pace.	Does your product or service give the user enough time to complete a task or allow them if needed, to easily increase the time allowed?

Both the Universal design filters [76], [77] and the Swift 9 tables [78] reordered and facilitated the UD principles to align them more closely to identify the differing abilities one encounters when going through the process

of using a product. This process can be broken down into different steps, which are necessary to achieve an intended goal with a particular product.

Dexterity and Mobility

As well as considering the approaches mentioned above it is important to outline how dexterity and mobility feature in the UD principles and guidelines as they relate to the older person since they will need to feature in the final UD Survey Tool used and developed in this study. The 7 UD principles and guidelines refer to different physical and cognitive abilities. Physical abilities, which include manual manipulation of tasks, are represented in the UD guidelines and Principles number 2, 6 and 7. These are outlined next to demonstrate how dexterity and mobility can be catered for in the design of technology for older people.

Principle 2: Flexibility in Use

- The design accommodates a wide range of individual preferences and abilities.
- Guidelines:
 - 2a. Provide choice in methods of use.
 - 2b. Accommodate right- or left-handed access and use.
 - 2c. Facilitate the user's accuracy and precision.
 - 2d. Provide adaptability to the user's pace.

Principle 6: Low Physical Effort

- The design can be used efficiently and comfortably and with a minimum of fatigue.
- Guidelines:
 - 6a. Allow user to maintain a neutral body position.
 - 6b. Use reasonable operating forces.
 - 6c. Minimize repetitive actions.
 - 6d. Minimize sustained physical effort.

Principle 7: Size and Space for Approach and Use

- Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.
- Guidelines:

- 7a. Provide a clear line of sight to important elements for any seated or standing user.
- 7b. Make reach to all components comfortable for any seated or standing user.
- 7c. Accommodate variations in hand and grip size.
- 7d. Provide adequate space for the use of assistive devices or personal assistance.

These three Principles will feature in the final Survey Tool to be developed. This development is explored in the next chapter.

CHAPTER 4: CURRENT STUDY APPROACH - SURVEY TOOL DESIGN & METHODOLOGY

In this study, a tool was developed which is to be used to assess an older cohort of people in, in this case, the Liberties in Dublin 8 in Ireland. The approach taken is essentially a hybrid of the approaches outlined in the previous section.

A Hybrid Approach

This new tool is similar to “Approach 3” in that it uses elements of Bells design [77] (Approach 3-1) and combines them with the Approach of the Swift 9 [78] (Approach 3-2). Questions asked at each step of the product evaluation process are facilitated from mostly the “The Guide for Evaluating the Universal Design Performance of Products” [68] and the “Product Evaluation Countdown” [69]. However, some content is also considered from Lenker [72]. The main aspects of this hybrid approach are that it looks to reorder questions to match the chronology of using a product (as in Swift 9 and Bell), considers the abilities of the user at each step (like, for example Bell), utilises a grid layout of the questionnaire for ease of use (as in Bell) and includes additional questions to incorporate user experience and perception. The assessment is designed to be carried out in the during-use phase of the product. These are described next.

During-Use Assessment

Since older people have problems with short term memory it is not desirable to ask them questions *after* they use a product as they might not remember the steps they have gone through or the difficulties they encountered exactly. This new tool development presents a way where users can communicate the task difficulties **during use** and not post-use as is the case in most other tools, such as Lenker’s and Beecher’s UD surveys.

Rephrasing of Questions for Accessibility

The questions that were reported in Lenker and Beecher as being difficult to understand or were not applicable were reviewed and rephrased. The other UD principles and guidelines were, where possible, expressed in a more simple way to make it easier (accessible) for the older person to understand. This was done by attempting to express the questions in plain English (as done in Swift 9).

Abilities and Ability-Categories

The existing UD survey questions served as a template i.e. guidance on which abilities were deemed important. The universal design principles represent physical and cognitive abilities, where physical abilities can be divided into sensory abilities (eyes, ears, haptics), physical

strength available to a person, and body size. Cognitive abilities refer to the ability to learn, comprehend and memorise a task sequence to achieve an intended goal. Bell's checklist used the task approach i.e. for each stage of a task they describe what is necessary in terms of abilities. The following abilities were considered:

- *Mobility*: Example UD questions might be: I often need assistance.... in holding the earpiece, ..in finding the remote control, ..in pressing the buttons on the remote control, ..picking up the remote control is easy to do
- *Hearing*: I cannot hear the feedback the remote control gives me when I press a button
- *Vision*: I cannot see the indicator light on the TV when I change the channels
- *Speech*: n/a
- *Cognition*: For example - A step in a task takes too much time

Using Bell's UD filters [76], [77] as a template design we slightly altered them by **substituting the 5 abilities with abilities specifically connected to performing the task sequence** according to Swift 9 [78]. We then also extended these to include an overall impression factor. This leads us to a set of **5 ability- categories**:

1. Perception
2. Understanding
3. Interaction
4. Task completion/ success
5. Overall impression factor

These 5 “ability-categories” give the structure to the questionnaire (as shown in column 1 of Table 2) which reflects the steps in the performance of a task. The 5th ability-category, “overall impression factor” was added to test the overall impression evaluation of the user, which will reflect not only functional requirements but also a more evaluative layer of thinking and aesthetics, i.e. looking at the holistic user experience.

Questionnaire content: Combination of Questions

The questionnaire developed in this study is shown in Table 2. Suitable UD questions from Lenker, Beecher, the Universal Design Performance Measure for Products, the “Product Evaluation Countdown” and the Swift 9 [78] were incorporated into the questionnaire. These were selected, adapted, and structured so as to fall into the 5 ability-categories and match the task sequence flow of carrying out a task with the product(s).

Contextual Validity

Unlike the UD survey tool of Beecher and Lenker, this tool will be used in the context of a real world environment - the user's home, with products that the user has selected (difficult technology) or applied for in the Senior's Alert scheme with SICODA (pendant).

Methodology of Home Assessments: How this tool will be used:

The older person will be asked to describe and guide the experimenter through tasks they perform with the product. At each step of the task the older users are asked to describe what difficulties they encounter with the task.

The exact step sequence of the Experimenter interacting with the User is as follows:

1. At the beginning of the questionnaire the user is asked to select the product, for example a remote control to change channels on a TV.
2. The Experimenter will then quickly populate the 4th column named "Applicable" to see which questions apply to this product and which do not.
 - This will serve to potentially reduce the number of questions to be addressed in this visit and ensure that the user is not being asked to address any non-applicable questions.
3. They are then asked to guide the Experimenter through the individual steps of using the product as they would in their normal day to day operation of the product.
4. While the user is demonstrating the individual steps to the Experimenter, the Experimenter uses the tool to write down individual problems the user encounters in the grid.
 - In the grid, the UD questions (2nd column) are associated the abilities of the user (1st column). The tasks (subtasks) are also associated with the abilities of the user in a specific task sequence. The tasks and associated abilities listed in the grid are provided by the survey tool for guidance for the Experimenter on how to and what to ask for with reference to checking for difficulties.

Table 2: Survey Tool. Grid for use to test for UD in products. At each step of the task interaction users are asked UD questions as relevant to the task sequence

Ability	Subtask 1.1	Applicable?	(example) Answers
Perception	7a) Is it easy to see/ read/ recognise/locate _____?	yes	Yes
Understanding how something works (Cognition)	3a) Is it simple/ easy to understand how _____ works? (4a add) Can you (I) understand how it works: without hearing/understanding _____? without seeing/ reading/ recognising the ___? Is it simple/ easy to remember how _____ works?	Y	Yes No No No
Interaction (use phase)	(7b) Is it easy to reach (move, press, grabs, lift) the _____? (7c) Does this (do these buttons/ controls) _____ fit my (finger) size or hand-size? (7d) Is there enough space (between buttons/ controls) to operate, push, turn etc this _____? (2c) Does the _____ give you (me) enough time for input i.e. to press the button, turn the dial etc ? (4d) Can you use _____ with your hearing aid, glasses? (4a) Can you (I) operate _____ without hearing/understanding the _____? (4b) Can you (I) operate _____ without seeing/reading/ recognising the _____? (3b) Does _____ behave like you (I) expected? (6c) Does it work first time around or do you (I) have to repeat (pushing, turning, reaching, grasping, lifting) _____?		Yes No No Yes Yes No No Yes No
Task Achievement/ success	(6b) Does it strain (annoy) you (me) to use _____? (6d) Are you (am I) exhausted after using _____ or need a break, a rest?		No/ N/A No/ N/A
Overall impression (fun factor)	(6a) Is it easy to use this _____ comfortably? Do you like the looks/design of it? Do you enjoy/ is it fun using it? Do you feel embarrassed using this product?		No Yes No No
No. of yes/no answers			7 Yes 13 No
Overall UD score			35% UD 65% not UD suitable

5. Finally, the user's responses will be used to populate the final "Answers" column.
 - In the Pilot studies we will assess if it is necessary/practical to employ just a yes or no score or have a 5-item rating scale similar to that used in Lenker's – based on the 5-point Likert scale of endorsement(e.g., strongly agree, somewhat agree, neutral etc.).

Pertinent Design Elements for Use in the Home – User Experience and Open Conversation

A further element of note is included in the questionnaire grid (Table 2) in order to include the evaluative dimension of the user in terms of how the differing abilities contribute to the overall impression of having fun, enjoying the product and liking it [79-81]. That is, at the end of the questionnaire the user is asked about their overall impression of the interaction, if it was fun, pleasurable to use or frustrating.

The grid design enables the evaluator to engage in a conversation with the user while the user is showing them how they would use the product for the main task. However questions may also be used in the same sequence in a questionnaire sheet, without the grid structure – the grid just helps the experimenter to make and visualise the connections between abilities, task sequence and perceived problems with the task of a particular population or user group.

So for each step of the task the UD content of the product in question is assessed i.e. which of the limitations are disabling the task at this stage. At the end a profile can be given, where disabling aspects at each step are summarised. A list of disabling steps and associated difficulties will be generated in the end. This gives a usage profile for a particular population of people.

Pilot Studies

In the pilot tests it will be investigated if:

- The number of questions can be further reduced,
- It is necessary/practical to employ just a yes or no score or have a 5 item rating scale similar to that used in Lenker's – based on the 5-point Likert scale of endorsement, e.g., strongly agree, somewhat agree, neutral etc.).

Tool Users

Much has been said about the shortcomings of some Universal Design Resources (UDRs) in that they have many times been made inaccessible to product developers who would like to use them [82]. While these are potential

users of the survey tool being developed here, the main user's that it is aimed at would most likely include users who have a knowledge of usability testing and assessment, which is a view similarly shared by tool developers in the literature [72],[73]. Nevertheless, the experimentation of the pilot studies and the actual trials will uncover the extent of possibilities of the tool and who the potential users of it might be.

Summary of Key Aspects of the New Survey Tool

- Approach used is a hybrid of those in the Literature (but also including improved aspects);
- Questions are to be addressed in the “during-use” phase;
- Questions that were reported in the literature as difficult to understand are rephrased for this tool;
- Tool will address abilities of the user and will work to a specific question order. This is to mirror the task sequence order of using a product;
- The tool extends beyond the chronological stages used in the Literature and also includes an impression factor of the user experience
- A grid design can be used to facilitate ease of use and open conversation between the user and the Experimenter.

CHAPTER 5: SURVEY TOOL PACK - CHANGES TO THE PILOT TEST TOOL

Introduction

Three pilot home visits were conducting using the Tool shown in Table 2 in the previous Chapter. The researchers discovered a number of practical issues and confounders as they progressed through the pilots and identified other aspects that were not included in the original Tool. The structure of the new tool is explained next with a rationale for the changes to the original design.

Post-Pilot/New Test Tool

The new Test Tool is given in Appendix A. The tool is made up of a number of parts (#1-4):

1. Demographics Questions (D1-D16) (SURVEY TOOL Part #1 of 4)
2. Contextual Questions (C1-C7) (SURVEY TOOL Part #2 of 4)
3. Cheat Sheet of Questionnaire (SURVEY TOOL Part #3 of 4)
4. Main Questionnaire/Observation Set (Q1-Q22) (SURVEY TOOL Part #4 of 4)

Only one copy of Part #1 is needed per user/resident. It looks to gather demographic data from the user.

Part #2, Part#3 and #4 are device/product specific so one copy of each is needed **for every technology**/product assessed.

Part#3 can be used as an optional reference navigation guide for the Experimenter and can also be used for gathering answers (check boxes). If used for gathering answers, one is needed per product assessed.

Sequence of Use of Survey Tool Parts

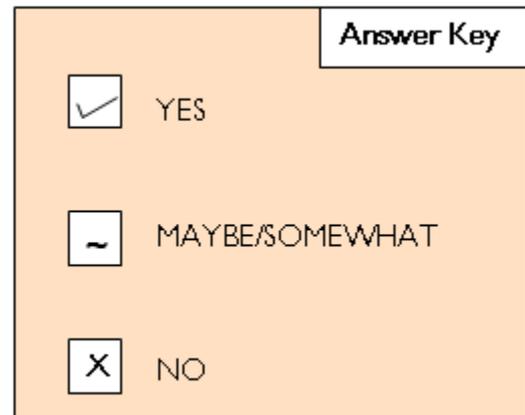
- The Survey Tool (Parts #1, 2, 3, 4) is shown in Appendix A.
 - Firstly, the demographics questions (Part#1) are asked, then
 - The “difficult technology” contextual questions (Part#2 for the difficult technology), then
 - The “difficult technology” Main questionnaire (using either or both Part#3 and Part#4 for the difficult technology).
 - The Experimenter continues assessing this technology until he/she has gathered the answers and user experiences.
- Then the Experimenter explores the Pendant Alarm:
 - Firstly, the Experimenter goes through the Contextual questions for the pendant (Part#2 for the pendant) with the user, then
 - The main questionnaire (Part#3 and/or Part#4 for the pendant).

- The Experimenter continues assessing the pendant technology until he/she has gathered the answers and user experiences.

The sequence follows demographics questions, difficult technology questions and finally the pendant technology questions. This then completes the home visit and use of the Survey Tool.

Use of the “Answer” field

Answers to questions can be either Yes, No, Somewhat. These are represented by a “Tick”, an “X”, and a “~”, respectively (see Answer Key in the graphic on the right). These can be placed in the quick sheet or the Main Questionnaire (2 options) in the small box in each cell of the questionnaire during observation.



Non-Applicable questions can be completely X’ed out once the Experimenter knows what technology is being addressed. For example, for the pendant, there is only a single button so the 3rd question in the Main questionnaire regarding space between buttons would be X’ed out (non-applicable) and would therefore be excluded from the interview.

Changes Made to the Tool

The table (Table 3) below lists the issues with the pilot tool and the solutions identified to address these issues (shown in the 2nd column). Detailed notes of the changes are then discussed.

Table 3: Changes Made to Pilot Test Tool - Issues and Solutions

#	ISSUE(s)	SOLUTION(s)
1	Answers & Experiences Reported Lacked Context	- Added Demographic Q’s - Added Contextual Q’s
2	“Warming-up Period” needed	- Task added after contextual questions (Questions addressed to user directly later in interview if required)
3	Conversational Flow Interruption & Difficulty in Real-Time Choice of Questions	- Quick Cheat Sheet included for navigation (by Experimenter) through questions - Questions converted to

		observations (Questions addressed to user directly later in interview if required)
4	Self-Reported “Contentment with Everything” - A Large Confounder	- Questions converted to observations by the Experimenter
5	5-Point Scale of Answers inappropriate	- Use of 3 point scale (yes, no, maybe/somewhat)
6	Order of questions not perfect	- Adjust of the order to match the order of carrying out a task with a product.
7	Some questions unnecessary	- Removal of some questions

Details of Changes

In this section the changes detailed in the table (Table 3) in the previous section are described. They are listed in the order that they appear in Table 3.

1. “Answers & Experiences Reported Lacked Context”

Answers and user-reported experiences seemed to be lacking supporting context of the user’s background and context of use of the product.

- We have now added demographics questions for factual information at the very start of the interview (Survey Tool Part#1 of 4)
- We have also added in additional contextual questions for each product to discover the motivation for getting the product and typical use cases - where and when - of the product etc. (Survey Tool Part#2 of 4).
- These 2 sets of questions can be completed quite quickly as tested in the pilots.

2. “Warming-up Period needed”

User’s tended to only “open up” towards the end of the interview and come up with more experiences and opinions after questions had been asked.

- As outlined in the next bullet point, after some initial demographic & contextual questions, a task will be given and more direct conversation and questions left until later in the interview.

3. “Conversational Flow Interruption & Difficulty in Real-Time Choosing of Questions”

The user’s tended not to give useful information in answering

some of the questions. This is a known potential issue which requires a different approach in asking the questions

- Instead of asking the user directly, the method of the new Survey Tool outlines an approach where the Experimenter now **observes** the user while carrying out a typical task with the product. This allows the Experimenter to determine answers to questions in the Survey Tool through observation. Direct questioning of the users is also employed as appropriate, with questions unanswered by observation at the end of the task being posed directly to the user. This gives the user a “warming up” time period for the user to open up more and the experiences expressed in this latter part of the interview are anticipated to be of more significance.
4. **“Self-Reported Contentment with Everything - A Large Confounder”**
Some of the questions were not appropriate to ask at certain times during the interviews, which would have interrupted the flow of the conversation.
- The restructuring of the interview as in the Quick Sheet (Survey Tool Part#3 of 4) aids in the identification of questions that remain to be addressed. In addition, the new approach of using an observational survey rather than asking direct questions will facilitate better information extraction from the user - with **less self-reporting bias**. Finally, the use of a Quick Sheet of the questionnaire facilitates navigation through the questions by the Experimenter who is under the constraint of keeping the interview flowing to capture additional user experiences.
5. **“5-Point Scale of Answers inappropriate”**
The use of 5-point Likert Scale was excessive for the cohort of older people.
- Answers of “yes”, “no”, and “somewhat” will be determined by the Experimenter by observation of the task being carried out. This could also be done by direct questioning of the user but as already stated the Experimenters found these answers to be unreliable if asked directly.
 - Specifically, users contradicted themselves in the interview - for instance when asked about being “embarrassed” about using the product one resident categorically said they were not but later on in the interview after “warming up” he spoke of a hypothetical scenario in a pub with friends which revealed he would be - and he mentioned directly that he would not be seen with it. Or when asked if something was difficult to press a lady answered “No” but it was clear to the Experimenter that *she found it was* - from a usability perspective. These discrepancies will also be recorded via written qualitative comments from the interview.
6. **“Order of questions not perfect”**
The order of the questions did not fully match the task to be completed

and so these were adjusted to match the order of carrying out a task with a product.

7. “Some questions unnecessary”

Some Questions Removed

- A few questions were removed. For example, those relating to understanding how the technology works, with these now incorporated into questions 8, 9, 10, 11, and 12.

CHAPTER 6: MIXED METHODS DATA ANALYSIS

Introduction

Both quantitative and qualitative data were captured from the home visits to the older people in the community. The following chapter explores the data following the sequence that the questions were asked from the survey tool. The data are examined under the following sub sections:

1. Analysis of demographic data
2. Analysis of data investigating the use of the pendent alarm (including contextual questions)
3. Analysis of data investigating the use of the difficult-to-use technology (including contextual questions)

Analysis of the demographic data:

There were 30 participants recruited to the study, 28 female and 2 male. All participants were over 65 with the eldest being 90. Seven (7) of the 30 participants wore a hearing aid, another participant was in the process of getting one, and another user, having tried, was not able to wear one. All 30 participants wore glasses. Analysis of demographic data was carried out by first grouping the qualitative responses into groups or clusters.

The professions (shown in Fig. 5) of the participants were generally manual labour orientated, with only two people having worked in an office/administration environment. The three most used technologies in those occupations were low tech devices such as vacuum cleaners, tills/ cash registers and sewing machines. Very few of the participants had used digital technology in their work life, with only one having had used a computer (in a role in a financial institution).

Only 23% (n=7) of the people interviewed owned a computer - either a laptop or desktop computer - while 33% (n=10) had attended a formal computer course. However, 47 % (n=14) said that they had used a computer in their lifetime.

Only 1/3 (n=10) of people interviewed were motivated to use a computer. The main motivation for computer use was for communication purposes i.e. using Facebook, Skype, or email. The second motivation was for finding information on the Internet using search engines like Google or Yahoo. The main reason the remainder of the participants were not motivated to use a computer was that they did not see how a computer could contribute to improve or enhance their life or how they would benefit from it. One person who was motivated stated that she lacked the confidence to master and learn how to use a computer.

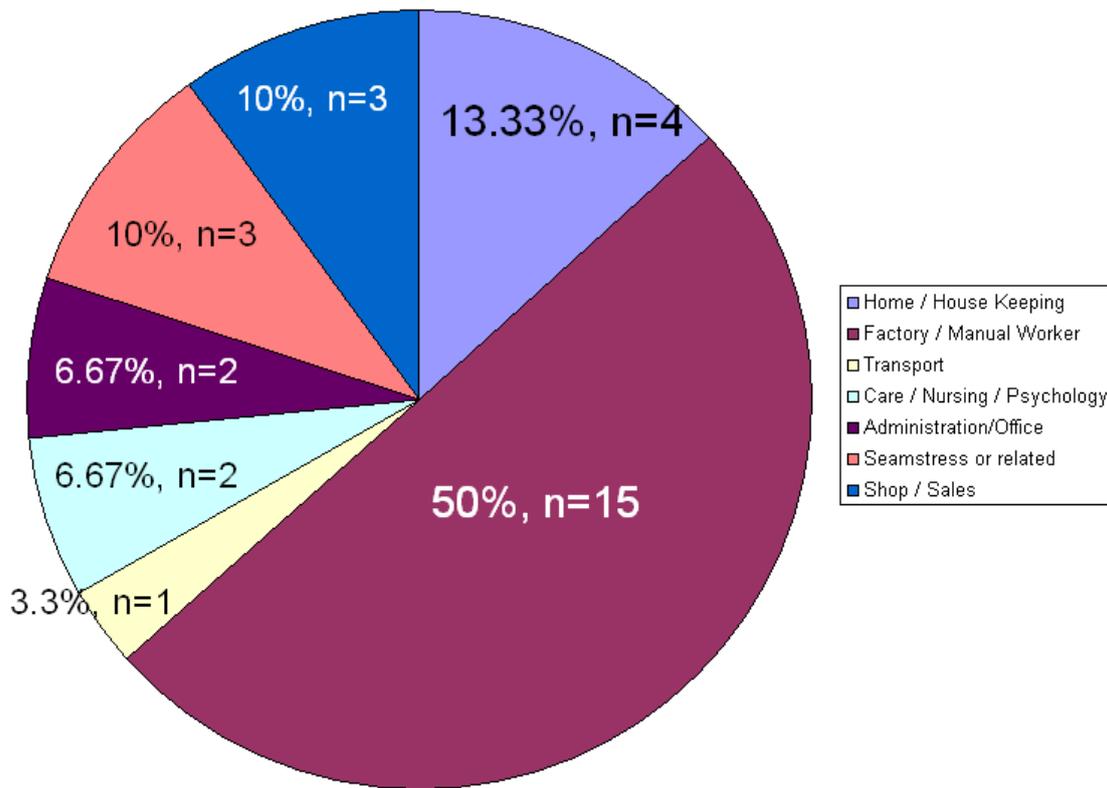


Fig. 5: Type of work the older participants engaged in during their working life.

Answering the question “do you use a digital camera” only 43% (n=13) of respondents owned a digital camera. All of those who own a digital camera have never retrieved the pictures themselves from the camera for the purpose of downloading, storing or printing the photos on a home printer. All sought help and most availed of the services of chemists such as Boots to get the photos developed. None of the owners of a digital camera had an idea or understanding as to how they could possibly retrieve the photos from the camera themselves to a PC or Laptop.

In the study, 90% (n=27) of the participants owned a mobile phone. However, none of the mobile phone owners bought or chose the mobile phones themselves: they were either bought by relatives or were hand-me-down phones.

The participants were also asked the question “How do you figure out how something works”, for example when a new product is bought. The distribution for this is shown in Fig. 6. Nearly 67% (n=20) of participants said they would need someone to show them or would ask someone else to perform the task.

Similarly, when asked the question “What do you do when something goes wrong?” only five of the thirty study participants said they would “have a go” first themselves. Most said they would ask for help and would not attempt to fix or solve the problem themselves. One woman in her 80’s however noted

that she tends to use manuals for everything, the UPC (satellite television provider in Ireland) manual for learning how to record live TV and even a “Windows 7 for Dummies” manual which she found better than courses she had been on. She spoke of being able to ‘rip’ a CD, ‘burn’ a CD, and even to do a ‘System Restore’ which she found from Windows Help & Support. She however, did have a willing nephew in the US who was enabling her to learn for herself and who keeps in touch by email.

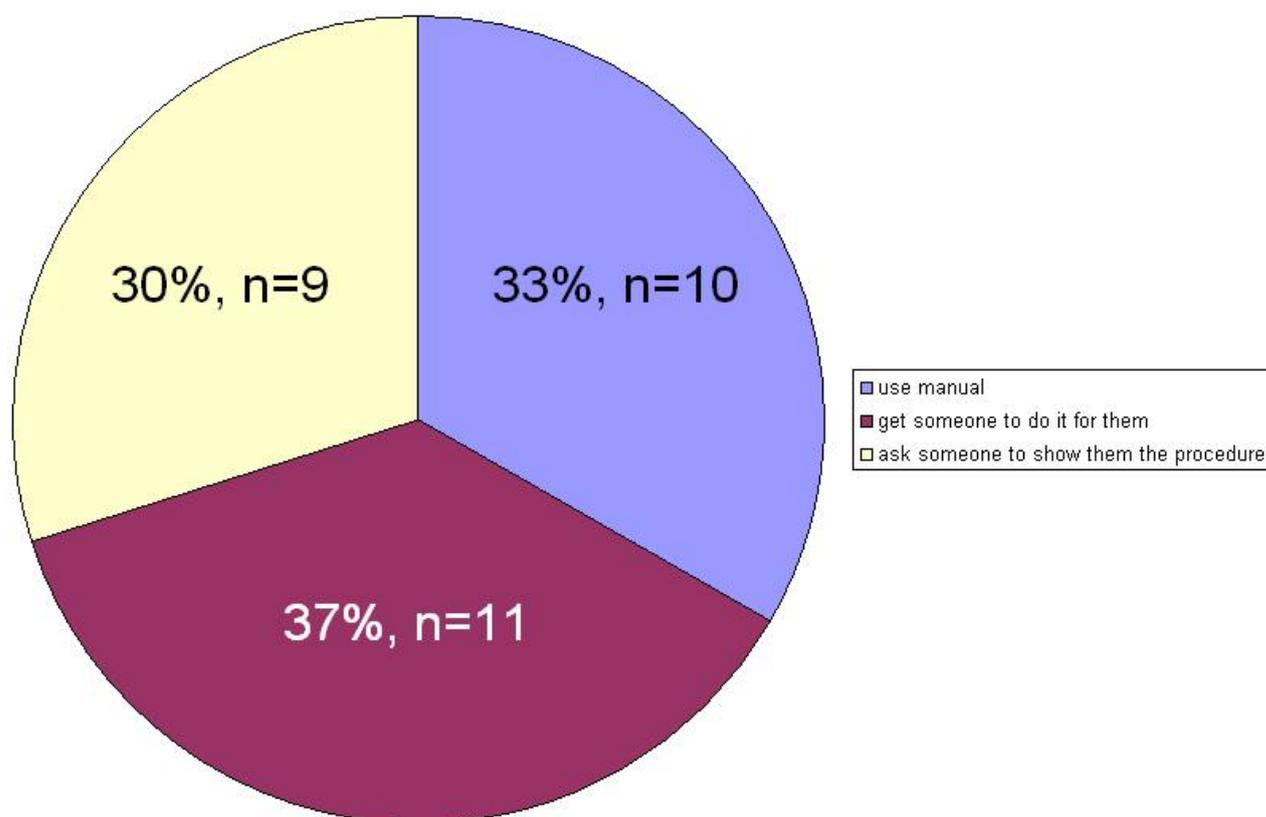


Fig. 6: Categories of strategies the older people employ to figure out how something works.

THE PENDANT ALARM- Data Analysis

Introduction

In the assessment of the pendant alarm technology using the questionnaire, the researchers used the tool to look at one task only. While there are

multiple functions that the pendant system can perform, we looked only at the case of the user pressing the pendant button. This required the user to carry out the follow subtasks:

1. Press the pendant, then
2. Listen for a response from the base unit, then
3. Interact with the Agent on the base unit
4. In some cases when the call was over they would need to press the green button on the base unit to reset the unit. This was in the minority of cases.
5. If the user makes a call and wants to cancel it they need to press the green button (another function of the green button on some systems).
6. If the user was not able to get to the base unit or project their voice loudly enough as to be heard by the Agent via the base unit (as in the case of a fall perhaps) they would need to know the following steps:
 - If the Agent cannot get a response from the user via the base unit the Agent would then hang up, then
 - The Agent calls the house phone (or mobile depending on what is set up for that particular account)
 - If there is no answer the Agent would begin to call 3 pre-agreed telephone/mobile phone numbers which could be relatives, friends, neighbours etc. and ask them to check on the user
 - If none of these three contacts answered the Agent would get a member of An Garda Síochána to the scene to investigate the issue who might then call for an ambulance.

While pressing the pendant button is fairly straightforward, the subsequent steps of the service are not evident to the user from the device interface. Understanding the sequence initiated by pressing the button, requires the user to have remembered the steps as communicated by the engineer installing the device. The user was asked about these steps and if the steps were unknown to the user it impacted on questions 11 and 12 of the questionnaire (shown in Part #3 of 4 in Appendix A) regarding the sequence of steps.

The user would also need to know the function of the green button on the base unit for cancelling a call or in some cases for resetting the device to monitoring mode. This would affect question 8 and 10 and possibly question 15 depending on the response. As detailed below, also note that 3 of the 22 questions were not applicable to the pendant system.

It should also be noted that most of the users visited had the same pendant system. However, since the Seniors Alarm scheme has started, SICCCA (local Community Development Agency who manage the scheme in Dublin 8) have

worked with different companies which supplied different devices. There were 6 different pendants and 4 different base units in the study. However, all shared the same common features and used the same colour scheme for the base unit buttons - red and green. The pendant colours and shapes did differ however, but were similar in size.

In this section on assessing the Pendant Alarm technology use, the contextual questions are considered first, followed by the questions from the main UD questionnaire. An account is given of each question in the UD questionnaire, which considers the statistics across all users for each individual question. A number of design alterations or new features is also tabulated in this section most of which were requested by the users and some prompted to the users by the researchers.

Analysis of questions investigating use of pendent alarm (Contextual):

The first two questions in the Contextual Questions of the Survey Tool (see Appendix A Part #2 of 4) were related to the motivation for getting the pendant. Qualitative analysis of these contextual questions returned six main responses categories from users which are shown in Fig 7. Multiple motivations were given by some older people and so the number of older people who gave a particular motivation is indicated in Fig. 7.

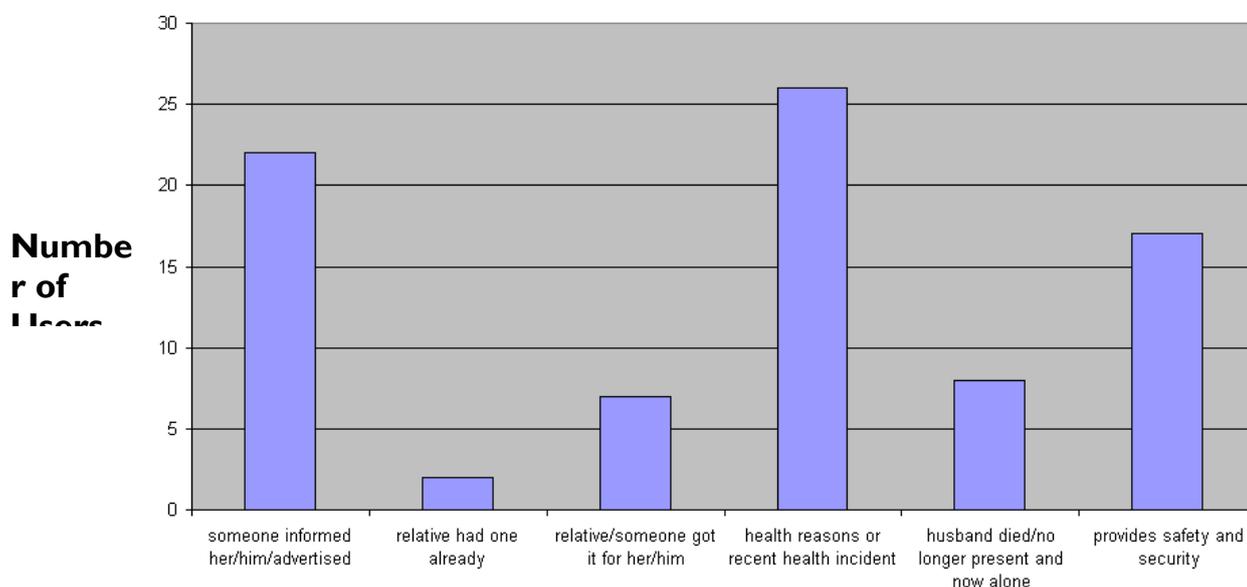


Fig. 7: User motivations for getting the Pendant Alarm. (Y-axis is in units of the number of users that reported a specific motivation).

The majority of older people were motivated to get one because it was recommended by their peers or they felt (for one reason or another) unsafe and felt an additional need for protection and security, which another person (such as their spouse) would have normally provided to them but they are now living on their own. Some users did not actively seek the pendant alarm but availed of it just because it was advertised.

When the study participants were asked the following question - “Where would you use the pendent or wear it?” - three use categories emerged as follows:

- **Category 1:** Wears the pendant pretty much all the time, either around neck, wristband or keeps it in his/her pocket;
- **Category 2:** Only wears it when they feel that they are in danger, for example with activities where they are more accident prone (such as travelling up and down the stairs);
- **Category 3:** Doesn’t wear it at all, but keeps it somewhere where they feel it is most needed in case of an emergency (e.g. beside the bed on a locker).

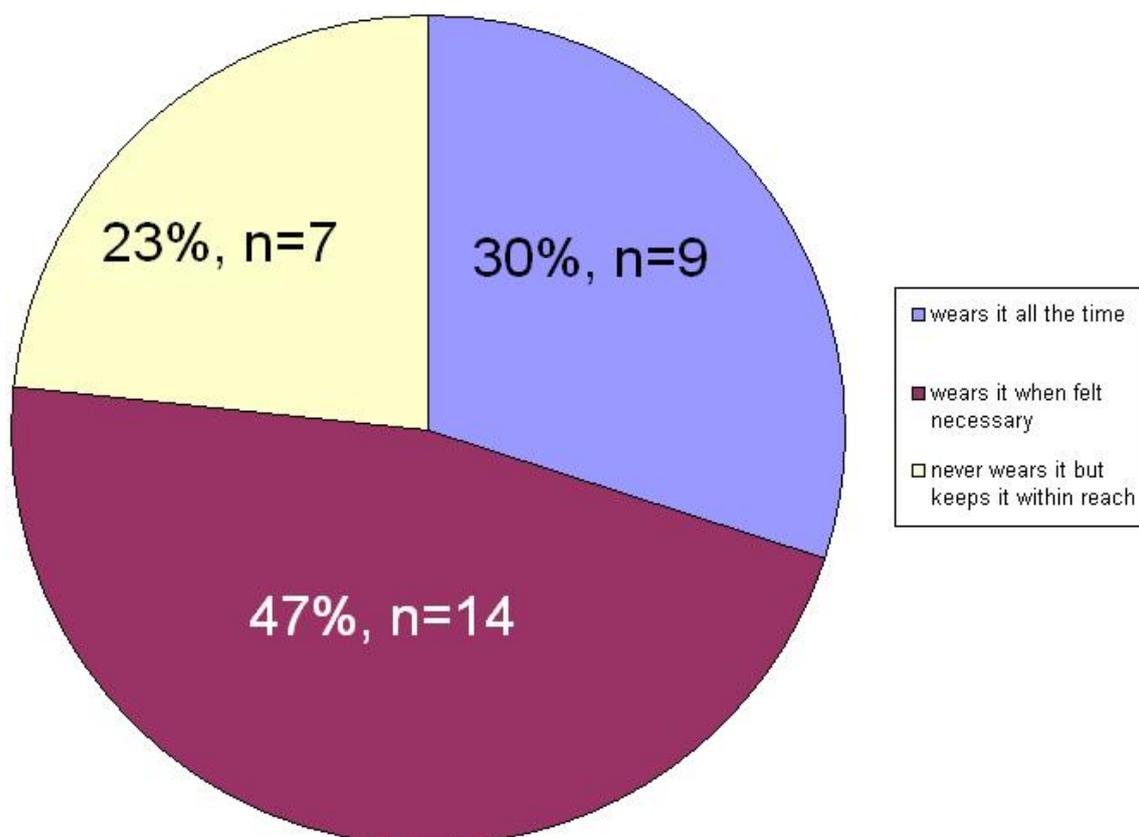


Fig. 8: Categories for when users wear the pendant which indicates the associated frequency of wearing of the pendant (across all subjects)

All users reported that they had at some stage accidentally set off the alarm by pressing either the base unit or pendant button by accident. Many reported that they in fact had never tested it before except when the pendant was installed. This consequently means that some of the pendant systems, upon which people rely, may not work anymore due perhaps to battery failure - but this goes unnoticed by the user.

Assessment of the Pendant Alarm

There were 22 possible questions in the survey - where only 19 were deemed applicable to the pendant alarm system. The responses to the questions either from the user or from the researcher's observations are listed in Table 4. Instructions for the table are given in the next section. Following this there is a section which considers each question from the survey Tool in turn and the main points that arose from the visits which pertain to the Universal Design of the product are highlighted.

Description of Table

In the table (Table 4), the first column refers to the home visit reference number (the prefix "RT" meaning 'real-trials'.) The 2nd column refers to the user identifiers. Column 3 to column 24 are the answers to the 22 questions in the survey Tool, where:

- "1" indicates an answer of "Yes"
- "2" indicates an answer of "Somewhat"
- "3" indicates an answer of "No"

The "TOTAL" section is a running total of all the answers either for an individual user or for an individual question across all users. The minimum for this table would be 19 since there are 19 questions. "#Yes" refers to the total number of "Yes" answers, again for the individual (left hand side statistics) or for a single question across all individuals (bottom statistics in Table 4). "%Yes" gives the percentage of "Yes" answers. Similarly, for "#SW" and "%SW", and for "#No" and "%No". Note: "SW" stands for the answer "Somewhat".

Table 4: Quantitative Data from Survey Tool: The Pendant Alarm

#	Name	Pendant																				TOTAL	#YES	#SW	#NO	% YES	% SW	% NO
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20							
RT1	UN04	1	1	1	1	1	1	2	1	2	2	2	2	3	1	3	1	1	1	2	1	29	11	6	2	57.9%	31.6%	10.5%
RT2	UN05	1	1	1	1	1	1	2	1	2	2	2	2	1	1	3	1	1	3	2	3	31	10	6	3	52.6%	31.6%	15.8%
RT3	UN06	1	1	1	1	1	1	2	1	2	2	2	3	1	1	1	1	1	1	3	1	27	13	4	2	68.4%	21.1%	10.5%
RT4	UN07	1	1	1	1	1	1	2	1	2	2	2	3	1	1	1	1	1	1	3	1	27	13	4	2	68.4%	21.1%	10.5%
RT5	UN08	1	1	1	1	1	1	2	1	2	2	2	1	1	2	1	1	1	3	3	1	28	12	5	2	63.2%	26.3%	10.5%
RT6	UN09	1	1	1	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1	1	1	22	16	3	0	84.2%	15.8%	0.0%
RT7	UN10	1	1	1	1	1	1	2	1	2	2	2	3	1	2	1	1	1	3	2	1	29	11	6	2	57.9%	31.6%	10.5%
RT8	UN11	1	1	1	1	1	1	1	1	2	2	2	3	3	2	1	1	1	1	3	2	30	11	5	3	57.9%	26.3%	15.8%
RT9	UN12	1	1	1	1	1	1	2	1	2	2	2	2	1	1	1	1	1	1	1	1	24	14	5	0	73.7%	26.3%	0.0%
RT10	UN13	1	1	1	1	1	1	2	1	2	2	2	2	1	1	1	1	1	1	2	1	25	13	6	0	68.4%	31.6%	0.0%
RT11	UN14	1	1	1	1	1	1	2	1	2	2	2	2	1	3	1	1	1	1	3	1	28	12	5	2	63.2%	26.3%	10.5%
RT12	UN15	1	1	1	1	1	1	2	1	2	2	2	2	1	1	1	1	1	1	2	1	24	14	5	0	73.7%	26.3%	0.0%
RT13	UN16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	22	16	3	0	84.2%	15.8%	0.0%
RT14	UN17	1	1	1	1	1	1	2	1	2	3	3	2	1	1	1	1	1	3	3	1	30	12	3	4	63.2%	15.8%	21.1%
RT15	UN18	1	1	1	1	1	1	1	1	1	1	1	3	3	2	1	1	1	1	2	1	25	15	2	2	78.9%	10.5%	10.5%
RT16	UN19	1	2	3	1	2	2	1	2	1	1	1	3	3	1	3	2	1	3	2	1	35	8	6	5	42.1%	31.6%	26.3%
RT17	UN20	1	1	1	1	1	2	1	2	2	2	2	1	2	1	1	1	3	2	1	28	11	7	1	57.9%	36.8%	5.3%	
RT18	UN21	1	1	3	1	1	2	1	2	2	2	3	3	1	1	1	1	2	2	2	32	9	7	3	47.4%	36.8%	15.8%	
RT19	UN22	1	1	1	1	1	2	1	2	2	2	2	1	1	1	1	1	1	2	1	25	13	6	0	68.4%	31.6%	0.0%	
RT20	UN23	1	1	1	1	1	3	1	2	2	2	2	2	1	1	1	1	2	1	1	27	12	6	1	63.2%	31.6%	5.3%	
RT21	UN24	1	1	3	1	1	2	1	2	2	2	2	3	1	1	1	1	1	3	1	30	11	5	3	57.9%	26.3%	15.8%	
RT22	UN25	1	1	1	1	1	3	3	3	3	3	3	2	1	3	3	1	3	3	1	38	9	1	9	47.4%	5.3%	47.4%	
RT23	UN26	1	1	1	1	1	2	1	2	2	2	2	1	1	1	1	1	1	1	2	25	13	6	0	68.4%	31.6%	0.0%	
RT24	UN27	1	1	1	1	1	2	1	2	2	2	2	1	3	2	1	1	1	2	1	27	12	6	1	63.2%	31.6%	5.3%	
RT25	UN28	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	3	3	1	25	15	2	2	78.9%	10.5%	10.5%	
RT26	UN29	1	1	1	1	1	2	1	2	2	2	2	2	1	1	1	1	2	3	3	30	10	7	2	52.6%	36.8%	10.5%	
RT27	UN30	1	1	1	1	1	2	1	1	1	1	1	2	2	1	1	1	3	3	1	26	14	3	2	73.7%	15.8%	10.5%	
RT28	UN31	1	1	1	1	1	2	1	2	2	2	2	1	1	1	1	1	1	3	1	26	13	5	1	68.4%	26.3%	5.3%	
RT29	UN32	1	1	1	1	1	1	1	1	2	2	2	1	1	1	1	1	1	2	2	23	15	4	0	78.9%	21.1%	0.0%	
RT30	UN33	1	1	1	1	1	3	1	3	2	2	2	2	1	1	1	1	2	3	1	30	11	5	3	57.9%	26.3%	15.8%	
TOTAL		30	31	36	30	31	57	32	57	58	58	60	48	40	38	31	30	53	69	39								
#YES		30	29	27	30	29	6	29	5	4	4	7	19	22	26	29	30	16	4	23								
#SW		0	1	0	0	1	21	0	23	24	24	16	4	6	0	1	0	5	13	5								
#NO		0	0	3	0	0	3	1	2	2	2	7	7	2	4	0	0	9	13	2								
% YES		100.0%	96.7%	90.0%	100.0%	96.7%	20.0%	96.7%	16.7%	13.3%	13.3%	23.3%	63.3%	73.3%	86.7%	96.7%	100.0%	53.3%	13.3%	76.7%								
% SW		0.0%	3.3%	0.0%	0.0%	3.3%	70.0%	0.0%	76.7%	80.0%	80.0%	53.3%	13.3%	20.0%	0.0%	3.3%	0.0%	16.7%	43.3%	16.7%								
% NO		0.0%	0.0%	10.0%	0.0%	0.0%	10.0%	3.3%	6.7%	6.7%	6.7%	23.3%	23.3%	6.7%	13.3%	0.0%	0.0%	30.0%	43.3%	6.7%								

Assessment of the Results from Individual Questions

1. Q1 *Can reach buttons/controls easily*: No one found it difficult to reach the pendant button as they can all be pressed by thumb or a finder. However, the use case set up by the researchers assessed the pendant in the users' hands or around the neck and over their clothes. In daily use, most users wear the pendant under their clothing and this could make it difficult to reach in the case of any incident (e.g. fall). Some had the pendant rolled up under their undergarments and many hung it on beds etc. away from their normal movement patterns during the day. The importance of this context of the position of the device relative to the person is somewhat unique to the pendant. In future iterations of the UD Survey Tool, a contextual question could be included to look at "reach" as it pertains to normal use. Alternative technology designs could restrict the degrees of freedom that the user has to place the device, avoiding cases where it can be placed "out of reach". For example, maybe it could be embedded in clothing that is worn - so called "wearable computing".
2. Q2: *Buttons/ controls fit (finger) or hand-size*: One user reported the button size being too small. It took her a few attempts to make the button work for her. She asked for the button to be made bigger (has arthritis). However, the design here should ideally cater for individual preference since other more able bodied individuals asked for the pendant as a whole to be smaller in size.
3. Q3: *Gives enough space (between buttons/ controls) to operate, push, turn*. n/a
4. Q4 *Can move/press/grasp/lift buttons/controls easily*: Three individuals were not able to press the button easily.
5. Q5: *Provides enough time for input i.e. to press the button, turn the dial etc* n/a
6. Q6 *Can be used with hearing aid, glasses etc*: All pendant systems could be used with hearing aids and glasses. However, some users may find it more difficult to hear the base unit if it is remote from their location at the time of a button press on the pendant
7. Q7: *Can see the features (perceptual)*: One person was not able to see the LED (Light Emitting Diode) feature mounted on the pendant next to the button since her customised chain was too short. While many of the users did not **recognise** the LED this user could not **see** it because of the chain length. In this case, the user altered the design which was originally set by the manufacturer by making the chain longer so a question on "customisation" could be incorporated into the UD survey tool in future developments.
8. Q8: *Can recognise the features (cognition)*: Most of the people interviewed (80%, n=24) did not recognise all the essential controls of the system. Many did not know what the green button on the base unit did as there was no writing or labelling on it or beside it. A symbol was provided in some designs but it was not understandable even by the researchers. Others did not recognise what the red button was for. One lady actually

thought that the necklace accessory (that the pendant is mounted onto for wearing it around the neck) was another button itself - where she had said "I have two" pendants! As such, she had been going around with a piece of inert plastic as the pendant which could have been disastrous if an incident had occurred. This could be due to lack of instruction on the part of the company/engineer who installed the device. Indeed, a number of users would benefit from a quick cheat-sheet type instruction card indicating the functions etc of the device - including pictures of where and how to initiate an emergency response.

9. Q9: *Can locate/find the main functions (perception + cognition):* All main (required) buttons were in plain view to the user and easy to locate. None were hidden behind panels or underneath main surfaces. However, this result does not cater for the scenarios that make the buttons truly non-locatable. Some users never wore the pendant. One in particular took over 5 minutes to find it since her husband had "tidied it away". Many people had their base units in hard to reach places such as under lockers or under plug boards and books and others had it very low to the ground. This context of use could be controlled for by ensuring that engineers mount the device to a fixed surface as in the case of some of the homes visited where it was mounted to the wall at approximately chest height.
10. Q10: *Can identify what the functions are for (perception + cognition):* Over 80% (n=24) of users were not able to identify what the functions were for. In particular, for the case of the green button function - some users suggested it was used to call - as could be understood if one considers the traffic light model where green means "go". Some users reported that they could just "try every button" if they didn't know which one they should push to make an emergency call. However, the green button cancels a call so if in a frenzy to make a call the red button were pressed first, followed by the green button, the call would be cancelled! However, one of the companies have assured us that such a call would still be followed up since they have had such a case in the past where a user had fallen on the green button after having pressed the red button. However, we cannot comment on the other companies' procedure for this risk event. Again, labelling would help the user identify which button to push.
11. Q11: *Can easily identify in what order sequence the controls/buttons are intended to be used in:* Most users (~87%, n=26) were not able to tell us the steps that occur after the alert button is pressed. It was not clear to the users what the green 'cancel' or 'reset' button was for or when to press it. One company have two versions of their pendant alarm system - one requires the user to press the green button to reset the device after a call has been finished. If it is not done, the unit resets itself 15 minutes later. Another version the Agent can reset the device from his/her end and would tell the user this after the call. Another company's system always resets the device and the green button is only to cancel a call. In one instance the

researchers noted discrepancies between the use of the green button as described in the manual and that recommended by the supplier.

One could argue that the user needs only know to press the alert button and help will get to them somehow. However, in the case of the pendant alarm, it is important for the user to be aware of the full sequence of events. After the alert button has been pressed, the Agent will speak to them via the base unit, and will follow with a phone call to their home if they have not responded. If there is no response, the Agent follows with calls to their three contacts. Finally, the Agent will contact a member of An Garda Síochána or someone else to come to their aid.

The responses from respondents support the view that an understanding of the events set in train by pressing the alert button is important. When asked what they would do if they could not (were not able to) speak to the Agent, some users said they would drag themselves to the phone or somehow try to get in contact for help. This could potentially worsen any injuries they may have sustained from the event leading to the emergency call - such as further trauma and possibly increased anxiety. A number of users when asked what the next step would be if the Agent were not able to get through to the 3 contacts, stated that they would "be left to die" and another said that they would need to "revert back to basics...Dial 999". As an additional design feature the alert system could more clearly elucidate the actions in progress after an alert is initiated. At a minimum, users would be aided by having a simple cheat-sheet of all the steps in the chain so they know what will happen and avoid making any potentially injurious decisions like moving themselves from a more stable position while waiting for help. Indeed, this is the strategy used by some of the users for getting into Facebook and other services even though they use them frequently (e.g. UN33 with getting onto and logging into Facebook).

12. Q12 *Knows how to use/ operate the functions [press, turn, lever flick- operate the sequence]*: Essentially for the case of the pendant Q11 and Q12 are not separable and returned the same results (87%, n=26).
13. Q13 *Behaves like expected (feedback)?*: Feedback was another significant design issue for over three quarters of users (n=23). Many users did not know what the LED indicator on the pendant was for. Some thought it was "dirt". One user thought it was the button that had to be pushed. One user thought maybe it was a "microphone" for the Agent to hear the user from (which is a future design suggestion some put forward). This LED indicator illuminates for ~2 seconds which was found to be very short. If the user was wearing the pendant around the wrist the light tended to be hidden by the hand that pressed the button, and was not visible at all during operation. Some systems gave no feedback on battery status. One system has a monitoring facility where the company issue a new pendant in the post when the battery is operating at only 70%. Many participants asked "What do I do when the battery runs out", others didn't think that

there was a battery in the pendant. In one case, we visited a lady whose battery was dead. We are not sure for how long. Such cases have been reported to us by a public health nurse [Personal Communication] recently. This would have severe consequences since the service would be unusable and the user left without access to their alarm system. A simple design improvement would be an audible alert when a low battery charge is detected.

14. Q14: *Works the first time around without repeating (pushing, turning, reaching, grasping, lifting)*: Approximately one third of people (n=11) had to press the alert button a number of times to make contact with the Agent. In the majority of cases this was due to dexterity limitations of the user. In others, it was found that a clear response was not received from the monitoring centre within a few minutes of pressing the alert button and the users were asked to try for a second time. All worked the second time around. Some systems took 3-4 minutes to get a clear response from an Agent whereas many users expected (and one company has reported) it to take less than 30 seconds [Personal Communication]. It is interesting that most users praised their systems for its speed in making contact with an Agent. This was usually informed by a prior experience of accidentally pressing the button. Nevertheless, when the button was pressed during the research visit, many commented that contact with the Agent was taking longer than they had remembered. It could be speculated that with their previous experience of system activation users heard the base unit come on a few minutes later after accidentally pressing the button, but supposed that they had just pressed the button.
15. Q15 *Simple / easy to remember how it works*: The result of this question on memory (Q15) suggests that it is simple and easy to remember how the system works (>73% of users, n=22) within the basic functional context of system activation. Of course, if 'how it works' is taken to incorporate a full understanding of the sequence of events initiated by a system activation, then the results are less favourable (Q8, Q11). However, we cannot delineate in this study which elements of this lack of understanding relate to memory. Since the system is rarely activated (some users went years without a single button press) the likelihood of forgetting how the system and service works is high.
16. Q16 *It does not strain (annoy) to use*: In terms of the task achievement and post-use phase, most of the users were highly satisfied with having the pendant and it didn't annoy them (~87%, n=26). One user called it "Her pal" and that she "takes him for a walk" when going up the stairs (since she had a previous incident of falling on the stairs). Another called it her "little companion". Others stated that she "wouldn't be without it" and would "recommend it to anyone". While this is the case, some did state that it affected their independence and made them "feel old". This annoyed them somewhat. Another user who had arthritis said that the pendant was too heavy for her neck.

17. Q17 *Not exhausted after using*: One arthritic user stated she has soreness in her hands after pressing the button.
18. Q18 *No need for a break, or a rest*: No one needed a rest after using/pressing the pendant button. However, again, in the use case of the base unit sometimes the users would feel the need to go upstairs to answer the pendant alarm base unit after pressing the pendant button - some reported “running” up or down stairs to do so. They could have waited for the house phone to ring but were unsure of this step in many cases and feared an ambulance or something coming to their door if they didn’t get to it!
19. Q19 *Do not feel embarrassed using this product?*: Looking at the fun factor and experience by the user, some were somewhat embarrassed by using the product (>45%, n=14) - mostly because of the look and design - but others because it made them feel old. The researchers were hesitant to ask this question directly since the users might be made to feel that they should be embarrassed or because it might induce some negative sentiments towards the interviewers/researchers and impact on the interview. It was usually posed as “do you mind wearing or having to wear the pendant”. It was clear that some participants were embarrassed by wearing the pendant as they spoke of not wearing it around other people or about hiding it under their clothing. However, some users put the pendant under their clothing because it “gets in the way”, so it may not always be embarrassment that causes this behaviour or action. The approach to uncovering user’s sentiments towards this or other technologies in the survey may need further development.
20. Q20 *Like the looks/design*: In terms of the design and look of the pendant it was somewhat obvious starting out that it was not going to score well. Only ~13% (n=4) were happy with the design and look of the pendant - again self-reported. Some felt it made them look and feel old while others just thought it looked “gaudy” and the red button “jarring”. One asked for it to be “pink” for it to have “a bit of bling!” and to “dazzle it up”. Another suggested “some diamonds or something”. Many wouldn’t wear it for this reason of poor aesthetics. One asked for it to be made as a “broach” where she would then consider wearing it. Another didn’t want to wear it at all but asked for a version she could have in her pocket. (see Table 5 for a full list of design suggestions).
21. Q21. *Easy to use comfortably*: Most users (~77%, n=23) found the pendant easy to use comfortably. Some however, as mentioned already, found that the strap was not breathable enough or left a rash on their wrist. It is suspected that the reason more did not say this is because most didn’t wear it all the time (when ideally they should). Many associated the comfort question as relating to being pleased with the service too which overlaps with Q16. One lady found the pendant too heavy for her neck since she had arthritis in it.

22. Q22. *Enjoy/ is it fun using it:* N/A: It was felt that this question was not suitable to ask the users for this security alarm device as many got it after and as a result of their spouse that had died and used it for reasons of contacting someone in case of an emergency. However, it could be interpreted that many did enjoy using it as many said it was “reassuring” gave them “comfort”, “peace of mind”, “like someone holding your hand”, and “my pal” and “my little companion”. It gave many users comfort just knowing the service was there and felt more at ease in bed at night.

Summary of Pendant Alarm Assessment

To summarise, during the interviews and watching the users handling and interacting with the system, the following usability issues were observed:

- The majority of the participants had a positive view of the pendant alarm systems as an aid to independent living.
- The basic activation function of the pendant alarm was generally well understood. A small number of participants had difficulty in pressing the activation button due to dexterity issues.
- Participants were generally unclear about the functions and use of the buttons on the base station since the buttons did not have any labelling.
- There was lack of understanding of the sequence of events initiated by activating the alert button. The design of the devices and associated labelling do not clearly convey the steps taken by the Agent or the progression of these steps during an activation.
- Regarding feedback on device, the small light (indicator that lights when the button is pressed on the pendant) on the pendant was typically not noticed by the users. In addition battery status was not indicated on some systems.
- The base station unit was usually located in another room, making it difficult for the participants to hear the Agent’s voice when the button was pressed. This led to uncertainty among users if the system worked. Furthermore, for reassurance they noted that they would like to be able to talk to someone and keep talking to them in the case of an emergency until help has arrived.
- The Pendant chain was too long.
- People felt in general embarrassed wearing the device and wished it was smaller, so that it can be hidden under clothes.

- In general, users had never really experienced use of the system other than when shown the system by the installer.

See also Table 5, summarising design modifications suggested by and discussed with users during the visits.

Table 5: Design Suggestions for the Pendant Alarm Systems

#	DESIGN SUGGESTION
1	The material in the wrist strap causes rash from much use (back of hand). Alternative strap material needed.
2	Prefer to have base unit in another room - cannot hear unit from the bedroom
3	Somehow be able to communicate in a room other than where base unit is located
4	Like to have a microphone in the pendant to talk with the Agent (and loudspeaker)
5	Diamond-like design in the pendant!
6	Strap keeps loosening (grey strap and mode). Better strap.
7	Prefer a neck strap (only has a wrist version) - more choice for the user (available in some models already)
8	Button is too sensitive (stopped her wearing it) although might prefer to have this than it being too hard to press
9	Need an information sheet on what base unit buttons do and other system steps
10	Reposition base unit away from phones to reduce accidental pressing
11	Make pendant a bit smaller (one person suggested for it to be like the size of the miraculous medal she wears)
12	Information - what if battery dies, do I change it
14	Warning or cyclic facility to check if your 3 contact phone numbers are still suitable or in use e.g. mobile phone numbers can change
15	Pendant needs to be smaller. Too bulky for wrist. (never wears it)
16	Shorter strap for neck - (one person adjusted this for herself)
17	Bit big under clothes as wrist watch (she likes to conceal it under her sleeve).
18	Red button is a bit jarring (although understands it is a colour that might help people with poor sight)
19	Make the pendant waterproof
20	Bigger button preferred (for Alertline blue pendant)
21	Constant light indicator - red when on standby, green when pressed
22	Pop out button when it is pressed (like the TV) - indicates proper activation
23	Smaller base unit box

- 24 Would like a wrist watch version - only has neck pendant - would wear to bed then.
- 25 Make it washable - gets gritty underneath on wrist. Washes some of it but researchers observed considerable dirt remaining
- 26 Button a bit stiff (arthritis) so make looser -she suggested it might loosen up after a while
- 27 Monitoring station or local system should flag a dead battery (as in this woman's case her pendant was dead)
- 28 Information on how to use the system more ready to hand (mistook necklace accessory as the actual button)
- 29 Leaflet to keep checking how it works? In an accessible format
- 30 Don't wear around neck because it doesn't look nice. Wears it under her undergarments. Needs to look nicer
- 31 Would wear as a broach type on t-shirt. Would then start to wear it.
- 32 Radius of use of pendant should be wider so she can go to brothers next door.
- 33 Another base unit downstairs (has one upstairs)
- 34 Bit of bling! - still trying to be glamorous - too plain - dazzle it up a bit
- 35 Pink colour
- 36 Not enough strap length for wrist. Longer strap for wrist.
- 37 Not elastic enough strap for wrist. More elasticity in the strap.
- 38 Centre answers too slowly - 1-2minutes. Faster response time.
- 39 Pendant should work everywhere - otherwise what is the point
- 40 If going to wear outside need different design (none suggested)
- 41 Would not wear on wrist or on neck since she likes her medals and watch. So would keep in pocket if it was square in shape
- 42 Would prefer round type pendant - like watch but not a watch
- 43 Strap heats up when on wrist. Need to take off for while to cool down - better material - perhaps breathable.

THE DIFFICULT TECHNOLOGY - Data Analysis

Introduction

In the assessment of the older people's difficult technology, the researchers used the Survey Tool to assess one task only. This task was the main task that the older person would use the technology for. For example:

- Gas Fire – turning it on and off and using the lighting functions.
- Mobile phone – making and receiving a call. However, if the normal use of the phone was texting, we had the older person make and receive a text message.
- TV – navigating the channels, changing the volume, and turning the TV on and off. However, if the older person used more advanced features we asked them to perform this task for us to observe. For example, to record a TV programme or to navigate to the 'RTE Player' and select a programme they would normally watch, and afterward to return to the normal TV viewing (exit the 'RTE Player' service).
- DVD Player – turning it on and off, and to put on a DVD and use the controls to play it.

The steps in these tasks were not as well defined as the steps used to assess the pendant alarm system since there were various 'use cases' of the devices. For example, in the case of the mobile phone, some older people assessed only used the phone to make calls; whereas others used the mobile phone mainly to send and receive text messages. A further complexity in setting up and assessing the task for the user was there were many different models of phones (e.g. iPhone, Touchscreen Samsung, Nokia) so navigation for making a call or creating and sending a text message differed greatly between phones. Therefore, we selected a task by asking each participant what task they would "normally" carry out on the mobile phone.

Almost all technologies assessed were rich in their feature set and so all questions in the Survey Tool (22 questions) were applied. In the original design of the Survey Tool (shown in Chapter 4) we had suggested that during the home visit, before assessing the difficult technology, the researcher would highlight what questions from the questionnaire were not applicable to the technology being assessed. Nevertheless, it was found that all 22 questions applied in all cases since none of the difficult technologies assessed were simple single button devices or had minimal controls. We purposefully endeavoured to assess difficult technologies that were feature rich and complex in their controls in order to address the memory and cognitive function of the cohort of older people.

It was an overriding theme in the home visits that the older people tended not to be forthcoming with any technology they found difficult. As such, it took

some steering and investigation on the part of the researchers to find out what technology was difficult for them to use in their home.

In one case where a lady (UN07) reported that everything was “fine” and that nothing was difficult for her to use, we nevertheless found that she had a gas fire for years which she still, on many occasions, needed to ask neighbours for help in getting it to light and emit heat. The design was indeed found to be poor. This tendency to not come forward with a difficult technology may be because they do not want to appear incapable especially in their own homes. A more likely explanation would be that the participants do not have the same conception as the researchers (and perhaps a younger generation) of the meaning of “difficult to use”. It is possible that they may not consider items which have inherently poor usability-but which they have ‘gotten used to’-as “difficult to use”, but reserve this phrase primarily for new technologies.

In another instance, a lady (UN23) who said she had no “difficult to use” technology mentioned that she had a radio/tape/cd player for many years. She did not know how to skip forward or back through the tracks and when asked if she knew how she said that she doesn’t like to - that she likes to listen to it all the way through. Later on when showing her how to do it she was very excited and spoke of how happy she was to know this now. Therefore, she may have told us she doesn’t like to skip through the tracks because she didn’t want to say she didn’t know how. Or, yet again perhaps it is more likely that she may have convinced herself she only likes to use it in this manner because this is how she has always used it - the only way she knew how. This shows the significant weakness of a remote (web based/postal based) questionnaire being used to assess difficulties in the lives of older people. It requires researchers to enter the “context of use” of a device in a user’s home to determine what “difficult to use” technology the users have.

Assessment of Difficult Technology

The Survey Tool has 22 possible questions and all of these were deemed applicable to the technology assessed in the home visits. The responses to the questions, either from the user or from the researcher’s observations, are listed in the Table on the next page (Table 6).

Description of Table

The first two columns are the same as described for the table of results (Table 4) for the Pendant Alarm technology. The third column however, lists the technology assessed for a particular individual - their “difficult technology”. The rest of the columns are the same as described for the Pendant Alarm table of results except that all 22 questions now apply, rather than only 19 for the pendant alarm.

Table 6: Quantitative Data from Survey Tool: Difficult Technology

#	Name	Tech	Difficult Technology																				TOTAL	#YES	#SW	#HO	% YES	% SW	% HO	
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20								21
RT1	UN04	Laptop	1	1	1	1	1	1	2	1	2	1	1	1	1	3	1	1	1	1	2	1	1	27	18	3	1	81.8%	13.6%	4.5%
RT2	UN05	TV-Remote	1	1	2	2	1	1	1	1	2	1	1	1	1	2	3	1	1	1	1	1	1	29	16	5	1	72.7%	22.7%	4.5%
RT3	UN06	TV-UPC Remote	1	1	1	1	1	1	1	1	2	2	2	1	1	1	2	1	1	1	1	2	1	29	17	5	0	77.3%	22.7%	0.0%
RT4	UN07	Gas Fire	3	3	1	3	1	1	3	3	3	3	3	2	3	3	3	3	2	1	2	3	3	54	4	4	14	18.2%	18.2%	63.6%
RT5	UN08	Laptop	2	1	1	1	1	1	2	2	2	2	2	3	3	3	3	2	1	3	2	1	41	8	9	5	36.4%	40.9%	22.7%	
RT6	UN09	CD, Tape/Radio Player	2	1	3	3	1	1	1	3	3	3	3	3	3	3	3	2	1	1	1	2	47	8	3	11	36.4%	13.6%	50.0%	
RT7	UN10	Laptop	1	1	1	1	1	1	1	1	2	2	2	1	3	3	1	2	1	1	2	1	31	15	5	2	68.2%	22.7%	9.1%	
RT8	UN11	Mobile Phone	3	1	1	2	1	1	2	1	2	1	2	1	3	2	1	3	3	2	1	3	40	10	6	6	45.5%	27.3%	27.3%	
RT9	UN12	DVD Player	1	3	3	3	1	1	3	3	3	3	2	2	3	3	3	3	3	1	2	3	53	5	3	14	22.7%	13.6%	63.6%	
RT10	UN13	iPhone	1	1	1	1	1	1	1	2	1	2	1	2	2	1	1	1	1	1	2	1	27	17	5	0	77.3%	22.7%	0.0%	
RT11	UN14	Mobile Phone	1	1	1	1	1	1	1	2	2	2	2	1	1	3	3	1	1	1	1	2	31	15	5	2	68.2%	22.7%	9.1%	
RT12	UN15	Digi. Terr. TV UPC (no box)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	22	22	0	0	100.0%	0.0%	0.0%	
RT13	UN16	DVD Player	1	2	2	2	1	1	1	1	1	1	1	1	3	1	2	1	1	1	3	1	30	16	4	2	72.7%	18.2%	9.1%	
RT14	UN17	TV-UPC Remote	1	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1	1	3	2	1	28	17	4	1	77.3%	18.2%	4.5%	
RT15	UN18	Laptop - Win7	1	1	2	1	2	1	1	1	1	1	1	2	2	1	1	1	2	1	2	2	29	15	7	0	68.2%	31.8%	0.0%	
RT16	UN19	Mobile Phone	1	2	2	1	1	1	2	1	2	1	1	1	2	1	3	2	1	1	1	2	31	14	7	1	63.6%	31.8%	4.5%	
RT17	UN20	TV-UPC Remote	1	1	1	1	1	1	1	2	1	1	3	2	3	2	1	2	1	1	2	1	31	15	5	2	68.2%	22.7%	9.1%	
RT18	UN21	TV-UPC Remote	1	1	1	1	1	1	2	2	1	2	2	1	3	3	1	3	1	2	2	3	38	11	6	5	50.0%	27.3%	22.7%	
RT19	UN22	TV-UPC Remote	1	1	2	1	1	1	1	2	1	2	3	1	3	2	2	1	1	1	2	1	32	14	6	2	63.6%	27.3%	9.1%	
RT20	UN23	CD Player/Radio	3	1	3	2	1	1	2	3	3	3	3	3	3	3	3	1	1	1	1	3	46	9	2	11	40.9%	9.1%	50.0%	
RT21	UN24	SkyBox & TV	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	2	1	25	19	3	0	86.4%	13.6%	0.0%	
RT22	UN25	Mobile Phone	1	1	2	1	1	1	1	2	3	2	2	1	3	2	2	1	1	1	1	3	35	12	7	3	54.5%	31.8%	13.6%	
RT23	UN26	Oil Radiator (plug-in)	3	1	1	1	1	1	3	3	3	3	3	3	3	3	3	3	1	1	2	3	48	8	2	12	36.4%	9.1%	54.5%	
RT24	UN27	Oven	1	1	1	1	1	1	1	2	1	2	2	1	1	2	1	1	1	1	3	1	28	17	4	1	77.3%	18.2%	4.5%	
RT25	UN28	Cordless Eircom Phone	1	1	1	1	2	1	2	2	1	1	1	1	2	1	1	1	1	1	1	1	26	18	4	0	81.8%	18.2%	0.0%	
RT26	UN29	Radio/CD/Tape player	2	1	1	1	1	1	1	3	1	2	1	1	1	3	1	1	1	1	1	1	28	18	2	2	81.8%	9.1%	9.1%	
RT27	UN30	TV-UPC Remote	1	1	1	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1	2	1	25	19	3	0	86.4%	13.6%	0.0%	
RT28	UN31	Touchscreen phone	1	1	1	1	1	1	1	2	2	2	2	2	2	4	2	2	2	2	1	1	35	11	10	0	50.0%	45.5%	0.0%	
RT29	UN32	Laptop	2	1	1	2	1	1	1	2	2	1	1	1	3	3	2	3	1	1	2	2	35	12	7	3	54.5%	31.8%	13.6%	
RT30	UN33	Laptop - Win Vista	1	1	1	2	2	1	1	2	1	2	2	2	3	3	2	3	1	1	3	3	39	10	7	5	45.5%	31.8%	22.7%	
TOTAL			42	36	42	42	33	30	45	57	53	52	51	43	64	68	51	57	39	34	41	63	39	36						
# YES			22	26	21	21	27	30	18	9	13	13	15	20	11	7	16	14	23	26	22	7	24	25						
# SW			4	2	6	6	3	0	9	15	11	12	9	7	4	9	7	5	5	4	5	13	3	4						
# HO			4	2	3	3	0	0	3	6	6	5	6	3	15	13	7	11	2	0	3	10	3	1						
% YES			73.3%	86.7%	70.0%	70.0%	90.0%	100.0%	60.0%	30.0%	43.3%	43.3%	50.0%	66.7%	36.7%	23.3%	53.3%	46.7%	76.7%	86.7%	73.3%	23.3%	80.0%	83.3%						
% SW			13.3%	6.7%	20.0%	20.0%	10.0%	0.0%	30.0%	50.0%	36.7%	40.0%	30.0%	23.3%	13.3%	30.0%	23.3%	16.7%	16.7%	13.3%	16.7%	43.3%	10.0%	13.3%						
% HO			13.3%	6.7%	10.0%	10.0%	0.0%	0.0%	10.0%	20.0%	20.0%	16.7%	20.0%	10.0%	50.0%	43.3%	23.3%	36.7%	6.7%	0.0%	10.0%	33.3%	10.0%	3.3%						

User's difficult technologies

There were 11 different devices/technologies assessed in the home visits which were deemed difficult to use. These were:

1. Laptop (various Operating Systems)
2. Digital TV with UPC Set Top Box (STB) and Remote Control
3. Digital TV with Sky Set Top Box (STB) and Remote Control
4. Digital Terrestrial TV (no STB) and Remote Control
5. Mobile Phone (various models including iPhone and other touchscreen models)
6. Gas Fire (with button starter)
7. CD/Tape/Radio Player (various models and designs)
8. Oil Radiator (plug in)
9. Cooker Oven
10. Cordless Telephone
11. DVD Player (various models)

It is worth noting that most technologies explored could be considered entertainment devices, e.g. TV, Radio, and DVD Player. The technology categories of difficult-to-use technologies assessed with the users are listed below.

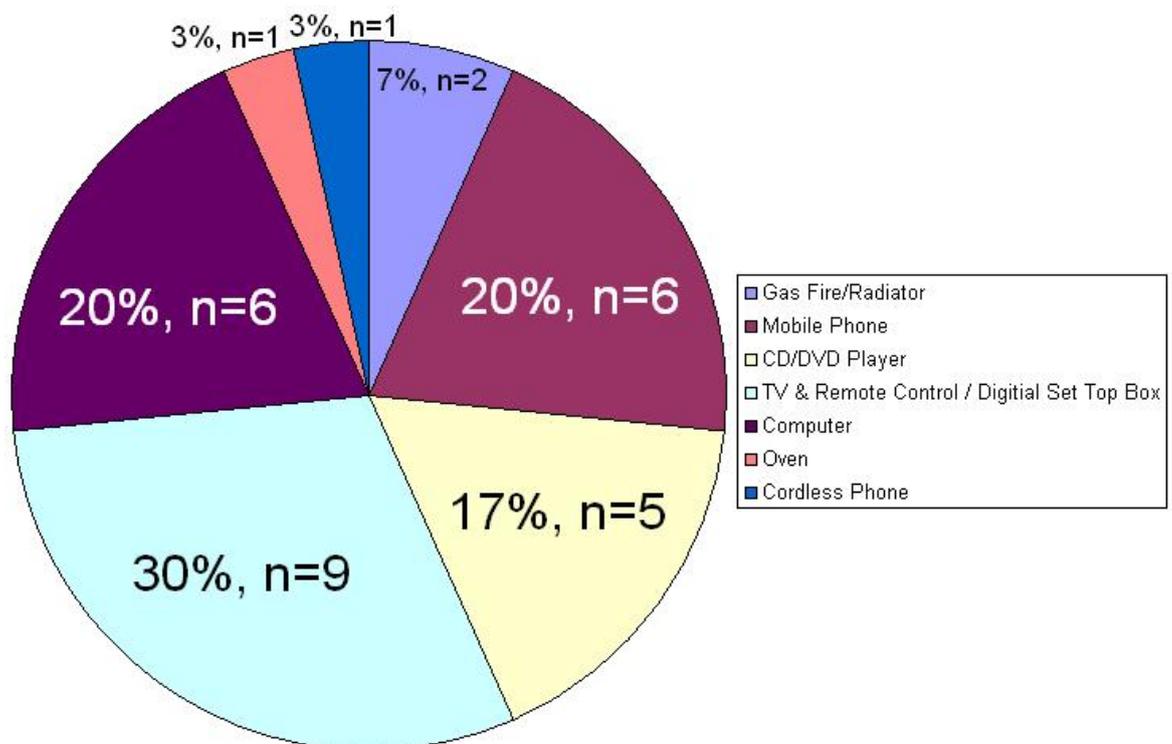


Fig. 9: Type of technologies perceived as difficult to use by older persons and the contribution of each categories shown expressed in percentage.

Some common usability problems emerged with the difficult technologies assessed and these are explored next. Following this, some findings from each question are posed which are an assessment across all difficult technologies assessed in this study.

Usability Issues and Violations in the user's Difficult Technologies

Usability problems which were observed while interacting and observing the older people using selected hard-to-use pieces of technology in their home were related to general bad design and bad usability. This was therefore a case of the technologies violating the usability principles and as such the difficulties encountered by the users were in all instances (except two cases) not related to ageing.

The following violations of usability principles (see Figure 1 in Chapter 3 for examples of these) in the designs were found:

- Controls were placed out of sight, too low to the ground or were too small, which could be accessed only by either kneeling down or tilting the device to gain access to view the controls
- CD/ cassette players violated the principle of proximity. Controls were disassociated with the functional elements and were located elsewhere on the device away from the functional elements.
- Functions were in general not labelled, leaving the user to wonder what the functions are for and how to operate them.
- People got stuck in a mode. Modes were very popular with most designs and users got trapped in a mode function and did not know how to get out of it again.
- The Principle of Consistency was violated in particular with the digital recorders and program guides (TV set top boxes) where different colours were used for confirming an action. For example, in one step the colour yellow (representing the yellow button on the remote control) was used to confirm an action whereas in a further step in the same submenu the yellow button was used to 'delete' things.
- Feedback and clues on how to execute a function was not provided. For example, one SkyBox menu did not provide any indication that the function to view "other channels" had to be confirmed by pressing a button ("Select") which lead to multiple attempts by the Researchers in trying to add this program.

Assessment of Difficult Technologies – Individual Questions from the Survey Tool

1. Q1 *Can reach buttons/controls easily*: Most users (73%, n=22) did not have any issues with reaching a device or control easily. One exception was the gas fire where the buttons were placed on the top left hand side of the fire. Curiously, the user originally upgraded from a gas fire which she reported had the buttons on the underside of the bottom of the fire, making them harder to “reach”. However, she now finds that the new design is even more difficult to use than what she previously used. This poor choice in a device was perhaps down to a lack of testing the device before purchasing it. The difficult in starting it was the complexity (by transparency) of needing to know that the button had to be held for a number of seconds and then importantly released to allow the fire to ignite. The Researcher took a few attempts to figure this out, possibly by searching strategies he knew from other technology which he was able to apply to the current model. The older user in this case did not have this strategy in memory possibly down to a lack of exposure to technology and its variety of common designs. The other technology was the oil radiator. The user reported having never seen an LCD panel in over a year of use since it was very low down. Even if the researcher were to suggest that this panel was not used, the actually controls for basic use were such that the radiator needed to be tilted in order to be able to read the symbols (which were also poor). To further compound the issue, this user had arthritis.
2. Q2: *Buttons/ controls fit (finger) or hand-size*: DVD players and CD players were found to be the worst for having buttons that were too small for the users.
3. Q3: *Gives enough space (between buttons/ controls) to operate, push, turn*: Similarly, DVD players and CD players were also found to be poorly designed (some models) with very little space between buttons.
4. Q4 *Can move/press/grasp/lift buttons/controls easily*: Overall users were able to press buttons and operate controls easily (70%, n=21). However, it was found that older users tended to press buttons harder (with hands trembling) than necessary in order to ensure an activation of the control. In some cases, this tended to repeat the action of the control (as if they had pressed the button multiple times) causing them to have to try again.
5. Q5 *Provides enough time for input i.e. to press the button, turn the dial etc*: Laptops were the main technology which didn’t provide enough time for the user to input to the device. Pop-ups appeared on screen or other windows came to the foreground while the user was engaging in a task. The unwelcome interruptions caused confusion and made them think they had done something wrong.
6. Q6 *Can be used with hearing aid, glasses etc*: All devices could be used with hearing aids and glasses.

7. Q7 *Can see the features (perceptual)*: Some users had difficulty seeing the features of the device. A common flaw with DVD players is that the buttons are the same colour as the casing of the device. Users tended to have to “feel around” for the buttons without visual feedback. The gas fire was similar with small black buttons on a black background. Some users had advanced ocular diseases and required aids in the home such as “bump-ons” to determine where settings were such as cooker knobs. This question distinguished this group but it also was confounded with cases of poor design – such as buttons being the same colour as the casing (this confounder is discussed in chapter 7).
8. Q8 *Can recognise the features (cognition)*: Recognition of features was again highlighted as an issue in the design of these consumer products. Only 30% (n=9) were found to recognise features sufficiently. Labelling, instructions, and other indicators were seen as lacking in some of the technologies.
9. Q9 *Can locate/find the main functions (perception + cognition)*: Over half of the users (~56%, n=17) had difficulty locating the main functions of the devices. This was prominent in laptop devices where more training is required and perhaps bespoke interfaces for the novice could be developed. Such simplified interfaces do exist on mobile phones and could be extended to the PC and laptop to reduce the feature set for the user - in the beginning at least in order to familiarise the user with the new concepts and have them gain confidence in using the technology.
10. Q10 *Can identify what the functions are for (perception + cognition)*: Over half of users (n=17) were not able to identify functions of a device. One example was a CD player. Two users interviewed had the term “Tape” confused with the term “CD”. They called a CD a Tape. As such, when going to use the CD they actually used the “TAPE” settings and switched the main power switch to “TAPE” rather than to “CD”. This would of course could be helped with training (which we conducted in the homes) but it would be best if it were designed to be more easy to use and more obvious in how it should be used. One user actually pressed play on the TAPE controls and later pressed play on the CD controls. This reinforced the incorrect assumption that the TAPE play button is somehow the correct one to use as well as the CD play button. The design flaw here was that there was no linking graphical information beside the buttons that the different groups of controls pertained to either the TAPE of the CD player. While this is not an issue for the younger generation who has this rich symbol set built up, the older user struggles especially when living on their own. The two users in this case, had the CD/Tape players for many years so it wasn’t a lack of familiarity but a lack of training (which they do not get since they live alone and do not expose this technology to other people), lack of clarity in the design, a lack of information (for familiarity with symbols), or a lack of labelling on the device which should specify what buttons pertain to what subdevice on the device.

11. Q11. *Can easily identify in what order sequence the controls/buttons are intended to be used in:* Half (50%, n=15) of users were not able to identify the order sequence intended of the use of controls to work a device. This was especially true of users of the internet where many options are available to the user at any one time. The iPhone was an example of a device where the sequence was more easy to navigate. This was due to the fact that few categories of inputs (for general navigation) were presented at any one time on the screen (for playing music for example). Google search engine is another good example of a stripped down interface reducing the likelihood for incorrect use.
12. Q12 *Knows how to use/ operate the functions [press, turn, lever flick- operate the sequence]:* While half of the users were not able to identify the order sequence that the controls should be used in, they sometimes guessed it and so only 33% (n=10) of users were not able to operate the sequence satisfactorily. In other cases they made do by pressing a few different controls until it started to do what they wanted it to. Like the pendant alarm, there is a danger that if all buttons are pressed there may be a negative consequence. In their struggle to operate a sequence they may try many buttons and may incur negative consequences. This happened in the case of an older user in this study with her TV. She mentioned that she was “hopeless” with technology and that she only knows how to change channels up and down. Sometimes however she told us that she lost all the channels from doing something incorrectly in the sequence. This incurred a loss of independence for her where she relies heavily on family members to do most things for her, especially with regard to technology. She couldn’t understand why she had two remote controls for her TV and asked if it could maybe only be one remote control with only channel up and down buttons, volume and power on/off.
13. Q13 *Behaves like expected (feedback)?:* The user mentioned in the previous question had a case where her TV would go on standby after a certain period. She expressed her frustration at this as it would often happen at crucial moments in her TV programme (Fair City). The researcher later discovered that there was an energy saving setting on her TV which put it in standby after 4 hours and this was disabled during the visit. While there was feedback that the TV was going to go into standby there was no instruction as to how to disable it. The user was completely helpless here. The device did not behave as expected. This was a significant issue for the users where over 63% (n=19) found that their device did not behave as expected.
14. Q14 *Works the first time around without repeating (pushing, turning, reaching, grasping, lifting):* Over 73% (n=22) of users had difficulty in getting something to work first time around. They needed to repeatedly press a button to get it to work. This was many times due to a lack of feedback from the device that the device was activated or their lack of understanding what the feedback cues given actually meant. It was a theme

of the study that users tended to press a button a number of times to get it to work. The gas fire example was one such case, where it took 2-3 attempts by the user and 2-3 attempts by the researcher to finally figure it out.

15. Q15 *Simple / easy to remember how it works*: Memory was a difficult factor to assess in the questionnaire. Many users reported the need to be told multiple times by a son or relative as to how something worked. They expressed that the person teaching them did not “speak slowly enough” and did not “repeat” the instruction often enough to them. Some were frustrated and said that the younger generation had “no time” for the older people and how the younger instructors often said “how can you not” do this or that – “it’s easy!”. Again, as the authors will explore later, this is most likely more of an issue of the sheer volume of information the older user is unaware and unfamiliar with such as common symbols on electronics. Users may even blame memory incorrectly, although this would need to be substantiated. Some users did suffer from memory lapses as expressed by themselves but the majority are possibly affected by lack of knowledge and familiarity than memory and its decline with age. Further work is needed to explore this theme of memory assessment with perhaps a simple task given to the user which could be memorised and then later the task could be given again to see if there is a trend across the older people.
16. Q16 *It does not strain (annoy) to use*: Many users (~64%, n=19) were annoyed or frustrated by the technology assessed. It was sometimes down to pain due to arthritis but more often was the frustration with not being able to get a device to work. In one case, a lady using a laptop was not able to access her email. This email provider (it was found by the researcher during the visit) was not functioning all of the time. During the visit, multiple attempts to access the email failed. At the end of the visit the user was able to access the email account. The webpage that came up had much text about not being able to work but a clearer more direct page could be given to say “The email service is not working at the moment and is of no fault of yours. Please try again later in a few minutes to see if we have it back working for you”. Users expressed that they would sometimes try to use the technology for a while but then abandon it if it was not working for them.
17. Q17 *Not exhausted after using*: Very few users were exhausted by the use of the device. Devices/technology assessed usually only required hand actions so it did not affect them in this way. However, in some cases bending down to a DVD player was tiring for them and caused discomfort.
18. Q18 *No need for a break, or a rest*: Very few users needed a break after using the technology.

19. Q19 *Do not feel embarrassed using this product?*: Most users (73%, n=22) were not embarrassed using their difficult technology (generally a self reported assessment unless otherwise obvious to the researchers).
20. Q20 *Like the looks/design*: Most users would prefer a change in design of their devices. Bigger buttons, bigger writing, better fit to hand size were put forward as design changes. Some just asked for something that worked better. In particular the oil radiator would need better labelling, colour coding of functions, and clearer feedback on the state of operation of the device at any time.
21. Q21 *Easy to use comfortably*: Most users found the devices comfortable to use (~80%, n=24). Some were less comfortable due to the need to bend down to operate them (DVD players, gas fire).
22. Q22 *Enjoy/ is it fun using it*: Most people enjoyed or had fun using their difficult technology (~83%, n=25). It is worth noting that most technology assessed was used for entertainment or communication purposes and so would be more likely to be enjoyable.

Closing

Having presented and analysed the data and discussed some implications of these, the next chapter explores the efficacy of the UD Survey tool developed and the future research required. It also examines some of the key findings of in the assessment of older people's use of technology and the major themes and trends that arose.

CHAPTER 7: DISCUSSIONS & CONCLUSIONS

Introduction

Having carried out an assessment on 30 older person's in their homes using a newly developed UD Survey Tool, this section outlines the findings on the efficacy of such a tool and its use and development going forward. We also discuss the major themes and factors regarding older people's use of technology and its implications for future research in Universal Design and Survey Tool development.

UD Survey Tool Synopsis

The synopsis of the Survey tool looks at the overall assessment of the tool, its limitations, its future development, and the potential users of this tool.

UD Survey Tool – Assessment of Use

Two researchers gathered data from interviewees using the UD Survey Tool Pack in Appendix A. As mentioned in previous sections, an element of experimentation was needed in refining the tool to its current state. The three pilot studies were used to implement this and there were changes made to gather additional context of use from the user as well as looking at their background of technology use and motivations for using the technology assessed. Some flexibility is given in the use of the tool, whereby a researcher can use either the quick Cheat Sheet (Part #3 of 4 of the STP in Appendix A) for gathering data and/or can use the longer format for documenting responses from the user (using Part #4 of 4 of the STP in Appendix A). One researcher (Researcher A) preferred the former method; but the other researcher (Researcher B) preferred the latter – with some cross over of use. It was found that depending on the interviewee assessed, a longer format may be required if the user gives more pertinent data than can be gathered in the Cheat Sheet. Researcher A found that in order to keep the conversation flowing, the Cheat Sheet was preferred since it allowed quicker and focused navigation of the questionnaire. After the interview, the researchers would document additional data which they were not able to document at the time it was said as it would have introduced too much silence and pauses, causing potential frustration in the interviewee. This format worked well.

UD Survey Tool - Limitations and Future Design

When the Experimenters observed the older people performing a particular task with a technology (which they indicated was difficult for them to use) it became apparent that the usage difficulties were founded in violations of usability principles (see Figure 1 in Chapter 3 for a list of these). For example, they tended to lack necessary “Feedback” or were lacking provision of “Consistency” - to name only a few usability guidelines that were breached (details of design issues can be found in the assessment of the difficult technologies in Chapter 6). As such, the struggle to use this “difficult

technology” was not necessarily a function of age (cognitive decline or poor memory) but was more so founded in a violation of general usability. That is, both older and younger user groups would struggle with these common design flaws. In these cases the designers have clearly violated the usability principles [67]. ‘Difficult to use’ as discovered in this study, does not necessarily reflect on an older person’s lack of cognitive ability to perceive/undersand something but is a function primarily of poor design.

When using UD questionnaires such as those published by Lenker and Beecher and the Tool designed for this study, one needs to be aware of the impact of the underlying usability of the technology concerned. If a product or service is badly designed and consequently violates one or more usability principles, it will be difficult to use the UD survey to unambiguously detect design issues which are solely a function of specific users’ abilities. It is advised for this purpose to assess general usability of a design first, to make sure that the design does not exhibit any gross violations of usability guidelines. Only a “usable” design when being assessed with a UD questionnaire will lend itself to be differentiated in the quantity or quality of UD embedded in this design, enabling assessment on the range of users who are able to use this design.

In future it may be worth considering an extended UD questionnaire providing a section with usability assessment questions, which then may lead on to introduce the UD questions. This design would provide non-expert users with a means of guidance on how to arrive to a viable and reliable assessment of UD content.

Potentially the Survey Tool presented here could be used with two cohorts, one older and one younger with the aim of discovering if a technology is suitable for both or either groups. For example, the Tool may suggest that an older user is not as able to use a particular design. The conclusion could then be made that the design is not suited to/sufficient for the older user. Further exploration would then be needed to decipher what, in particular, were the design issues that present difficulties to the older user.

Users of the UD Survey Tool

One element of investigation in this work was to assess what potential users could use the Survey Tool effectively. Two researchers participated in this study. Researcher A was an Engineering postdoctoral researcher in technologies for older people; whereas Researcher B was an ergonomics and usability expert. Researcher B gave some informal training to Researcher A into usability and universal design to complement the individual research carried out.

It was found that the Engineer was able to use the tool successfully although a formal assessment of this is beyond the scope of this work. Other researchers have stated that their UD tools should be targeted to be used only by experts who are knowledgeable and familiar with usability studies and their assessment

(Lenker [72], Beecher [73]). Furthermore, in the previous section the authors have stated the need for a general usability study if the tool is to differentiate between abilities and bad design. For this, a usability expert or further usability training would be required of the user of this Survey Tool.

Nevertheless, the questionnaire can be used to identify if a design caters for the needs of users of different abilities. The qualitative data captured by the researchers in this study identified some design flaws which made the technology difficult for the older person to use. As such, the tool was usable by the Engineer (Researcher A) as well as the Usability expert (Researcher B). Thus, the potential users of this tool extend from the Usability expert to engineers or similar persons with similar technology backgrounds.

To complete the discussion of the study an assessment of the major themes and factors of the older user's use of technology is needed and is discussed next.

Older Users of Technology: Major Themes and Factors

Older users share many of the same issues with technology that other age groups would have. The authors have found that these shared issues were mostly due to poor design and violation of the usability principles. These, as well as other major themes and factors regarding older user's use of technology, are explored in this subsection.

Symbols and Labelling – A Foreign Language

The researchers found that the older people in this study in many cases were not familiar with the symbols that were used to provide design cues on function and operation. As a result the older people struggled to decode the symbols (such as those on buttons) and use them for the purpose intended: to provide valuable cues on how to use something. This again has very little to do with their cognitive decline, their poorer memory, or their ability to learn things in their older age. It is rather due to poor design which violates usability principles [67].

Older people do in many instances have the burden of having to catch-up with 20-30 years of technology development. This means that they are not always familiar with the latest graphical symbols and the functions associated with these.

The experimenters have observed that there was a strong trend by designers to provide symbols rather than text labels in product design solutions used in the domestic environment. This could possibly be due to the interest of manufacturers to restrict language-specific instructions to written manuals where the symbols can be explained. However, these manuals tend not to be accessible or at least most of the cohort do not refer to these for help but prefer to ask someone. We have found in some cases that they learn to cope with limited functions and features of a device – in one instance a user playing

a whole CD through rather than skipping through tracks since she didn't know how (even though she mentioned she prefers to listen all the way through). This lack of familiarity with symbols means that an older person, has no other means of identifying a function. If the graphical symbol is not commonly known by the user group, it is like reading a different language: it just doesn't make sense.

In this case, what transpires is that the older users rely on their procedural knowledge, i.e. they ask someone to show them the steps to do something. Going through the sequence of steps, they rely on memorising the procedure. However, there is a limited short-term memory capacity and hence if the task is very complex and contains more than 7 ± 2 chunks then the procedure cannot be remembered – regardless of the person's age (Wickens and Andre [29]). The authors of this study have found that older users tend to keep hand written procedural steps for logging in to services such as Facebook or Skype to cope with the combination of 1) the variety of symbols (complexity) and 2) the navigation of bespoke menus (memory – where such memory limitations are similar to all user groups).

Technology Experience of the Cohort

One needs to see the context and background of the participants when interpreting their difficulties and behaviours. Most users interviewed were female and had not worked in jobs which involved getting familiar with technology. In most cases, these women had worked at home and had very limited exposure to technology, with some indicating their spouse had primarily dealt with technology in the home. Typically participants reported that they relied on second hand procedural instruction on how to use technologies in the home.

No Symbols – no cues

Given the experience of the majority of the cohort, many will have had to operate technology relying only on procedural knowledge. Most participants answered that they relied on someone to show them how something works, rather than figuring it out for themselves. Participants in this study seemed to have had no cues to fall back on and relied on remembering sequences which they has been shown. This might help explain the apparent difficulty of the participants had in understanding the symbols on devices and in relating these symbols to their associated functions. If one has no cues as to how to remember a procedure by symbols or writing, it is a much more challenging task than if one can use additional cues [29, 31, 34, 35]. Moreover, if one only infrequently uses something, then regardless of age, all would need to rely on cues to trigger the memory, which is not possible if a person is not familiar with the cues provided by the technology (Wickens and Andre [29]).

For example, one user was able to operate a tape recorder which had a function to 'play the tape from two sides' without turning the tape over. She had memorised the sequence of events as to how to play and stop a tape [62].

However, when she was asked by us to play a tape, she pressed the play button fine, but when asked to stop the tape she pressed the button to play the tape on the reverse side. This button, when pressed once, had the same effect as the “stop” button – i.e. the tape stopped playing. When we asked her for more information as to what the button was or what the symbol “meant” to her she said it was the stop button. She managed to get by using the wrong functions over the years since they “work for her”. What possibly happened is that she remembered the sequence she was shown (or had learned) slightly wrong many years ago, but the procedure got reinforced by the seemingly correct result that the tape started and stopped when she pressed the two buttons. This all showed that she was never familiar with this type of symbol code used for the cassette player and she just relied on the procedural steps which may have been shown to her originally. Nevertheless, this is not a matter of ability decline with ageing at all and thus should not be confused as such. One such solution may be to provide a “technology language class” to older people [Mead ([56] in [50])].

Two Dominant Factors – Poor Usability & Symbol Familiarity

These results challenge the common beliefs about how, and the reason why, older people struggle to use technology. From this study two dominant factors emerged from the results of the home visits.

- The first factor was that most technical things older people struggle with were just primarily design related, with the Experimenters also finding some of the designs hard to use. These designs violated basic usability guidelines and principles.
- The second factor was unfamiliarity with symbols i.e. coding used by designers to describe the different functions in a device or interface. As such, it can be considered similar to using a device with text in a different language that the person using the device doesn't know.

So this conclusion challenges the common belief that older people are not able to cope with technology because of their declining memory and physical abilities, but rather it is predominantly because of their unfamiliarity with modern symbols and poor device/technology design which does not provide appropriate use cues [Rogers [31], [33]] .

It was surprising to see how people with physical disabilities still managed to press small buttons with good accuracy and how one 90 year old person with arthritis, who struggled to write and hold a pen, had no apparent difficulty typing text quickly on a laptop keyboard. However, where participants seem to struggle is with the unfamiliarity of symbols. So while it undoubtedly helps to increase button size and increase contrast (amongst changing other physical characteristics of the device) the real enabler in the older people's ability to use technology may be to provide familiar cues and explain unfamiliar cues. These cues can then be used as memory aids rather than relying on procedural memory for the operation of some device or technology. Reliance

on procedural memory is far more challenging and curiously this may mean that older people are actually performing far better in a task compared to younger people, given that fact that they rely solely on procedural memory [37]. It would be interesting to see how well a younger person would cope if one could take away all the familiar visual cues from them, show them a procedure, and then ask them to remember it by only remembering the steps with nothing else to go on as an additional cue such as symbols to remember how to do it.

Contextual Procedural Knowledge

Most participants' interactions with technology seemed to be facilitated by contextual-procedural knowledge rather than an understanding of the underlying theory of operation. Someone regarded as "tech savvy" may in fact simply have access to a library of codes that can be easily transferred between technologies. Educational programs developed for older people should consider the above to tailor an educational experience to the specific problem set older persons deal with.

Future Work and Recommendations

National Study

The current study was carried out on a cohort of older people living in the Liberties in Dublin 8. This group of users is quite a distinct group socio-economically in Ireland. A larger national study on technology use by older people through the lens of universal design could position Ireland as a leader in this space internationally. A more representative study could be carried out using a variant of the Survey Tool developed in this work. A number of iterations would be needed to further validate the tool before it could be used in such a study. This validation would be based on the findings of the current study and on other pilot studies which could be conducted at different sites across the island of Ireland. It would be of interest to examine everyday technologies that older people have in their homes which they find difficult to use and how the universal design principles and guidelines can help in the identification and design of products that are easy to use.

Use as a Pre-Fabrication Tool - Designers

It is envisaged that a UD Survey tool be usable by designers at the early stage of development, as well as for the assessment of existing products. The authors recommend that further research be carried out on the utility of the Survey Tool developed in this study as a guide and prompt for a designer in the early stages of product design. As such, it could be considered as a UD Pre-Fabrication Tool (UD-PFT) for designers. Nevertheless, it would also potentially be useful for prototype stages right through to final production. A project could be initiated to engage designers to use this Survey Tool and for the researchers to design the next iteration (based on observation of its use by designers and their feedback) specifically for the designer at multiple stages of the design process.

Further Development of the Survey Tool – Transfer Matrix linking UD Principals to Product Features based on User Feedback

Another potential development of the Survey Tool would assist designers by allowing isolation of specific design features and their relative impact on the UD of the product in its design stages. In this development, in parallel with the utilisation of the Survey Tool, a usability and UD assessment would be carried out by the researchers on the technology in the lab. In this process, the device would be broken down into a number of product features. These features or components would be correlated to the user responses as measured using the UD Tool. This would generate a set of “weights” (or relative importance/significant from a UD perspective) which would indicate the relative importance of specific aspects and features of the design for that particular user. Assessed across a number of users, a transfer matrix would be generated which would link the UD principles to the product features and these features in turn would link to the weights indicating the relative importance of different aspects of the design. As such, the designer using this transfer matrix would be able to predict the “impact” that certain aspects of their design would have on the ease-of-use of their product. For example, it may be found that for a particular technology, say a mobile phone, that feedback and instructions are very important to the user and so it would be relatively unacceptable to ignore these features from a UD point of view. Essentially this further development would translate the UD principles and guidelines into a set of product features (e.g. button size, button colour, contrast, size of screen, etc) and their significance (weights) to the ease-of-use of the device for users. Thus, the designers would effectively be using the UD principles and guidelines in their design process but would only be exposed to them via product features which they are familiar with. This would potentially increase the accessibility and acceptability of the UD principles and guidelines for designers and engineers to utilise them in their product development processes.

Closing Remarks

While memory and cognitive decline inevitably play a role in the older person’s ability to use technology, the authors have nonetheless found that in many cases it seems it is just bad usability that prevents older people from successfully engaging, understanding, and using technology easily [48]. Further work would need to be done to allow the Survey Tool isolate design aspects that affect older age users exclusively.

The authors have mentioned some specific questions such as one referring to ‘embarrassment using technology’ that require further refinement and testing. Indeed, the tool developed has only been through one iteration of refinement, based on a pilot of three home visits. More extensive testing and multiple refinement rounds are needed to assess the validity of the data captured and the efficacy of that data capture - i.e. are there better ways of asking the questions. While the questions used are based on those validated in the

literature, the authors have found in the course of the 30 home visits (post pilot) that there are areas that need further exploration to facilitate data collection. In the pilot tool, asking questions alone was found to be wholly unreliable. Self-reporting bias was reduced significantly (compared to the pilot survey tool) by having the researcher also observe a task a user carries out rather than asking all questions directly.

The tool developed has sought to provide a means for potential users of the tool to navigate smoothly through the interviews and observations by providing a “Task Oriented Sequence” (TOS) to the questions including the phases of product use: from the pre-use phase, use phase, to post-use phase. An emphasis was placed on examining memory and cognition in this tool. A further emphasis was placed on the post-use user experience as this may affect potential future product use. Comfort, aesthetics, enjoyment, and feeling of embarrassment were explored which significantly determined if a user would use a product in future.

More research is needed in order to assess how Universal Design survey tools, such as the one developed in this study, can be used by, and used to, urge designers to improve their designs such that they are usable by the older person and ultimately by all. A number of potential projects have been suggested which could facilitate the uptake and accessibility of the UD principles and guidelines by product developers.

APPENDIX A: SURVEY TOOL PACK (STP)

The Survey Tool Pack (STP) used for assessing technology design in older peoples homes in Ireland is shown in this section and is referred to in the main text.

SURVEY TOOL PACK

UNIVERSAL DESIGN IN TECHNOLOGY FOR OLDER PEOPLE

v.1.3

SURVEY TOOL - Part #1 of 4 (Demographics Questions)

Resident/User: _____

Date: _____

Time: _____

Experimenter: _____

Demographic Questions:

- D1. Do you have a hearing aid?
D2. How would you rate your hearing from 1-10?
D3. Do you wear glasses?
D4. How would you rate your sight from 1-10?

- D5. What was your previous job?

- D6. What equipment did you use in that job?

- D7. Do you own a computer?

- D8. How often do you use a computer?

- D9. What do you mostly use the computer for?

- D10. Do you use a digital camera?

D11. Do you use a mobile phone?

D12. How do you figure out how things work when you get something new?

- a. Teach yourself (trial & error- figure out yourself),
- b. use a manual,
- c. or ask someone for help?

D13. What do you do if something goes wrong (with the technology)?

Difficult Technology Questionnaire - Establishing a Device to Query

D14. Name 3 technologies that you find difficult/hard to use?

D15. What is the worst one?

D16. Could you show it to me - do you have it here?

...Now lead into the contextual questions (Part #3 of 4) and then the main Questionnaire (Part #4 of 4) for the Difficult Device. Use the Quick sheet in Part#1 of 4 for easier navigation through questions and for observing the task carried out by the user.

SURVEY TOOL - Part #2 of 4 (Contextual Questions)

Resident/User: _____

Date: _____

Time: _____

Experimenter: _____

Technology (optional): DIFFICULT [_____]

C1. How and where did you get the _____?

C2. Why did you buy/get the _____?

C3. Where would you use the _____?

C4. What **time of day** would you typically use it?

C5. What would **you be doing** when you use it? (e.g. cooking, talking...)

C6. What do you use it for?

C7. How often do you now use the _____ (daily/weekly/monthly etc.)?

SURVEY TOOL - Part #3 of 4 - (UD Survey Tool Quick Sheet (for Experimenter Navigation))

Resident/User: _____

Date: _____

Time: _____

Experimenter: _____

Technology (optional): DIFFICULT [_____]

Answer Key	
<input type="checkbox"/> ✓	YES
<input type="checkbox"/> ~	MAYBE/SOMEWHAT
<input type="checkbox"/> X	NO

#1 - Demographics Questions				
#2 - Contextual Questions				
#3 - Suitability of device – size and space [PRE-USE - Physical Ability]				
7b) Can reach buttons/controls easily <input type="checkbox"/>	7c) Buttons/controls fit (finger) or hand-size <input type="checkbox"/>	(7d) Gives enough space (between buttons/ controls) to operate, push, turn <input type="checkbox"/>	7b) Can move, press, grasp, lift buttons/controls easily <input type="checkbox"/>	2c) Provides enough time for input i.e. to press the button, turn the dial etc <input type="checkbox"/>
1	2	3	4	5
#4 - Identifying and making sense of device features [PRE-USE - Underst/Percep/Cognit]				
Can be used with hearing aid, glasses etc <input type="checkbox"/>	7a) Can see the features (perceptual) <input type="checkbox"/>	7a) Can recognise the features (cognition) <input type="checkbox"/>	Can locate/find the main functions (perception + cognition) <input type="checkbox"/>	Can identify what the functions are for (perception+cognition) <input type="checkbox"/>
1	2	3	4	5
#5 - Interaction (use) of device [USE PHASE]				
Can easily identify in what order sequence the controls/buttons are intended to be used in <input type="checkbox"/>	Knows how to use/ operate the functions [press, turn, lever flick-operate the sequence] <input type="checkbox"/>	3b) Behaves like expected (feedback)? <input type="checkbox"/>	6c) Works the first time around without repeating (pushing, turning, reaching, grasping, lifting) <input type="checkbox"/>	Simple/ easy to remember how it works <input type="checkbox"/>
1	2	3	4	5
#6 - Task achievement [POST USE]				
6b) It does not strain (annoy) to use <input type="checkbox"/>	(6d) Not exhausted after using <input type="checkbox"/>	(6d) No need for a break, a rest <input type="checkbox"/>		
1	2	3		
#7 - Fun/ pleasure factor [EXPERIENCE - Impression]				
Do not feel embarrassed using this product? <input type="checkbox"/>	Like the looks/design <input type="checkbox"/>	6a) Easy to use comfortably <input type="checkbox"/>	Enjoy/ is it fun using it <input type="checkbox"/>	
1	2	3	4	

SURVEY TOOL - Part #4 of 4 (Questionnaire for Mixed Methods)

<input checked="" type="checkbox"/>	YES
<input type="checkbox"/>	MAYBE/SOMEWHAT
<input type="checkbox"/>	NO

Answer Key

Resident/User: _____

Date: _____

Time: _____

Experimenter: _____

Technology (optional): **DIFFICULT** [_____]

Answer

#3 - Suitability of device – size and space [PRE-USE - Physical Ability]

Q1. Can reach buttons/controls easily

Q2. Buttons/ controls fit (finger) or hand-size

Q3. Gives enough space (between buttons/ controls) to operate, push, turn

Q4. Can move/press/grasp/lift buttons/controls easily

Q5. Provides enough time for input i.e. to press the button, turn the dial etc

#4 - Identifying and making sense of device features [PRE-USE -

Underst/Percep/Cognit]

Q6. Can be used with hearing aid, glasses etc

Q7. Can see the features (perceptual)

Q8. Can recognise the features (cognition)

Q9. Can locate/find the main functions (perception + cognition)

Q10. Can identify what the functions are for (perception + cognition)

#5 - Interaction (use) of device [USE PHASE]

Q11. Can easily identify in what order sequence the controls/buttons are intended to be used in

Q12. Knows how to use/ operate the functions [press, turn, lever flick- operate the sequence]

Q13. Behaves like expected (feedback)?

Q14. Works the first time around without repeating (pushing, turning, reaching, grasping, lifting)

Q15. Simple/ easy to remember how it works

#6 - Task achievement [POST USE]

Q16. It does not strain (annoy) to use

Q17. Not exhausted after using

Q18. No need for a break, a rest

#7 - Fun/ pleasure factor [EXPERIENCE - Impression]

Q19. Do not feel embarrassed using this product?

Q20. Like the looks/design

Q21. Easy to use comfortably

Q22. Enjoy/ is it fun using it

SURVEY TOOL - Part #2 of 4 (Contextual Questions)

Resident/User: _____

Date: _____

Time: _____

Experimenter: _____

Technology: **PENDANT ALARM**

C1. How and where did you get the **PENDANT ALARM**?

C2. Why did you buy/get the **PENDANT ALARM**?

C3. Where would you use the **PENDANT ALARM**?

C4. What **time of day** would you typically use it?

C5. What would **you be doing** when you use it? (e.g. cooking, talking...)

C6. What do you use it for?

C7. How often do you now use the **PENDANT ALARM** (daily/weekly/monthly etc.)?

SURVEY TOOL - Part #3 of 4 - (UD Survey Tool Quick Sheet (for Experimenter Navigation))

Resident/User: _____

Date: _____

Time: _____

Experimenter: _____

Technology (optional): **PENDANT ALARM**

Answer Key	
<input type="checkbox"/>	YES
<input type="checkbox"/>	MAYBE/SOMEWHAT
<input type="checkbox"/>	NO

#1 - Demographics Questions				
#2 - Contextual Questions				
#3 - Suitability of device – size and space [PRE-USE - Physical Ability]				
7b) Can reach buttons/controls easily <input type="checkbox"/>	7c) Buttons/controls fit (finger) or hand-size <input type="checkbox"/>	(7d) Gives enough space (between buttons/ controls) to operate, push, turn <input type="checkbox"/>	7b) Can move, press, grasp, lift buttons/controls easily <input type="checkbox"/>	2c) Provides enough time for input i.e. to press the button, turn the dial etc <input type="checkbox"/>
1	2	3	4	5
#4 - Identifying and making sense of device features [PRE-USE - Underst/Percep/Cognit]				
Can be used with hearing aid, glasses etc <input type="checkbox"/>	7a) Can see the features (perceptual) <input type="checkbox"/>	7a) Can recognise the features (cognition) <input type="checkbox"/>	Can locate/find the main functions (perception + cognition) <input type="checkbox"/>	Can identify what the functions are for (perception+cognition) <input type="checkbox"/>
1	2	3	4	5
#5 - Interaction (use) of device [USE PHASE]				
Can easily identify in what order sequence the controls/buttons are intended to be used in <input type="checkbox"/>	Knows how to use/ operate the functions [press, turn, lever flick-operate the sequence] <input type="checkbox"/>	3b) Behaves like expected (feedback)? <input type="checkbox"/>	6c) Works the first time around without repeating (pushing, turning, reaching, grasping, lifting) <input type="checkbox"/>	Simple/ easy to remember how it works <input type="checkbox"/>
1	2	3	4	5
#6 - Task achievement [POST USE]				
6b) It does not strain (annoy) to use <input type="checkbox"/>	(6d) Not exhausted after using <input type="checkbox"/>	(6d) No need for a break, a rest <input type="checkbox"/>		
1	2	3		
#7 - Fun/ pleasure factor [EXPERIENCE - Impression]				
Do not feel embarrassed using this product? <input type="checkbox"/>	Like the looks/design <input type="checkbox"/>	6a) Easy to use comfortably <input type="checkbox"/>	Enjoy/ is it fun using it <input type="checkbox"/>	
1	2	3	4	

SURVEY TOOL - Part #4 of 4 (Questionnaire for Mixed Methods)

<input checked="" type="checkbox"/>	YES
<input type="checkbox"/>	MAYBE/SOMEWHAT
<input type="checkbox"/>	NO

Answer Key

Resident/User: _____

Date: _____

Time: _____

Experimenter: _____

Technology: PENDANT ALARM

Answer

#3 - Suitability of device – size and space [PRE-USE - Physical Ability]

Q1. Can reach buttons/controls easily

Q2. Buttons/ controls fit (finger) or hand-size

Q3. Gives enough space (between buttons/ controls) to operate, push, turn

Q4. Can move/press/grasp/lift buttons/controls easily

Q5. Provides enough time for input i.e. to press the button, turn the dial etc

#4 - Identifying and making sense of device features [PRE-USE -

Underst/Percep/Cognit]

Q6. Can be used with hearing aid, glasses etc

Q7. Can see the features (perceptual)

Q8. Can recognise the features (cognition)

Q9. Can locate/find the main functions (perception + cognition)

Q10. Can identify what the functions are for (perception + cognition)

#5 - Interaction (use) of device [USE PHASE]

Q11. Can easily identify in what order sequence the controls/buttons are intended to be used in

Q12. Knows how to use/ operate the functions [press, turn, lever flick- operate the sequence]

Q13. Behaves like expected (feedback)?

Q14. Works the first time around without repeating (pushing, turning, reaching, grasping, lifting)

Q15. Simple/ easy to remember how it works

#6 - Task achievement [POST USE]

Q16. It does not strain (annoy) to use

Q17. Not exhausted after using

Q18. No need for a break, a rest

#7 - Fun/ pleasure factor [EXPERIENCE - Impression]

Q19. Do not feel embarrassed using this product?

Q20. Like the looks/design

Q21. Easy to use comfortably

Q22. Enjoy/ is it fun using it

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