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Inclusive technologies for enhancing the accessibility of digital interactive television for older adults

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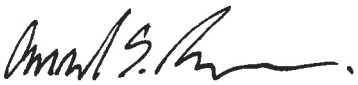
Declaration

I declare that I am the author of this thesis, that all references cited have been consulted by me, that the work of which this thesis is a record has been done by myself, and that this thesis has not been previously accepted for a higher degree.

Signed:  .

(Amritpal Singh Bhachu)

Abstract

Digital Interactive Television (DITV) has revolutionised television, with a multitude of new channels, services and features available through this platform. However, the way in which we interact with TV remains the same, with the traditional remote control used to control the various on-screen options. This brings with it a range of issues considering the complexity of DITV menu systems and the limited simple functionality of the remote control.

This poses problems for the general population. However, for older adults, these problems can be further amplified, particularly with the potential of age related declines in physical, sensory and cognitive abilities.

This thesis describes the studies done to investigate if there are viable alternatives to the standard Digital Interactive Television (DITV) remote control for use by older adults over the age of 60.

An extensive literature review was first conducted, followed by exploratory studies to investigate further the findings from the literature review. These exploratory studies took the form of a focus group with older adults followed by an initial exploratory study to understand how older adults reacted to a gesture based controller, in this case the Nintendo Wii, in a DITV like environment.

A larger study was then conducted to directly compare a standard remote control against a tablet PC that was used as a second screen interface, and a gesture controller. This gave indication of whether the tablet PC, gesture controller, or both could be considered as alternatives to the traditional TV remote control.

The results of this study showed that the tablet PC and gesture pointer had the potential to be alternatives as control devices for older adults accessing DITV. The quantitative results did not show the standard remote control to be superior to the other devices in any of the tasks conducted, and the qualitative results showed that the participants were open to the other devices taking the place of their remote control in a DITV environment with considerations taken on board.

1. Introduction to Digital Interaction Television

1.1 History of Television in the UK

The first outside broadcast of television (TV) programming in the UK was the coronation of King George VI on the 12h of May 1937. The TV service was then was then suspended because of the Second World War. In June 1946, the TV licence fee was introduced and in 1949, the BBC TV service spread to outside of London. July 1954 saw the start of a daily news bulletin and by 1958, the number of households that had a TV exceeded the number of households that had a radio only. BBC 2 started a news review programme for deaf viewers in April 1964 and started colour transmission in 1967. In the early 1970s teletext was demonstrated and Video Cassette Recorders (VCRs) went on sale (1973 and 1974 respectively). 1976 saw colour TV sets outnumbering black and white TV sets. The next major step in UK TV was in 1989 when Sky TV started its domestic satellite services. The digital terrestrial service began in November 1998 and in June 2001, the BBC broadcast its first interactive programme ("British TV Landmark dates," 2006). In 2007, the first analogue switch off was done and in the same year, the BBC iPlayer, an online TV on demand service, began. It is expected that all analogue TV broadcasting will be switched off by 2012. The full table of the history of British TV is in **APPENDIX 1A**.

1.2 What is Digital Interactive Television?

Digital Interactive Television (DITV) was introduced in the UK in 1998 and gave the viewer more channels and more services than analogue television, with arguably a better picture quality. Terrestrial analogue television in the UK traditionally offered the viewer four general television channels, with a fifth being added later in the 1990s. Additional ‘interactive’ services offered were limited to teletext, which gave the viewer access information about news, sports, weather, community and holidays amongst other things.

DITV can carry more channels and more services that the viewer can interact with than analogue TV. In the UK, the government argued that people should have more options in the ways to get their digital television, which had been restricted to pay TV options from satellite and cable companies. The switchover to terrestrial DITV makes

DITV available to almost all. Through the process of a complete digital switchover in a country, transmission networks can be upgraded to newer and better technology and cost can be saved on broadcasting in both digital and analogue formats. Switching off the analogue signal also makes more of the broadcasting spectrum available for digital content. Most European countries aim to have a completely digital network by 2012 ("Why Switchover?," 2001-2009).

In the UK, most of the DITV channels will have a particular dedicated genre that it falls into, such as entertainment, sport, news or history. Freeview offers 50 TV channels and 24 radio stations without any subscription ("Freeview Channels," 2012). The Sky satellite service in the UK offers over 700 TV and radio channels on its platform, although a subscription is required for many of these ("List of Channels on Sky," 2012). This is unlike traditional analogue channels, such as BBC1, BBC2, ITV, Channel 4 and Channel 5, which would, and still do, offer a wide variation of genres on the one channel.

DITV has had a major impact on the way in which we now watch TV. The simple act of browsing through channels, or ‘channel surfing’, to find a suitable programme to watch is no longer a worthwhile task because of the multitude of additional channels. This makes it difficult to get an overview of what is on each channel in a short space of time. A service that has been introduced to help manage viewer programme selection is the Electronic Programme Guide (EPG).

An example EPG is shown in **Figure 1-1**. In the main, most EPGs are designed in the same format. They offer a grid layout of programmes plotted against their channel and broadcast time. This gives the viewer the overview of programming for a given time period. The viewer can also find programming for the next 7-day period. Highlighting a programme will normally display the information associated with that programme, such as actors and a short synopsis. In many ways, this is essentially the electronic version of paper based TV guides giving similar information. Additionally, most EPGs now also offer a ‘picture-in-picture’ view of the current selected programme so the viewer can continue watching while browsing the guide. Also, most EPGs have a ‘now and next’ bar that can be brought up at the bottom on the TV

screen to give information about programming on the current channel being viewed (**Figure 1-2**).

Figure 1-1 – Sky HD Electronic Programme Guide

Figure 1-2 – Sky HD 'now and next' banner

Capturing TV programming is something that has grown in popularity since the early 1970s when the Video Cassette Recorder (VCR) first went on sale. It gave the viewer a way to record live programming to watch at a later time. The viewer could record

programming while watching another on a different channel, or record programming when they were away from their TV set.

The VCR became an out-dated technology, unsuitable for the digital age. Although still capable of recording content, the VCR can now only record the channel that the digital tuner is set to. This means that the same channel must be watched as to the one that is being recorded. This also makes it more difficult to set a number of programmes on different channels to be recoded in advance through timer functions on the VCR.

Digital Video Disc (DVD) recorders and players became the norm in households as they offered superior sound and picture quality. Digital Set-Top-Boxes (STBs) made use of hard drive technology to record programming through a Digital Video Recorder (DVR) or Personal Video Recorder (PVR) interface. This is often connected to the EPG, and the viewer could set this to record a full series of a programme automatically. Also, there are a number of 'On Demand' or 'catch up' services such as the BBC iPlayer[1], Sky Go[2] and 4OD[3], available through STBs and online that allow viewers to watch programming outwith the times they are broadcast 'live' Although VCRs can still be used for recording digital TV, they can only record the current channel set on the STB.

Digital Teletext, or digitext, has taken over from the role of teletext. Teletext was a service launched in 1974 (Cooper, 2008) containing pages of information on current affairs, sports, games, jokes, programming and much more. However, this service was limited to 1000 pages. Digitext aims to provide much of the same information as teletext, but by taking advantage of better graphics, the greater space and faster loading speeds available through DITV. The rise in the number of people with smart phones and internet access has meant that a service such as digitext does not have as much benefit to viewers as teletext was in the past when these new information

[1] http://www.bbc.co.uk/iplayer/

[2] http://go.sky.com/vod/page/default/home.do

[3] http://www.channel4.com/programmes/4od

sources were not available. Newer TV sets come with Internet connectivity available, and many TV sets have a widget interface available to allow access to Internet services offered by the likes of YouTube, Yahoo and Flickr.

Subtitling is not a new concept to television. These are used to provide those with hearing difficulties a way of following a programme. The subtitles will display text on the TV screen mostly containing what is being said as well as highlighting periods of silence, music and sound effects. Analogue TV used the teletext service to provide subtitling to programmes, with a specific page (UK p888) of the teletext service normally set aside. DITV uses dedicated subtitling services to provide subtitling for programmes. The higher quality of modern TV sets means that these subtitles are clearer to read and less obtrusive than the teletext subtitles.

There are several services that are brand new experiences to the TV viewer, as they had no comparable analogue, or traditional, service. These include, but are not limited to, red button features, audio commentaries, games, box office TV, and betting.

'Red Button' features allow a user to be more involved in a TV programme. This may be in the form of voting during game shows or reality shows or access to further information such as recipes for cooking programmes or web/postal addresses related to a programme. Often, the red button will be used to allow access to alternate video stream. Alternate video streams allow the viewer to select the stream of their choice. This may be different camera angles or even different programming. These are often used on sports stations to give the viewer a more stadium like experience from the comfort of their living room, or to view the game of their choice. Examples of alternate video streams can often be seen during events such as the Olympic Games, The World Cup or the World Snooker Championships. There is also an increase in 'Green Button' interactive services associated with TV advertisements, giving the viewer more information about the advertised product when the button is pressed.

Audio commentaries increase the accessibility of programming to viewers with visual impairments. The commentary describes what is happening onscreen so that the viewer can experience the programme as the maker intended it to be.

1.3 DITV Equipment

1.3.1 DITV Tuner

Much of the equipment required to watch DITV programming has already been alluded to in this chapter. In the first instance, a DITV tuner is required. There are now a variety of ways of getting access to a DITV tuner. The majority of new TV sets are sold with a built in DITV tuner which gives access to all Freeview channels. Alternately, a Set Top Box (STB) can be connected to the television. For basic Freeview, a Digital box, or digibox, will give the viewer access to the basic set of channels through the TV aerial. There is also the option to subscribe to Digital TV services. In the UK this is available through Sky, Virgin Media and BT. When subscribing to these services, the provider will install their STB for the viewer to use, with satellite or cable technology being used rather than the standard TV aerial. These services will normally offer a greater range of channels than the basic Freeview box depending on the package the viewer subscribes to.

1.3.2 Remote Control

The other main piece of equipment that is used to operate DITV is the remote control. Although not necessarily required for operation, interaction with DITV is made easier through the use of a remote control, as the alternative is using the buttons on the TV or STB to control the device. A remote control can be thought of as a secondary interface in the use of a TV (Springett & Griffiths, 2007). The number of remote controls we now have to control our television viewing has multiplied in recent times, as has the number of buttons on these remote controls. In the US, it is estimated that there are more remote control devices than people (Fisk et al., 2009).

Previously, remote controls that controlled the TV had a set of basic buttons including the power on/off button, numbered buttons, volume control and buttons to allow the channels to be tuned and picture to be adjusted. As teletext became more popular, buttons appeared to allow control of this service, and in the eighties red, green, yellow and blue buttons were added to control fastext, giving direct access to linked pages(Cooper, 2008). Manufactures also started to provide control buttons for their other products on the television remote, such as control buttons for the video recorder and later the DVD player.

With the introduction of DITV, yet more buttons were needed to control the features and services DITV offers. A button is required to open the EPG menu. Four directional keys are required to navigate the menus, and a button is required to confirm a selection. A button is also required to return to a previous menu or cancel a selection. For the DVR, buttons are needed to record, play, pause, stop, rewind and fast forward video. In addition to this, a further set of buttons is usually included to bring up programme information and control additional features that the manufacturer/television provider may offer.

A good example of a typical DITV remote control is the Sky satellite remote shown in **Figure 1-3**. This remote control has the standard 10 number buttons (0-9), a 'rocking' channel button to allow the user to go through the channels linearly, a 'rocking' volume button, a power button, the DVR control buttons, the directional buttons to navigate menus, a 'Select' button for confirming choices, a 'back up' button to go back on selections and a 'TV guide' button to access the EPG. Also, this remote has an 'i' button to bring up programme information, 'text' to open digitext, the four coloured buttons, 'help' to access help pages, 'box office', 'interactive' and 'services' to access the named features and a 'TV' button to change the remote to control the TV.

Figure 1-3 - Sky HD Remote Control

1.4 DITV Issues and Complexities

The main issues with the control of DITV arise from the increase in options available to the viewer, adding complexity to the way in which TV is used.

In particular, the available menu systems have significantly increased amount of options in them than was previously available through analogue TV and the remote control has significantly more buttons available on it. In general this is an increase on the cognitive load of a user as there is more to learn and more to remember.

1.4.1 On Screen Menu Systems Issues

On screen menus are an integral part of DITV and are required to access the majority of interactive content and services. The most common menu used is the EPG.

Despite being an integral part of DITV since it was introduced to the mainstream, the EPG is often not used as intended, and in some cases not used at all. In 2003, when DITV was relatively new to consumers, a report by Clarkson and Keates (Clarkson & Keates, 2003) showed that only 1 person out of 13 were able to change channels using the EPG. Most of the users in this trial were over the age of 60, with only one being 24, although this was not the user who successfully managed to perform the task. The problems experienced by most focused around inability to find the correct remote buttons and being able to press the buttons because of dexterity issues. Also, the majority of the users had issues in remembering to press a button to confirm selection. A recent Ofcom report suggests that most people now use an EPG (*Accessibility of Electronic Programme Guides*, 2010), although no figures are given.

In its nature, the EPG is hierarchical and requires a sequential process to operate successfully. It can be argued that this is governed by its reliance on the remote control as a form of interaction. The EPG uses a ‘file explorer’ type layout, similar to that used on personal computers. The viewer is presented with a grid layout of programming once they have pressed the right sequence of buttons on their remote control to get into the EPG. Programmes are organised in the grid by the channel number and the time at which they are broadcast. Using the arrow keys of the remote control, the viewer can then navigate to the cell on the grid where the desired programme is displayed. The viewer may have to scroll along or down a page to find the desired channel or programme. Pressing the ‘information’ button on the remote control will, in most cases, display additional information about the programme for the viewer to read. If the viewer wishes to view the programme they must press the confirmation button on the remote control to select it. It can therefore be argued that

selecting a programme to watch using DITV is a relatively complicated process compared to analogue TV where the viewer simply had to select the channel to view a programme. There is also an increase on the cognitive demand of the viewer for them to remember the required sequence to find a specific programme.

Menu system design can also be make it difficult to see and read text for a variety of reasons.

Screen resolution is an issue. There is less information for the user per screen on the EPG than a typical TV guide because of the limitations of space available on screen. (Cesar & Chorianopoulos, 2009). This is largely because of the low resolution available on TV sets. Until recently, there was a frame of 720x576 or 720x480 pixels available through PAL and NTSC standards. This leaves only about 250 lines of effective vertical resolution available. 10% of this is then set-aside as a margin for possible display cut off, leaving a limited resolution available for graphics. Cooper compares this to the resolution now considered to be the standard minimum for PCs of 1024x768. Despite this, as high definition television becomes more common place, the resolution of 1280x720 or 1920x1080 pixels will be taken advantage of more by interactive TV application developers (Cooper, 2008).

The distance a viewer sits from the TV screen also causes problems with reading on screen text. The ideal viewing distance for a TV screen is conventionally judged by the height of the picture, normally four to six times the picture height. In a survey done by Nick Tanton of the BBC in 2004 (Tanton, 2004), the minimum absolute viewing distance recorded was 1.6 meters. This is a much larger distance then compared to a PC user who will normally sit within a meter of the screen.

The text itself can be an issue to the viewer, particularly those with visual impairments. During a presentation at the Euro iTV conference in 2009, Van den Breede and De Bruecker (Breede & Bruecker, 2009) commented on how the font on the majority of TV menu systems cannot be altered. The text cannot be magnified to viewer's preferences. Similarly, the text and background colours cannot be adapted to meet the viewer's needs. The ability to magnify screen text is important to those with low peripheral vision according to Springett and Griffiths who say "viewers with low

peripheral vision tend to scan parts of words, often having to make assumptions about the identity from a few letters. The addition of magnification would alleviate this problem" (Springett & Griffiths, 2007). A study by Gill and Perera (Gill & Perera, 2003) showed that the results of a questionnaire sent to four hundred visually impaired people included requests for the ability to change text size, colour combinations, the use of icons, speech input and output, audio description and the option to decrease the number of functions available as features they would like on their DITV.

The Tiresias screen font, developed Dr. John Gill from the Royal National Institute for the Blind (RNIB) and standardised by The Digital Television Group, aims to provide a solution by being easier to read than the mixture of fonts that those that had previously been used. It allows programme producers to choose which text background colours are used to suit their programming and predicted audience. It also aims to allow the viewer to select the size of the text on display (Gill & Slater, 2000). However, this freedom is yet to be given in most menu designs.

The design of the on screen menus are not normally consistent, and often vary greatly between different providers and different TV and STB manufacturers, despite the basic concept and operation being essentially the same. This is largely because of the lack of standards governing this area, with providers and manufactures not willing to share intellectual properties and designs. Design guidelines will normally be in the form of style guides distributed by broadcasters to production companies that recommend font sizes, safe screen areas and sometimes colours (Bonnici, 2003). The user is handicapped by this approach as they have to go through a learning process with each new device that they get, and once the controls are learnt for each, they must remember these controls.

1.4.2 Remote Control Issues

With the increase in the number of remote controls and number of buttons, many are of the opinion that the required user interaction has become more difficult. Jakob Neilsen illustrates this on his webpage (Nielson, 2004). He is faced with 239 buttons on his range of remote controls, and argues that he only uses 33% of these on a regular basis. The number of buttons cause issues for those with visual impairments

as it can be difficult to find the small buttons on the remote control, as well as read the labelling of the buttons (Keates & Clarkson, 2004). However, the design of remote controls is often limited to the number of keys required for the various functions (Bernhaupt et al., 2008). This paper goes on to say that they authors consider remote controls to be unusable and that the results of their studies suggest that the rendering capabilities of the remote control should be exploited.

Remote controls designed by different manufactures will seldom have the same layout. Each control manages the increasing number of buttons in different ways. Alex Carmichael speaks about the mappings of remote control buttons in his style guide (Carmichael, 1999). It is simpler to have a one-to-one mapping of button to function than many-to-one, as the user does not have to remember the different possible functions of each button. This would however significantly increase the number of buttons on a remote control. Fewer buttons may reduce the cognitive demands of finding buttons on the remote control, but this will also increase the workload as more functions have to be matched to less buttons. There is a weakened cause and effect on DITV remote controls now also. Keates and Clarkson (Keates & Clarkson, 2004) illustrate this with the example that a highlighted menu item on a DITV system is not activated until the ‘OK’ or ‘Select’ button is pressed.

Clarkson and Keates (Clarkson & Keates, 2003) argue that there is an increase on the cognitive demand of a user using DITV, with the user unlikely to have a clear mental model of how to interact with the STB, and inconsistencies with what is being displayed on screen and the remote control labeling.

A further issue with the remote control is that it is limited in the functions that it can perform with ease. It is difficult to enter text using a remote control device for services such as searching for TV content.

1.4.3 On-Screen Menus and Remotes in Combination

Traditionally, TV in the past was used as a ‘sit-back’ technology, where the only interaction required was to press the button of the channel the viewer wished to watch. Because of the interactive nature of DITV, operating the TV has now become more of a ‘lean-forward’ activity as the viewer engages with the variety of menus available for

the range of services and features in a similar way to the way PCs are used (Baudisch & Brueckner, 2002; Bonnici, 2003; Carmichael et al., 2006). It can be argued that this takes away from the relaxing experience that watching TV has traditionally provided to the viewer. In particular, this is affected by the limited input offered by the remote control as well as the distance the viewer sits from the TV screen.

The other major issue is the switch of focus between the remote control and the TV screen. The viewer will take in the information from on screen and find the correct button on the remote control to carry out the desired action (Hara et al., 2009). In this instance, the viewer must alter their visual focus from the TV screen and refocus onto the buttons of the remote control. Cognitively, the viewer has to store in their working memory what action is to be carried out, and apply this knowledge to the remote control button. If the viewer does not know the required button, they must then go through the process of identifying an appropriate button that may complete the desired action (Carmichael, et al., 2006).

1.5 Chapter Conclusions

This chapter has introduced the history of British TV, as well as DITV along with the hardware used to operate DITV systems and the features and services that are offered on this platform.

Finally, the issues that can be associated with DITV are outlined, both with the on screen elements and the remote control device.

2 Older Adults and DITV

2.1 What is an older adult?

The world population is ageing and older adults are the fastest growing group in modern day society. We now have a greater proportion of society that is over 60 and have an aging working population. Figures from The Office of National Statistics (*Older People's Day 2010*, 2010) show that the percentage of adults over the age of 65 in the UK has risen from 15% in 1984 to 16% in 2009, an increase of 1.7million people. In the same period, the population percentage under the age of 16 has fallen from 21% to 19%. By 2034, 23% of the population is expected to be 65 and older, with only 18% being under 16. In particular, the oldest old are the fastest growing population, with numbers more than doubling for those aged 85 and over from 1984 (660,000) to 2009 (1.4 million).

This group is also getting wealthier, with 80% of the wealth and disposable income (Gill & Perera, 2003). In the UK, the average gross income for a pensioner increased 44% in real terms between 1994/95 and 2008/09 (*Older People's Day 2010*, 2010). As a result, older adults are going to be in a position of consumer power for years to come and the design and implementation of new technology is likely to become more targeted at this group.

Many classify anyone over the age of 60 as an older adult. However, Fisk et al argue that comparing a 60 year old to a 90 year old is like comparing someone of the age of 13 to someone who is 45 (Fisk, et al., 2009) because of the changes that occur during this time span. Therefore, the younger old cannot be grouped with the older old. Following the recommendations in this book, this work is aims to consider specifically the 'young old,' aged 60-80.

2.1.1 Age Related Decline

With age, we develop a decline in our sensory, motor and cognitive abilities. It is also likely that we will develop multiple minor impairments as we grow older (Gregor et al., 2002; Keates & Clarkson, 2004).

The sensory abilities to see and hear are affected throughout the aging process. The detection threshold for human speech has a greater decline after the age of 60. By the age of 65, 50% of men and 30% of women have hearing losses that can hinder social interaction, compared to 10% of middle aged adults (Fisk, et al., 2009). Reading small print is affected by the age of 40 and 7 in 10 people over 40 need glasses. In regards to TV, this can make it difficult to read the labels or find buttons on a remote control. In most cases, by the age of 65, vision is affected severely, though in most cases vision can be corrected to 20/40 (can see at 20 feet what a person with normal vision can see at 40 feet ("Visual Acuity: What is 20/20 Vision?," 2012)) for at least 80% of over 65s (Fisk, et al., 2009). This may have an impact when watching TV, particularly if the user is having to read content of menus on the screen.

We experience greater issues with motor control as we age. There can be a decline in the control of movement and movement speed. Also there is the possible loss of kinaesthetic senses, meaning an inability to control movement or body position unconsciously (Fisk, et al., 2009).

Cognitive decline is also evident with age, and in particular, our working memory. The working memory is where information is temporarily kept active while it is being worked on, or until it is used. An example, when using a menu system, the goal of accessing the menu system must be kept in mind as it is being navigated. However, our long-term memory is less likely to be affected by age. Older adults are likely to perform less well in dual task conditions and are more likely to have difficulties in learning new automatic processes (Fisk, et al., 2009).

Despite these generalisations about older adults, it must be noted that they are not a homogenous group. Age related decline is likely to have progressed at different rates, and different people will have different ways to deal with their problems (different coping strategies). They have varying skill sets based on their life and work experiences and, as a result, are more likely to have a greater variation between abilities with age (Carmichael, 2002).

2.1.2 Looking at Impairments

It is important to outline what is meant by the terms of impairments as they will be used in this thesis.

When discussing visual impairments, the term will refer to individuals who have a difficulty reading text or seeing images from a few centimetres away up to three meters away, with or without the use of corrective lenses. These individuals may find it difficult to focus on the text or images at these distances.

When discussing motor impairments, the term will refer to individuals who find it difficult to make small, controlled movements of their hands and fingers. This may be as a result of arthritis or other conditions that affect fine motor movements. These individuals will include those who have slight pains when trying to perform these movements through to those who cannot physically perform these movements.

The term cognitive impairments will refer to those who have experienced a decline in their working memory as described above when discussing older adults. This can begin at a low level of extra time taken to access the working memory to complete memory loss of working memory.

2.2 Older Adults and Technology

In general, older adults are less likely to use technology compared to younger adults. However it is a common misconception that older adults are averse to using technology. Many argue that the data disproves this theory and that in fact older adults are receptive to technology. This is only though on the premise that the technology is of use to them, easy to use, and that they are provided with sufficient support and training. Although they may initially be more anxious when faced with new technology, if it is properly implemented then older adults are likely to grow more comfortable with it as they gain more experience using it. Also, if there are clear benefits of using the device for the older adult, they will make an effort to learn. (Bhachu et al., 2008; Czaja, 2005; Fisk, et al., 2009). A journal paper by Jelfs and Richardson emphasises this further (Jelfs & Richardson, 2012). This discusses research done by the Open University and showed that there was no such thing as a

‘digital divide’ between younger adults and older adults, though use of technology does vary with age.

Learning to use new technologies is not as easy for older adults as it is for younger people. They are more likely to be set in their ways in terms of how they operate a device, and if they have to learn how to use the device because of modifications, this has to be taken into consideration and time given for the older adult to ‘unlearn’ a known procedure in order to learn the new one (Fisk, et al., 2009). Minimising the number of steps aids older adults in performing tasks (Fisk, et al., 2009).

Older adults are also more likely to rely on system tools and manuals to support their use and learning of new technology devices. Fisk et al describe this as “placing knowledge in the world” rather than “placing knowledge in the head” (Fisk, et al., 2009). This makes it important that user manuals and features such as online help are well designed, clear and concise. Also it must be taken into consideration that older adults are more likely to want formal training with new devices, more likely to request help and will be more likely to make errors.

Older adults are willing to try and use new technologies in the right circumstances. The benefits of having the device must be clear, the system must be easy to use and the older adult must receive adequate instruction on how to use the system.

Examples of technologies that older adults have accepted in their lives because of the benefits they can gain from using it are the mobile phone and the Internet.

In 2005, Ofcom reported that just under half of people over the age of 65 owned a mobile phone, with 82% saying they used it to make at least one phone call a week but just 24% saying they sent any text messages (*Media Literacy Audit: Report on media literacy amongst older people*, 2006). A 2011 Ofcom report (*UK Adults' Media Literacy*, 2011) indicates that the number of those over the age of 65 that owned a mobile phone had risen to 62%. However, this was over 30% lower than the national average of mobile phone ownership (91%). The 2011 figures also show that 85% of those 65 and older preferred to use a home or landline phone to make a call than send a text message to get in contact with someone. A 2008 study by Bhachu et al (Bhachu,

et al., 2008) indicated that older adults would liked to have a mobile phone as they believed it to be useful in cases of emergency. There are now examples of smartphones being developed specifically with older adults in mind ("Doro PhoneEasy 740 smartphone hands-on at MWC 2012," 2012).

Internet take up has also increased amongst the older adult group since 2006. In 2006, 21% had the internet at home (54% UK adults average) (*Media Literacy Audit: Report on media literacy amongst older people*, 2006) and in the 2011 report, this had risen to 35% (74% UK average) (*UK Adults' Media Literacy*, 2011). Those aged 65 and over indicated in this report that they were most likely to use the Internet for getting information and less likely for relaxation or pastime. It also shows that almost half of non-internet users are likely to be older adults. Another Ofcom report about accessing the Internet at home (*Accessing the internet at home*, 2009) stated that many self-exclude themselves from using the Internet. Of this group, 37% said that they were simply not interested. 68% of this group were over 65 and 71% were retired.

Fisk et al describe a decision tree of a possible approach by older adults to selecting whether to use a technology or not (Fisk, et al., 2009). This is shown in **Figure 2-1**.

2.3 Designing for Older Adults

There are several design approaches that are continuously discussed throughout the research of the literature. Though not specific to DITV design, they can be used to design good interactive features and menus for DITV. Design will however normally focus on a 'normal' person or a person with a single major impairment. This often does not take into account older adults who are likely to have a number of age related physical and mental impairments making it difficult to find technology useful for them (Keates & Clarkson, 2004).

Much of the time, the default method designers take, knowingly or unknowingly, is designer centred design. Often, designers will focus on providing for people with similar capabilities to themselves, both physically and mentally (Keates & Langdon, 2002). This is often a result of the designer getting over confident in their designs and management pressure, making the designer believe that user involvement in the

design process is not needed. The designer may then expect the user to rely on instruction manuals, help systems and hot lines to cover any issues with the design. There is also often a belief that if the design guidelines and standards are followed, the product will be fine. This approach tends to alienate older adults from using the product. In Donald Norman's book, The Design of Everyday Things (Norman, 2002), he speaks about how it is important for designers to learn to watch and observe how things are used. He also highlights how marketing drives designers.

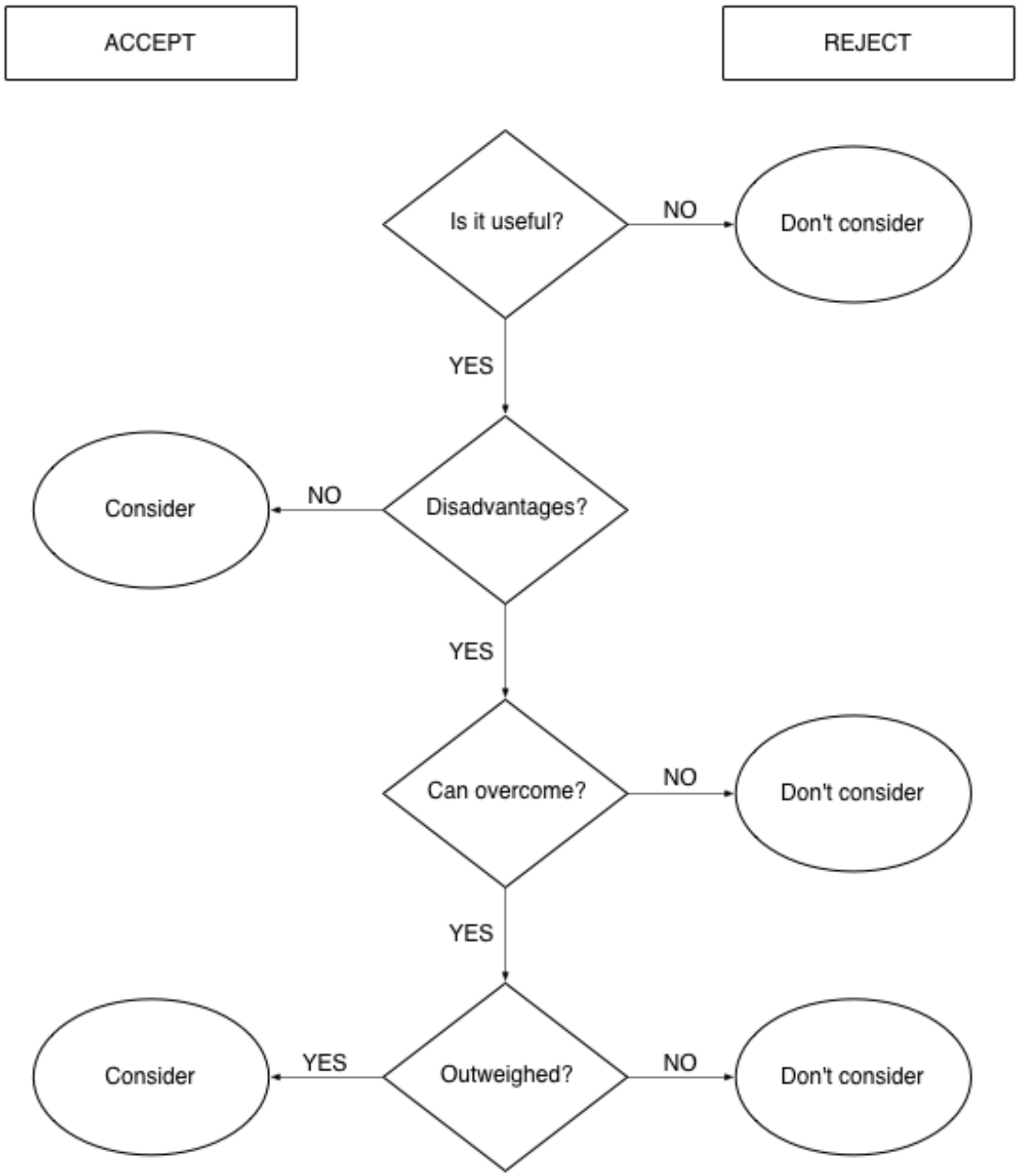


Figure 2-1 – Example Decision Tree

User Centred Design (UCD) aims to focus on the user and the tasks that they will need to perform early on in the design process. This design and development process in general will take longer than a Designer Centred Design as data has to be collected and analysed from the user and then iteratively designed and tested until a suitable solution is produced (Fisk, et al., 2009).

Universal, or Inclusive, Design is an extension of the UCD concept. Design should consider the end user at every stage in the process and should be usable by the largest group possible. To assess the inclusive design of a product, Keates et al state that orders of inclusive merit should be established. "The inclusive merit of an ideal product is the maximum proportion of the total population who could be expected to be able to use an ideal product. The inclusive merit of the product requirements is the maximum proportion of the ideal population who could be expected to be able to use a product derived from the requirements. The inclusive merit of the actual product is the maximum proportion of the population included by the requirements or the ideal design that could be expected to be able to use a product" (Keates & Langdon, 2002). The Inclusive Design Cube (IDC) is a model Keates et al. based around inclusive design methodologies developed to relate capability levels, population profile and design approaches into a graphical format. This can be seen in **Figure 2-2**.

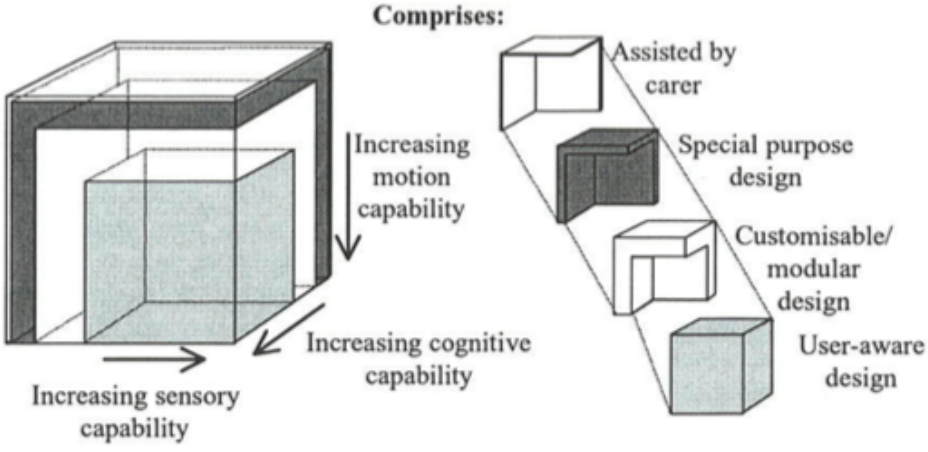


Figure 2-2 – Inclusive Design Cube

Gregor et al argue that User Centred Design approaches are not appropriate for older adults (Gregor, et al., 2002). They argue that UCD is for people with relatively homogenous characteristics but older adults tend be a diverse group of users. They

classify different groups of older people, the fit older, the frail older and the disabled who grow old. They recommend another approach to design for older adults based on inclusive design, User Sensitive for Inclusive Design. This methodology aims to bring to focus the variability that exists in user characteristics and the changing nature of functionality over both short and long time scales.

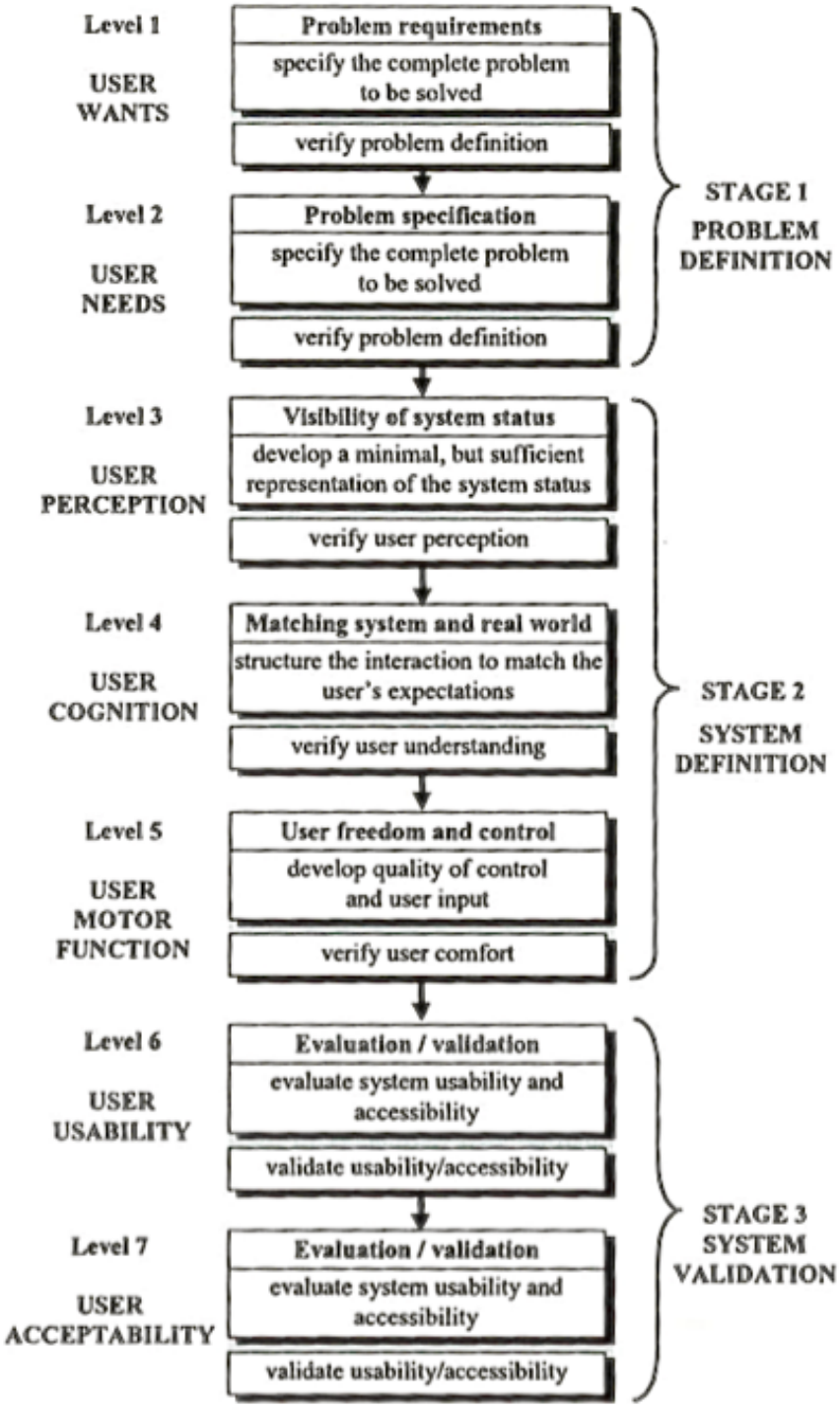


Figure 2-3 – 7-level design approach

Keates et al (Keates & Langdon, 2002) also comment on the need for a new inclusive design approach. Their approach also takes advantage of the strengths of inclusive design approaches. This is known as the 7-level approach, with each level representing a design aim. This can be seen in **Figure 2-3**.

This works takes an Inclusive Design approach to development, with the target user group being considered at every stage of the work. The target user group are older adults as a general population, all over the age of 60.

2.4 DITV for Older Adults

2.4.1 Watching TV

Throughout the digital switchover, there has been an increase in the uptake of DITV by older adults. However, in 2010, almost half (44%) of those with analogue only TV were those over the age of 65 (*The Communications Market Report*, 2011). A 2010 Ofcom report shows that those in the over 65 age group watched the greatest amount of TV throughout the day. Most of this TV watching is identified as being during the evening (*The Communications Market Report*, 2010). The amount of TV watched by older adults has grown from 4.9 hours a day in 2006 to 5.7 hours a day in 2010. This is compared to the national average of 3.6 hours in 2006 to 4 hours in 2010.

From the thirty most viewed TV channels, the channels with an older than average demographic, as reported in the Ofcom 2011 Consumers Market Report (*The Communications Market Report*, 2011), are BBC 1, BBC 2, BBC 4, BBC News, ITV 3, ITV 1, Yesterday and 5USA. This gives some indication of the channels that older adults are watching, although it does not show which are the most popular channels for older adults to be watching. For the general adult population, the five traditional 'terrestrial' channels occupy the five most watched channels, with BBC 1 having 20.2%, ITV1 16.6%, Channel 4 7%, BBC 2 6.6% and Five 4.5% of the share. Of all TV watching, the proportion of over 65s was 24% (*Public Service Broadcasting Annual Report 2011*, 2011).

Older adults are also more likely to watch 'live' TV, i.e. when it is scheduled to be shown, rather than time-shifted TV, recorded content or content accessed through on-

demand services, compared to younger adults. In 2006, recording was more common amongst older adults, with 2% of over 65s recording content compared to 0.9% amongst 16-25 year olds. In 2009, this had changed to 2.9% of over 65s recording content compared to 7.1% of 16-25 year olds. This is consistent with the growth of DVRs in homes (11% of homes in 2005 had a DVR compared to 47% in 2012). In 2010, 18% of over 65s used catch up TV services such as the BBC iPlayer compared to 40% of 15-14 year olds. The impact of these statistics was that those over the age of 55 watched 1522 minutes a week of live TV compared to 173 minutes of time-shifted TV. Those aged 16-24 watched 880 minutes of live TV a week and 315 minutes of time-shifted TV. The national average was 1209 minutes per week of live TV and 252 minutes of time-shifted TV (*The Communications Market Report*, 2010).

2.4.2 Satisfaction with TV

Nearly half of older adults indicated that programming in the UK had got worse (48%). This is compared to 31% of the general adult population. 44% said that it had stayed the same, and just 7% said that it had improved. Of the 48% that said it had got worse, 61% said there were too many repeats shown, 37% said that there was a lack of variety and 31% said there were too many reality shows (*The Communications Market Report*, 2011).

This also ties in with a report by Jenifer Goodwin in her blog on businessweek.com (Goodwin, 2010) where she says, “While watching TV, older people reported more feelings of sadness than younger people, and they found shows less relaxing as well. Some people also watch lots of TV because they feel they do not have any other options -- perhaps they no longer drive, their family lives far away, friends have died, or they have chronic illnesses or pain that make it difficult to do other activities.”

The above is evidence that older adults do watch more TV than any other population group, but appear to get less satisfaction from it. This is one of the issues that older adults have with DITV.

2.4.3 DITV Issues for Older Adults

A study conducted by Papa et al (Papa et al., 2011) found that ‘confusion’ was a word that could describe older adults’ opinions of DITV. This included the menu systems,

the number of remote controls required to operate the TV and other devices such as the STB and the size of the buttons on the remote control.

According to a report commissioned by Ofcom, manufacturers of technology, including DITV equipment, are unlikely to focus development specifically on the average older user (Freeman & Lessiter, 2009) (Freeman & Lessiter, 2009). There is a combination of reasons for this. They do not always get complaints about products with an attitude of "if there's a problem we will hear about it, but if there is not then it's like all business, we take it as a success." Interviews conducted as part of this report highlighted that manufacturers do not always involve the user in the development process, and even more so with older or disabled users, although they claim to speak to them "as part of what they do." Products, such as STBs are sometimes made in other countries, where production is cheaper and generic parts can be made, and cannot be changed to suit older adults or disabled needs as manufacturers see more lucrative markets to target. In general, they are of the opinion that there is no money to be made out of the older adult population.

DITV is likely to exclude at least twice as many people as its analogue equivalent for basic functions like channel selection as it requires more cognitive effort to learn and operate because of its increased functionality (Keates & Clarkson, 2004). The number of steps required to perform the task of selecting a channel on digital television has increased, as there are more channels than previously with analogue TV. This means the use of a service such as the EPG may be necessary to select a channel, or the user has to remember the channel number that they wish to navigate to. This has also become more difficult as the channel numbers are not the same using digital TV as they are for analogue TV e.g. 104 on Sky TV compared to 4 on analogue TV. As previously highlighted, for older adults, the cognitive decline and difficulties in learning new automatic processes, the once simple task of selecting a channel to watch has added complexity attached to it.

Hara et al conducted a usability study that highlighted several of the issues that older adults had when operating the EPG compared to younger adults. They found that the group of younger adults were more likely to explore the interfaces more, and that they were also more likely to learn from any errors made during the study, whereas older

adults would often repeat errors that they made. This paper also identified that the PC menu systems of DITV do not agree with the mental model that older adults have with the traditional TV systems, and therefore have issues adapting to using them (Hara, et al., 2009).

Age related decline in vision of older adults also increases the likelihood that they will have greater issues reading the on screen text of DITV menu systems than younger adults.

There are issues with the use of remote controls that are likely to affect older adults, but it must also be noted that these problems are not only associated to this group.

A report of the Bolton Digital Television Trial in May 2006 (*Report of the Bolton Digital Television Trial*, 2006) highlighted that older people found it difficult to adapt to the remote controls with the additional buttons on them. Also, according to the report, the best and most valuable source of support to remedy these problems was family and friends. Bernhaupt et al. also highlight in their study that many household members, and older adults in particular, found multifunctional remote controls complicated to use (Bernhaupt, et al., 2008).

The increase in the cognitive demand to operate the remote control is again a greater issue for older adults who experience age related declines in their cognitive abilities. Therefore, trying to learn and remember what each of the number of available buttons do in each mode can be difficult for older adults.

In addition to the increased cognitive demand of the remote control, older adults are likely to experience difficulties with the size of the buttons. Age related decline in vision can make it difficult to find the required button on the remote control, as the buttons are normally smaller than they were on traditional analogue controls. Also, labeling is small and the tactile feedback is often insufficient to know what button has been pressed through touch alone. The age related decline of motor movements also makes it more difficult for older adults to press these smaller buttons of the remote control (Keates & Clarkson, 2004; Rice & Fels, 2004).

A combination of motor, vision and cognitive decline also makes the issue of focus switching a greater problem for older adults. This is even more problematic for those with separate glasses for distance and reading (Keates & Clarkson, 2004; Rice & Fels, 2004).

2.5 Overall Research Question

At this stage it was identified in the literature that older adults had several barriers to accessing DITV content. These barriers mainly centred on the menu systems and the remote control devices. In its nature, interaction with the on screen menu systems is limited to the inputs possible with the remote control. So a question was formed for further research:

'What alternative remote control interfaces can be considered as replacements for the traditional Digital Interactive TV remote control for use by older adults and why?'

3 Possible solutions to DITV issues

3.1 Alternate Forms of Interaction

In order to answer the outlined question, it was first required to identify at an early stage what alternative forms of interaction were available.

The modern day remote control has proven to not lend itself to easy interaction with DITV. In particular, the buttons are small and confusing as to what they operate. There are therefore several alternate ways that were considered to control DITV.

3.1.1 Voice Interaction

Using a STB or remote device capable of voice, or speech, interaction is a reasonable approach for limiting the need for a user to operate a remote control, and in some cases it could allow the user to not need the remote control at all. In a telephone consumer study done in Finland with a random sample of 18-65 year olds looking at reactions to using voice commands to operate technology, 63% of their group found voice commands to be faster than pressing buttons on a remote control (Soronen et al., 2008).

The potential feedback the user can get from a spoken system is likely to be more informative than ambiguous beeps and blinking lights that can be associated with technology devices. An example of this is when inputting the parental code on the Sky STB, if the user gets it wrong then the box first beeps at the user. This is followed by onscreen text saying that the code is wrong. It could also remove the need to overlay text output or messages on the TV screen. Highlighted options during the use of menus and the EPG can also be read out to the user. This would help them to identify where the cursor is with greater ease and not need them to concentrate too much to read the text themselves. This would benefit older adult users who have age related visual impairments and find it difficult to read on screen text, as well as any other users who struggle to read this text.

However, using speech does bring in its own set of problems. An obvious issue is that TV produces noise, and this noise will normally be variable in tone and volume, making it difficult for a speech system to filter out. A further general problem with

speech systems is that people are likely to have different ways of saying words, different accents and different dialects depending on where they are from. This is an issue not just from country to country, but in different regions of the same country.

In the same Finnish study as above (Soronen, et al., 2008), 61% of the group did not like the idea of speaking to a device to control it and 67% indicated that a spoken system was unreliable as commands may be misinterpreted. This identifies the possibility that trusting a speech system is a major issue. Also in this study, the statistics gathered showed that older adults showed less interest in voice commands while those who were more technologically savvy were more likely to accept them. For older adults communicating with speech systems there are further issues. They are less likely to speak to the system in a way that is easy for the system to understand what they are saying. Older adults have a tendency to speak politely to speech systems, using common courtesies like 'please' and 'thank you'. Wolters et al show this in a study where older users were identified to have a lower task success rate with a spoken dialog system than younger adults performing the same task. The older users were less likely to speak to the system in a way that the system could understand. Given early help in the task however, the older users were able to adapt to suit the system better (Wolters et al., 2009).

It should also be noted that culture might have an impact on how speech interaction is accepted. A study undertaken by Tan et all (Tan et al., 2003) identified that Japanese TV users preferred the traditional remote control where as US users found speech interaction easier. Tan argues that this may be because Americans are more direct with their language, giving them better control over speech inputs, whereas Japanese are more polite, giving them similar problems with speech input that older adults are considered to have. Nakajima (Nakajima, 2001) claims that a user's current situation has an affect on their natural interaction with spoken systems. While cooking, voice interaction is more desirable, but when watching TV he argues that the remote control may be better.

There are two ways that a speech input system could be developed. The system can use a limited set of commands or a dialogue based system.

Using a limited set of commands means that the user must learn what they are able to say to control the device. Restricting the vocabulary set makes the system easier to develop and maintain. The user must though learn what they are able to say for the system to understand them. The user may not use the correct terminology or wording to control the device, leading to frustration when attempting to carry out a task. Error correction is also likely to be limited by this type of system (Wittenburg et al., 2006).

Another Finnish study used this approach to speech interaction in their system (Turunen et al., 2009). A Speech User Interface (SUI) was developed as part of this system and a limited vocabulary of 900 words was employed. The user was able to tell the system to open the EPG, search the EPG and select and record programming using this set-up. The user had a mobile phone device (Nokia 95) to speak the commands into. This device included an embedded speech recognizer as well as a recognizer on the server being used as part of the system.

A dialogue based system attempts to handle errors better and lead the user into using speech that the system can understand. This system however requires costly and complex design and development. Also, in terms of using this type of system with a TV, users want an instant response to their requests, and this type of conversational system does not lend itself to that (Wittenburg, et al., 2006).

The work by Wittenburg et al focuses on using a microphone incorporated as part of a remote control to allow the user to search the content. They use Spoken Query technology in a Speech-In-List-Out (SILO) interface. A SILO interface allows search terms that are unrestricted by vocabulary or grammar and gives the best matches as results even though the speech is ambiguous to the system. It does this by handling the input text not as a full set, but as words and/or bigrams that can be matched against an indexed target set by probability ratios. Wittenburg says that this appears to the user as a spoken version of Google.

There are several ways in which the microphone required for speech interaction can be produced. These include having a stand-alone microphone, having a remote control with a built in microphone or using another device such as a mobile phone, tablet PC or laptop PC. A stand-alone microphone causes issues with the potential

background noise, and also makes it difficult to choose where to position it. Using a remote control with a microphone built in allows a better way of closing off the background noise when speaking commands and also allows the user to have access to the traditional remote control layout. A mobile device however would seem to be the best solution for speech systems as it can provide the same functionality as the traditional remote control, but recognition software can be implemented on the device and it also offers the benefit of having a screen. This allows for other possible developments on the device, such as being able to view an EPG or programme previews directly from here.

There is potential for using a speech-based system to interact with TV. It appears to provide benefits over a traditional remote control and limits the motor and visual demands on a user. There does however appear to be difficulty in producing a reliable speech system based on current technology to work in a TV environment. The user must either learn a pre-programmed set of spoken commands or the development of system architecture is likely to be costly and complex. There is a great potential for users to become frustrated with such a system, as errors may be common and possibly outweighing its benefits. Manufacturers are also not likely to spend time and money to develop a system that requires different set-ups for different countries and different regions within countries when other, simpler solutions are available.

It can be argued that a remote control essentially works on a basic set of controls that users learn and get accustomed to, so given time to adapt, they may also be able to learn and use spoken commands. In addition to this, the system may be calibrated to work with a specific user or learn how a user says certain words.

3.1.2 Gesture Interaction

Depending on how gesture recognition technology is implemented, it can help with the issue of focus switching in a DITV environment as the majority of interaction is performed on a single interface, mainly the TV screen, with less need to look down at the controller.

Gesture recognition allows the user to control a device through using body-controlled movements. Although gesture recognition technology has been around for many years, it came to prominence in the public eye due to the Nintendo Wii gaming console. In the main, this area focuses on movements of the head, eyes and arms, although full body movement is now being used more in gaming environments, in particular in technology used in the Microsoft Kinect ("Introducing Kinect," 2011). Springett and Griffiths have shown that the use of gestures has the potential to be useful for users with low vision in a reference to their other work (Springett & Griffiths, 2007). The use of gestures also has the potential to reduce need for a multitude of buttons on remote controls, and in some cases remote controls may not be needed at all.

There are two main ways of implementing gesture recognition technology. The first is to have a hand held controller for interacting with the interface, and the second is the use of a camera system. The obvious disadvantage of having a controller is the fact that the user still has to hold a control to input gestures. While the use of a camera system takes away the need for holding a controller, this set-up is more complex. Tactile feedback is also limited through the use of camera-based systems.

Gesture controllers usually record a user's hand movements in a three-dimensional space by recording values on an X, Y and Z-axis. This information is then communicated to the interface being controlled through the use of wireless signals such as infrared, Bluetooth or radio communication.

With camera based systems, initially there were issues with cameras only being able to work in a two-dimensional (2D) environment. Improvements in technology then allowed cameras to pick up three-dimensional (3D) movements in an environment. Also, room lighting, the reflection of the sun and the unexpected movements of people caused problems for camera-based systems. It is now argued that these problems have been overcome, through the development work of companies such as Canasta[4] and GestureTek[5] (Vance, 2010).

[4] http://canasta.com

[5] http://www.gesturetek.com

An Ofcom Research Report (Freeman & Lessiter, 2009) did raise some questions about gesture recognition being used for all. In particular, the ability for people with cognitive impairment or who were blind or partially sighted to be able to learn the input gestures was questioned, as was the ability of people with mobility or dexterity impairments to reliably repeat various required gestures.

In the field of television, the development of gesture recognition systems is now taking a more prominent roll. There is a mixture of controller based and camera based solutions now available. Canasta and Softkenetic[6] are two companies who have produced camera based gesture solutions to control the television set using simple gestures.

Hillcrest and Philips have both produced remote controls that will act in a similar fashion to the Wii controller. The Philips uWand (Philips, 2009) has a small camera built into it that detects infrared sensors on the screen (or a plug-in USB infra-red sensor) and sends the coordinates to the device it is controlling. Philips say that the uWand can be used with a range of devices, including televisions, set-top boxes and DVD players. The Hillcrest Loop Pointer ("Loop Pointer," 2009) is an in-air mouse that can be moved around to control a pointer onscreen. LG have also developed a (Freeman & Lessiter, 2009)Wii type controller for their TV sets called the Magic Motion Remote ("LG Magic Motion Remote," 2011). They sell this gesture based remote control for their high-end TV sets, which highlights how manufacturers are now focusing heavily on this area to market their products.

Panasonic demonstrated a different approach to gesture recognition at the International Consumer Electronics Show and CEATEC 2008 ("Panasonic's EZ Touch multitouch remote control concept hands-on and video," 2008). Their EZ touch multi-touch remote control has two touch pads. Virtual buttons are then shown onscreen, removing the need to look down at the remote control and giving the user all the required buttons. The dual touch pads allow for multitouch data entry and zooming of the screen. Gestures can also be used to scroll the screen content. The

[6] http://www.softkinetic.com/

user is presented with a limited set of buttons for the current task being carried out, with the buttons on display changing as the task changes. This means that the user does not have to deal with a cluttered remote control with small buttons and also gets the advantage of one-to-one mapping of function to button. Choi et al (Choi et al., 2011) trialled a similar design, which had a single touchpad at the bottom of a traditional remote control, with a group of students. They argued that this approach to remote design was a viable option for use in a DITV environment.

3.1.3 Multitouch Second Screen Interaction

In this context, the majority of multitouch devices will have its own screen as part of the device. When used in a DITV environment, this can be considered as a second screen interface. This second screen can be used to display and control content that would traditionally be displayed in the menus on a TV screen, such as the EPG, leaving the TV screen free to perform its primary job of displaying programming. This also allows the user to interact directly with a menu as opposed to indirectly via a control device. The second screen can also be used to watch TV programming.

There are several types of device that can be considered for second screen interaction.

First of all, there are smartphones. These are now commonplace amongst many mobile phone owners, with smartphones also now being targeted at older adults ("Doro PhoneEasy 740 smartphone hands-on at MWC 2012," 2012). One of the first smartphone devices, and still one of the most popular today, is the Apple iPhone ("iPhone," 2011). The iPhone revolutionised the mobile phone industry when it was brought out in 2007. The device offers a multitouch screen as well as containing a 3D accelerometer. The multitouch screen allows the display to be controlled by a series of ‘flicks,’ ‘pinches’ and ‘taps’ as well as being able to zoom in and out using grabbing motions with fingers. An onscreen keyboard appears when text needs to be entered. The accelerometer allows the orientation of the screen to change depending on how the device is held. The user can also play games designed to use the accelerometer as a control. Most of the major mobile phone manufacturers now have a range of smartphone devices. Typically, these handsets have a screen size of between 3.5inches and 5inches.

More recently, there has been an increase in sales of tablet PCs. Again, Apple led the way with these devices, releasing the iPad in 2010 ("iPad," 2011). In many ways, this can be considered as a larger version of the iPhone with similar interface techniques as the smartphone. Many of the other mobile phone handset manufactures also have a tablet PC in their range now, as do several PC manufactures. The screen sizes on these devices range from 5inches to 11inches.

The use of a second screen interface for the viewer offers many benefits. As with gesture recognition, the issue of focus switching can be removed as all the interaction can be on the second screen interface. Added to this, the user can also adjust the distance to the second screen device to suit their eyesight. This is particularly useful for users with visual impairments.

Work by Cruickshank et al (Cruickshank et al., 2007) identified that study participants found there to be a conflict between the ability to watch TV and access menu systems on a single screen. They found that their participants wanted functions to be designed to "offer the quickest route to content, and not take away from the main viewing experience." As a solution, they put an EPG interface onto a PDA (Personal Digital Assistant) screen. It was found to produce a more lean-back approach to operation of the TV. Also, others watching TV were not disturbed by EPG interaction on the PDA and text was easier to read as the device could be "held like a book". The biggest issues that were highlighted during these studies were that the PDA was considered to have a small screen, the lack of a full size keyboard on the PDA and the lack of tactile feedback offered by touchscreen devices.

Cesar et al (Cesar, Bulterman, & Jansen, 2009) identify three areas in which TV could benefit from a second screen interface. These are content control, which they define as "to decide what and how to consume television content," content enrich, defined as "to actively manipulate the television content," and content sharing, "to socially communicate with others." Cesar et al also highlight that, "in specific situations people tend to multitask while watching television by using laptops, for example, to check emails or obtain extra information about TV programmes."

Choi et al (Choi, et al., 2011) also highlight the issue that the viewer's attention is taken away from the TV screen and their main objective of watching TV, with their focus being on the second screen. This in turn however brings with it a benefit of its own as the viewer can browse menus and information such as the EPG without interrupting the programme that they are watching on the TV. This has the potential to make TV a relaxing, sit back technology again.

Commercially, using second screen technology in the DITV environment is becoming commonplace. Cesar et al highlight that using a second screen device in a TV environment is not a new concept (Cesar, Bulterman, Jansen, et al., 2009). There are a number of on demand services and applications now available and specifically designed for smart phones and tablet PCs. However, these are for video playback and do not control a TV set. It is argued that, with the choice of watching TV on one of these devices or a TV set, the majority of people would choose to watch on the TV set. In the UK, there have been several applications produced that allow the user to control the recording of content over the internet ("The Free Sky+ App," 2011). These applications, or 'apps', allow the user to browse TV listings as they would their EPG on the TV, choose programmes to get more information and also have the option to record programmes. An example of the Sky+ app for the iPad can be seen in **Figure 3-1**. These applications usually require the user to have an account with their provider to which the application can log into.

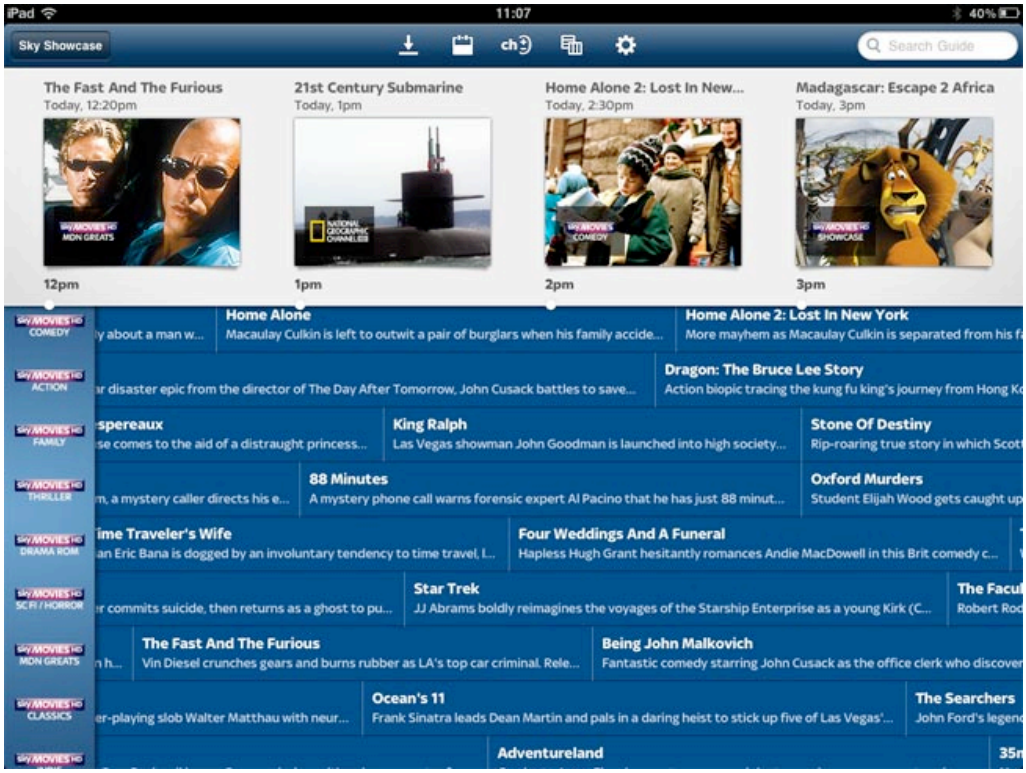


Figure 3-1 – Sky+ iPad App

In the US, there are several apps that have been produced to directly control the STB. An example of this is the Tivo application ("A groundbreaking new way to interact with your TiVo DVR," 2011). This goes a stage further than the Sky app and the TV Guide app as it allows the user to also manage recordings rather than just set recordings. The second screen could also be used for personal advertising and allow the viewer to participate in game shows and quizzes. Cesar et al also suggest that the second screen can be used to continue watching a programme from the place the viewer stopped watching it on the TV screen (Cesar, et al., 2009). They continue on from this to suggest that using a second screen could allow each viewer in a household to have a personal control device for the TV through the use of second screen devices. This would give them EPG like functionality on a personal display.

Personalisation also becomes easier with a second screen device, particularly if it is a personal device. This is something that is difficult on a shared TV (Park et al., 2006).

Eronen and Vuorimaa say in an early paper that information searching should be natural (Eronen & Vuorimaa, 2000). Multitouch devices offer a Natural User

Interface (NUI) that is more intuitive that Graphical User Interfaces (GUI) ("Natural User Interface a Major Factor in iPad Adoption?," 2010). Currently, the remote control and television setup can be considered to be non-intuitive, particularly in cases where a great level of focus switching is required. In a 2006 paper, Eronen highlights that pointing and selecting items with a remote control requires a sequence of actions which place a much larger cognitive load on the user than pointing and clicking a mouse using a GUI (Eronen, 2006). The NUI of multitouch devices should therefore improve this ability of users to search for TV content with greater ease.

Research work published by Viacom ("Tablets Are Leading Alternative For Full-Length TV Show Viewing After Television, According to Viacom's "Tapping Into Tabletomics" Study," 2012) indicates that tablet PCs were the leading second screen alternative for watching TV. This same report showed that many use tablets while watching TV to complement the TV experience.

3.2 Alternate Menu Designs

The current text heavy EPG layouts have already been discussed and considered to be problematic for users, particularly those with visual and cognitive impairments. Research into the literature has suggested several different approaches and techniques that could improve the current on screen designs.

The Finnish Media Centre Study previously discussed (Turunen, et al., 2009) developed an EPG as part of their study. They use Focus+ context techniques, which aim to “display the most important data at the focal point at full size and detail, and display the area around the focal point (the context) to help make sense of how the important information relates to the entire data structure. Regions far from the focal point may be displayed smaller (as in fisheye views) or selectively omitted” ("Usability Glossary: focus+context," 2002). The columns and rows towards the centre of the screen are slightly enlarged, with the active programme strongly enlarged. They use transparency to show the content under the enlarged area. The GUI (Graphical User Interface) is also fully zoomable, allowing the user to view a weekly overview to daily and hourly close-ups. This EPG does take advantage of the full area of the screen, and allows the user magnify the content they wish to. However, the continuously changing display may cause issues that confuse the user.

Other research has suggested that designers of interactive TV content such as the EPG should take into consideration the fact that viewers have different levels of attention to watching the TV and interacting with menus, depending on the purpose for which they are watching the TV. Bonnici (Bonnici, 2003) says that there are three levels of viewing. Level one is unplanned viewing where the user will flick through the channels to find a programme to watch and is usually done after school or work. Level two is normally pre-planned viewing of programmes such as soaps or games shows that are on at the same time on a daily or weekly basis. The viewer will set aside time to watch these programmes. Level three viewing is for programmes that require short term planning to view a programme, typically between a day before the programme and a week. In this paper, Bonnici also outlines a step-by-step plan to produce an EPG interface.

The use of images to represent programmes may be a viable alternative to the current text and grid layout. Open TV[7], who produce the middleware for STBs (the software on the STB to be interacted with) for companies such as sky, have researched the use of fully graphical environments for the design of EPGs. Cooper says, "the human visual system is able to take in a large amount of pictorial information compared to tabular text." However, he does say that it is difficult to represent programmes in a single image (Cooper, 2008).

As has been previously alluded to, the design of the EPG will be hand-in-hand with the control device that is used with it. Moving away from a standard remote control with arrows to control the cursor movement may reduce the need for the EPG to be sequential. However, the distance from the screen and screen size have to continue to be taken into consideration in EPG design.

A 'TV Guide' type layout, mimicking the layouts commonly found in newspaper and magazine TV Guides might also be a solution to the EPG design problem. This would be a step away from the standard sequential EPG grid. It may be a case however that this layout does not lend itself to being well displayed on a TV, again

[7] http://opentv.com

because of the distance and resolution of the screen. Without a grid, it may be difficult to follow and to find the programmes that the user is looking for. However, this type of layout may be better represented on a second screen device where the user can also use it in a similar way to that they use a paper guide.

The personalisation of the EPG is another option for design purposes. The user would be able to select what channels and programming to view on each screen of the EPG. In this way, programming could also be recommended to the viewer based on their personalised selections and displays. This would remove any channels and programming that the viewer is not likely to want to watch or would ever choose to watch. Although this may seem like a simple, effective solution, in practice it poses many problems. TV is normally seen as a social, shared experience, with different groups having different tastes. It is therefore difficult to personalise an EPG to suit a group of people, such as a family. Cesar and Chorianopoulos say that "the research community should refocus the mainstream research on content personalisation for interactive television by taking into account that: television is a shared experience, contextual information is essential and data gathering should be a non-intrusive process" (Cesar & Chorianopoulos, 2009).

3.3 Chosen Solution Path for Older Adults

Based on the results of the literature review, it was first decided to conduct exploratory studies with older adults to determine if their views supported what had been indicated in the literature review.

In particular, interest was focussed on gesture and second screen interaction, as these devices were easily and commercially available at the time of this work, and were devices that were currently being used in a growing capacity with DITV, as has been illustrated in the literature. The literature also shows that these forms of interaction appear to offer benefits in a DITV environment where the interaction needed is brought to a single screen rather that with the current TV and remote control set-up.

Voice interaction, while offering similar benefits, has complex system issues. The problems of the different types of implementation for voice interaction have been highlighted in the literature. Gesture and second screen interaction did not have the

same degree of complexity and issues associated with them, and so were deemed a better option moving forward with this study.

4 Exploratory Studies

Two exploratory studies were conducted, a focus group study and a study using a Nintendo Wii games console. Both these studies were conducted using a qualitative approach as the opinions and observations of the participants were considered important at this stage of the research.

4.1 Focus Group Study

4.1.1 Introduction

Two focus groups were conducted with older adults in October and November of 2009, before the digital switchover in this region, which was Dundee. The aim of these initial focus groups was to get an understanding of what older adults felt in general about the technologies around them and, more specifically, how they watched TV and what they used their TV for. The participants were also asked to bring in their remote controls to point out how many buttons that they used on them and what the different remotes controlled. Altogether there were nine participants, with no known disabilities. Five of the participants were between the ages of 65 and 75, three were between 75 and 85 and one who was older than 85. This was an early study in the work and so the age ranges had not been established at this point, although the study did give a good baseline. The participants were more technically capable than the average older adult due to attending computing classes. They all volunteered from the User Centre in the School of Computing at the University of Dundee. They had all previously shown a willingness to use technology and try out new technologies as well as give their opinions on them.

Data Collection and Analysis

Each focus group session was conducted over a one hour period. The author acted was the researcher and was present during each of the sessions, and the sessions were also video recorded with the consent of the participants.

The participants were first asked to read the information forms provided and were then given an overview of the session from the researcher. They were then asked to fill out the brief questionnaires (**APPENDIX 4A**). After this, the researcher worked through a list of questions, which are outlined in **APPENDIX 4B**.

Once both the focus group session had been completed, the video files were copied from the cameras to a hard drive. Each of the sessions were then analysed and using thematic analysis (Braun & Clarke, 2006), with comments being grouped into four main themes. These were everyday technology devices, older adults and television, older adults and DITV and older adults and remote controls.

4.1.2 Results

Everyday Technology Devices

There was an interesting discussion during both sessions about the technology devices the older adults identified that they, and others, used as part of an everyday lifestyle. Around the home the groups highlighted how cookers had changed and were easier to use with the integration of timers and the ability of them to switch off after a set period of time. The microwave was another kitchen appliance that was discussed as having made cooking easier.

The second group spoke about the changing ATM bank machines. Although the buttons remained similar most of the time, they felt that the on-screen interfaces changed often and they had to get used to the new layout each time.

Both groups spoke about the use of mobile telephones becoming more prominent in their everyday lives, but in most cases they were keen to stress that these were only used in cases of emergency and not for general "chit-chat." It was also commented that they had not taken the time to learn how to use all the features on their phones and so could not use them to their full potential. In most cases however this was not an issue as the basic operation of making and receiving phone calls was all they required this device to do. They did not like the idea of talking on their phone in a public space, and in some cases they felt it was rude and not taking into consideration others around them. This claim was also targeted at individuals who used MP3 players in public spaces. This may have an impact on older adults views of personalised TV as TV watching becomes more of an individual experience and available on the move. This is highlighted later in the second focus group where a comment from one participant about someone watching a video on their personal device on a train was:

"How do you speak to these people when it is quite clear you are interrupting them?"

The other prominent piece of technology that the older adults felt was important to them was the radio. This was a device that they often used to relax, and have on in the background when doing other things. They felt it was also mentally stimulating as images of a story could be formed when listening to them on a radio.

Older Adults and Television

The majority of the older adults who attended the sessions had access to DITV on at least one of the TVs in their home through either freeview or a subscription based service like Sky. Only two of the nine had no access to DITV. The main TV set in the house was found in the living room in all cases, with additional sets in the bedroom and, in some cases, the kitchen. DITV was mostly found on the TV set in the living room, with the other TV sets in the house only able to receive the analogue signal. In some cases this is because the STB connected to an indoor aerial did not get a good enough signal to operate.

The main TV set was normally a newer LCD or plasma television with the other, secondary TVs most likely to be an older CRT TV.

Interestingly, of those who said that they had a TV in the kitchen, they said that in the main it was for background noise only:

"The TV in the kitchen is just for noise."

One male participant mentioned that if they wanted to watch a different programme from their partner then they would watch it on the kitchen TV, although this was a rare occurrence.

When asked if they watched TV with family and friends or on their own, those in the group who had a partner said that the majority of the time they would watch TV together. This did not always necessarily mean that they were paying attention to the TV, as some said that they would often read a book while sitting with their partner who was watching a programme. Both groups unanimously agreed that they would switch off the TV when visitors would arrived as they felt it was good manners and

would prefer to engage in conversation with company. It was highlighted that this was not always the case when they visited others and that the TV would be on in the background. When it was close family that visited, both groups spoke of how their visitors would come in and switch the TV on, and sometimes not engage in conversation as their attention was drawn to the TV. One comment in the second session suggested that the TV is sometimes used socially with family:

> *"When family are around, TV can be a social instrument and can sit and watch it together."*

The 'water cooler' type conversations were also discussed at this stage. This is when people will discuss popular TV events such as what happened on a TV programme in its latest episode. The second group spoke of how TV sometimes came up in conversation amongst them, but the discussions would be more informative and rarely about entertainment programmes such as reality TV or soaps. One comment made here was:

> *"We don't gossip about TV."*

The groups were then asked why they watch TV. The main reasons given were for entertainment followed by for getting information. Other reasons given were to relax, and for company. Both groups were adamant that they were not dictated to by the TV schedule and sometimes only resort to watching TV if there was nothing else to do. The second group reinforced their dislike for reality TV when they commented that it was normally put on in prime-time slots, meaning that in the late evenings, if they wanted to watch TV they were practically forced to watch such programmes. It was also said that they could watch their favourite old programmes because of channels available on freeview TV. However, they were frustrated that episodes were regularly repeated within a short space of time of each other, which ruined their enjoyment of watching them. The weather was seen as a useful piece of information gathered from watching the TV as in some cases the forecast would determine if they were able to go out or not. The groups also preferred in most cases to use the radio for background noise than the TV. However, the first group highlighted that if they were to become homebound, the TV may become a more important part of their life, and even more so if they were alone.

Older Adults and DITV

The groups were then asked how they found out about programme information and how they choose which programmes to watch. Again, both groups were in general agreement with the answer to this question. Most would use a TV magazine or newspaper to plan any programming and would refrain from using the EPG. This is in the main part of their habit as it is something they have been used to doing for a long time. This is an example of older adults seeing no need to change the way that they operate, as it is not 'broken' and gives them the information they require. Both groups said that they found the EPG difficult, cumbersome and unfriendly to use. The first group added to this by saying that the information the EPG gave about programmes was insufficient and the second group commented on the complicated menu set-up and design of the EPG. One comment in the second session was:

"I wouldn't miss the EPG is it wasn't there."

It was suggested by the researcher that the viewer could use the EPG for channel selection. This was not seen as needed as in most cases the participants memorised their favourite channel numbers.

The EPG was seen to be useful in some situations however. The main uses of it were if the user was channel surfing, if programming times had changed or for quick information by using the 'now and next' feature. However, in most cases the groups said that they would often stick to watching channels 1-5 (traditional analogue channels in the UK). Both groups commented in the majority that they would rarely watch dedicated TV channels, with the likes of BBC News being the exception. One of the participants in the second group went against this grain and said that they preferred to watch freeview channels to the traditional set of 1-5.

Another discussion point in this section was the recording of TV programmes. One of the participants in the first group said:

"I'm not too bothered about missing programmes."

Again, this was a general agreement amongst both groups. However, most did make some attempt to record programming that they wanted to watch but could miss. Some still used traditional VCRs, but the limitations of this device were highlighted in both

sessions. These limitations included the difficulties in setting the timer and channel number of the VCR. Some also found it frustrating if the time of their programme changed meaning that their VCR would record the wrong programme. The second group mentioned that Video plus, which gave a number next to programme listing in a TV guide that could be used to programme a VCR, had made recording on a VCR easier. Several of the participants had used the Sky + DVR system and felt that it was a great system that was easy to use. It was felt that this made it easier to record programmes and watch them together as a family, and people in the second group gave examples of how their family had used it in this way. Others liked the fact that the service made it easy to fast forward past adverts. Not all the participants liked the system though, as one in the first group commented:

"I don't know how to use it but my 10 year old grandson does."

The second group discussed this area in more detail and spoke about how they chose what to watch. One participant described how their partner would choose films and programmes to watch based on who was in them. Another mentioned how they would be interested to find out more about how to use BBC iPlayer. They were impressed with being given the ability to choose programmes that they wanted to watch when they wanted to watch them, without the need to record them.

One member of the first group spoke at this point about subtitling. They were impressed that the Sky+ service also captured the subtitles with its recordings. However, the participant vented his frustrations at how subtitling on live programming was difficult to follow. They also mentioned how their young grandchildren were happy to sit and watch programmes with the subtitles on when they visited.

Despite the positive responses to DVRs and the possibility of using BBC iPlayer, neither of the groups were interested in the idea of using a programme recommendation system. The first group voiced their concerns about the TV screen getting more cluttered and how a recommendation 'pop-up' would add to this. The second group said that they would be cynical towards such a service with questions about the motives of them, wondering what the producers were 'after' and whether

they were just advertising rather than trying to help the viewer. This supports the argument that recommender systems for TV have to be implemented with care and consideration, particularly when used by older adults.

The groups were asked about the use of teletext. Participants in the first group had all used this service to get information about lottery numbers, weather and news. However, they found it annoying at the length of time it took to load up pages. Participants in the second group said that they used to use it but not so much anymore. When asked if they used the newer digital text service, the members of the first group said that they had tried to use it but did not like it. They found the picture-in-picture set-up annoying and a distraction. This was reinforced by comments in the second group that said:

> *"Things that come up on the screen interfere with the prime objective of watching TV."*

It was also felt that teletext and digital text was not needed as much anymore as they used the Internet to get the information that they used to get from here.

Groups were then asked what other possible features they may find useful on a DITV system. The response to this was fairly limited. There were suggestions of possibly integrating the Yellow Pages or weather information into widgets, but they felt that this information was just as easy to get from the Internet.

Older Adults and Remote Controls

Discussion then turned to the remote controls that the participants had brought with them in each session. Most of the participants who had DITV needed at least two remote controls, one for their TV and one for their STB. Altogether there was on average about fifty buttons on the remote controls. Of these, normally only the basic buttons were used, i.e. the number buttons, the power button and the volume buttons. Of the other buttons, it was said that the older adults did not know the function of at least half of them. In some cases, the second remote was needed simply to turn the TV on and off, as this could not be programmed into the STB remote.

The groups were then asked whether it became difficult to change focus from the remote control to the TV and vice versa. They felt that this was simply something that you had to get used to and that you become familiar with it. They also felt that as they learnt where the required buttons were on the remote, they needed to look at the remote less, although this did at times lead to errors being made:

"Don't always think what I'm doing and press the wrong button."

The participants felt that in general, there was some form of irritation when trying to interact with the TV with the added functionality and number of remote controls. This does not put them off though and sometimes see it as being their own fault:

"Usually blame myself for picking up the wrong remote."

They do not feel however that using the TV has become any more difficult with the added functionality. This sense of self blame can lead to the older adult not wanting to fully explore the system for fear of breaking it (Bhachu, et al., 2008).

4.1.3 Conclusion

As an initial insight into how older adults watched and used their TV this was a useful exercise. The results seemed to be in line with the thoughts and feelings that would be expect from older adults and in most cases supported the information in the literature.

It highlighted the fact that older adults are not afraid of technology, but the benefit to them has to be clear. In the case of the EPG, this group of older adults saw no benefit to using it and so stuck to their previous methods, such as using a paper TV guide or newspaper, or by finding coping strategies, such as memorising the channel numbers.

The benefits of using the DVR were highlighted by some of the older adults who had experienced this service. There was also a positive reaction to an on demand type services.

The remote control was highlighted by this group to also cause some irritation when interacting with the TV. However, there was culture of self-blame that meant that the

older adults did not feel the remote controls were a great issue and felt that they simply had to adapt to using them.

Older adults' viewing habits were also an interesting result from these focus groups. First of all, it is clear that they would watch TV with a partner where possible, even if they carried out other activities such as reading while the TV was on. The TV was used for many reasons, in particular for information and to help the individual relax. This does follow some of the statistics given in section 2.4. However, further comments about the quality of programming available, and the enjoyment that older adults get from them, also back up the statistics in this section. Furthermore, it was interesting to note that the role of the TV in their lives was felt to likely become more important if they became housebound or were living alone.

The next stage of work aimed to focus on an alternative remote control and interface combination to assess how older adults interact with the TV in this environment, and also understand if they see any benefit in a different on screen interface and control device.

4.2 Wii Study

4.2.1 Introduction

The literature review highlighted the benefits of alternate remote control devices in a DITV environment. In particular, the benefits of readily available technology such as gesture controls and multitouch second screen displays were of greatest interest. The feedback from the older adults' focus group sessions also highlighted several of the issues identified in the literature related to the standard remote control device. It was therefore decided to investigate the gesture and multitouch second screen controls further.

At this stage of the work, the group of older adults in the User Centre at the School of Computing in the University of Dundee had been observed using the Wii games console manufactured by Nintendo (Casey, 2006). The group were comfortable using the controller to play games such as bowling, tennis and golf. Also, the Wii was a readily available and accessible device, and with the BBC iPlayer being adapted to

suit the Wii interface, this was an ideal opportunity to explore how older adults interacted with a gesture control with little development effort and time required. In this study, it was decided to investigate this device further in a TV like environment.

4.2.2 Experimental Methodology

Research Question

For this specific study, the research question based on the hypotheses, and linking back to the overall research, was:

'Can the Wii controller be considered as a possible alternative for older adults to the traditional remote control to browse and select TV programming content and why?'

Hypotheses

The hypotheses for this experiment took into consideration the overall research question, and the manner in which this study would be conducted, with participants' opinions forming the results. Based on the literature review of gesture controllers in section 3.1.2, and taking into consideration the target population of older adults, the main benefits and potential disadvantages of this device related to older adults were also taken into account when forming the hypotheses. Therefore, the hypotheses comprised of:

H1. The participants will feel their attention is drawn more towards the television screen when carrying out tasks than they do with their current remote controls, with less need to look down at the controller.

H2. The older adults will find the Wii-mote difficult to control because of the need for gestures to operate the pointer. The required movements will become harder the further the participant goes into the study as their arm fatigues throughout the process.

Participants

There were eleven individuals taking part in the study, five younger adults (one female and four male) who were under the age of 33 (and older than 27) and six older adults (two female and four male) over the age of 65. One of the older men was over the age of 80 (86) but was considered for this study due to being one of the longer attendees of the computer class. Four of the older adult group indicated that they needed spectacles for watching TV, reading text on the TV and to use the remote control, including the 86 year old. The other two in the older adults group said that

they did not need spectacles for any of these tasks. Four of the younger adults said that they did not need spectacles for any of these tasks, with one saying that they did.

The younger adults were all staff and students from the School of Computing at the University of Dundee and were experienced computer users. The older adults were all from the older adults' computer centre in the School of Computing at the University of Dundee and had a good grasp of the basics of computing. Four of the older adults had also taken part in the previous focus groups. None of the participants had a great deal of experience of the using Nintendo Wii or gesture based remote controls, although most had played games on the console at least once. The only exclusion criteria was that participants were required to have had no experience of using the BBC iPlayer on the Wii, as this was the software that would be used for the experiment. Many of the younger adults group had however had experience of using the BBC iPlayer on a desktop platform. All the participants were healthy, experiencing no major disabilities, apart from any impacts of age related decline in cognitive, sensory or motor abilities. For this experiment, these were not specifically recorded, but are taken into consideration where comments refer to this.

Younger adults were included in this experiment as a contrast group. This was to identify if the usability issues (or benefits) uncovered during the study were specific to older adults or if they applied across a larger population. The computing experience of the younger adults in this experiment is likely to distinguish them from the general population. The older adults in this experiment also had more computing experience than the average older adult due to attending the computing classes. These elements must be taken into consideration in the results.

Hardware and Software

The hardware used during this experiment was the Wii games console with the Wii controller, the Wii-mote (**Figure 4-1**). A 28" LG TV was connected to the Wii as the display device.

Figure 4-4-1 – Wii-mote

The software used was the BBC iPlayer for the Wii (**Figure 4-2**). This software was introduced for Wii console owners to download in November 2009.

Figure 4-4-2 – BBC iPlayer on the Wii

Procedure

Each participant worked as an individual throughout the experiment, with the researcher present only to observe the actions of the participant and help only when the participant was visibly struggling. Each session lasted about an hour. They were first asked to read the participant information form (**APPENDIX 4C**) and complete a consent form (**APPENDIX 4D**). They were then asked to fill in a short questionnaire to establish if the lived alone or not, and if they required corrective glasses for any reason (**APPENDIX 4E**).

The participant was then asked to begin the experiment. They were encouraged to talk through what they were doing at each stage of the tasks. After completing the set of

tasks, the researcher then asked a set of questions related to the tasks that had been completed.

Pilot studies were conducted in the first instance to test out the experimental procedure and to ensure that all the equipment was working as required.

Tasks

There were six general tasks that each participant had to complete during the study. These tasks were chosen to give the participant an opportunity to experience a wide range of the user interface and the variety of different screens and menus available. The tasks chosen focussed on what the participant would watch on TV to suit their own unique TV watching habits. For this reason, in this study, time and errors were not taken as measurements as the results would not be consistent between participants as each had a different end goal. Therefore, the opinions and feedback from the participants was most important during this study.

The tasks were:

1. Ask user to suggest a programme from the BBC that they would like to watch
2. Ask the user to find this programme on iPlayer and select to view it
3. Ask the user to pause the selected the programme
4. Ask the user to browse to a specific time in the selected programme
5. Ask the user to turn down the volume of the iPlayer
6. Ask the user to mute the volume of the iPlayer

There were also three additional tasks that were outlined. Any or all of these tasks were requested by the researcher for the participant to complete in cases where the researcher felt that the participant had not had the opportunity to fully explore the system during the original six tasks. The additional tasks were:

1. Ask the user to find the most popular television show for today
2. Ask the user to find another way of getting the most popular show
3. Ask the user to find a specific show

Data Collection and Analysis

This study was conducted as a qualitative study. Each session was recorded with a video camera for later analysis, with the researcher also making notes during the session. The questions that were asked to all participants at the end of each session were:

1. Did you feel you were concentrating more on the screen or the controller?
2. How difficult was it to locate the cursor on the screen?

3. Does the vibrating feedback help the user to 'find' the icons on screen?
4. How difficult did the user find it to make selections?
5. Is it annoying to see the onscreen control icons?
6. How difficult is it to use the remote without the armrest?
7. Do you feel your arm weakening when using the controller?
8. How does it compare to the remote controls the user currently uses?
9. Is it something the user could get used to using?

As with the focus group study, the video recordings were analysed and thematic coding again applied to the data. The resulting themes that came from this analysis were viewer attention, tactile feedback, on-screen design, images representing programming and handling the Wii-mote.

Because of the nature of the tasks, time and errors were not appropriate to be recorded. Individuals were to select their own programme from the guide. This programme could appear anywhere in the guide, at different levels and with different required number of selections for each. Therefore, the time and errors recorded would be specific to the programme being selected and could not be compared between the participants to gain quantitative data. In this instance, it was decided in the experimental design to give the participants a choice in which programme they would select as it would more accurately reflect their TV viewing habits.

4.2.3 Results

Viewer Attention

When asked if the participants felt their attention was drawn more to the TV screen or Wii-mote using this set-up, the majority said that their focus was on the TV in both groups. Again, for both groups of participants, comments were made that attention was on a specific area of the screen when performing a particular task. Despite this, participants from both groups also highlighted the fact that there was a learning curve involved with the Wii-mote that gave them a need to look down to find a button, mostly the 'A' button to make selections. It can be argued that this is a learning curve that goes with most new technology a person is confronted with. In general, despite the fact that accurate times measures were not taken, the older adults appeared to take longer to complete the tasks than the younger adults. This learning curve getting used to this new technology, and new form of interaction, may account for some of the additional time.

Of the younger group, four of them said that they had no problems finding the cursor on the screen at any time. The other participant in this group said that they had to keep the cursor very steady, which was slightly awkward, but was something that they could get used to. Four of the older group also felt that the cursor was easy to find, including the 86 year old. The others felt it was difficult to find but once it had been found it was not a problem. Three of the six in this group felt however that the cursor was difficult to keep steady with the Wii-mote. One of this three also suggested that this was made even more difficult with the tremor in their hand.

Tactile Feedback

The tactile, vibrating feedback that the Wii-mote produced when the cursor went over screen elements got mixed reactions within both groups. Those in the younger group commented on how the feedback was only given when large, fast movements were made. Another in this group felt that the feedback was good to start with, but the longer they used it the more annoying it became while another felt it was annoying from the beginning and that they preferred to use sight instead. One of the younger group also commented that they did not even know what the vibrations were doing. Two of this group felt that the vibrations were what caused the slight movements of the cursor that irritated them. Of the older group, none of them found this feedback helpful. Four of the six admitted that they did not know what it was for, one of these being the 86 year old. Two of the four who said this commented on how it may be useful once it had been explained to them what it did, again with one being the 86 year old. The 86 year old went on to clarify this by saying that they like it when they are given meaningful responses to what they are trying to do and do not like it when systems are 'silent' with little feedback. Two of them found it annoying, but one of these two did highlight how they felt it might be useful for those who have visual impairments.

On-Screen Design

The majority of the younger group had no problems with the on-screen elements and one summed this up when commenting that they found the buttons:

> *"Big and easy to hit."*

The main issue that this group mentioned was issues with the scroll bars. They found that they had to be precise when controlling them and commented:

"I wouldn't like to use it if I was tired and watching TV."

The feedback from the older adults on this topic was slightly different. Many felt that they needed to get more familiarity with the layout and how each of the elements worked. This may a legacy of the fact that this group had little experience of using the iPlayer before and so did not know what the buttons did in each case. One comment was:

"I'm still at the stage of guessing and it's very much trial and error."

Two of the six older adults, mentioned how they found it difficult as the pointer moved when they were making selections. This was often a case of a movement that they would make as they hit the 'A' button to make selections. One of the six found that the on-screen elements were a bit small.

It was also obvious when watching the older adults using the 'Search' function that the older adults were more inclined to focus on a specific area of the screen when performing a task. This would often lead to them missing other things that were happening. In the case of the 'Search' they would miss the predictive output on the right of the screen as they input the text on the left. One of the group said:

"There is a focus on one thing and you get stuck in that area looking for the answer,"

Another commented:

"I didn't see that (the prediction) because I was concentrating (on entering the text)."

When completing the tasks, it was clear from observation again that the older adults were more likely to go down one solution path and keep looking in this area even if it was not correct. The younger adults were more likely to reject a path after a few seconds of trying.

One of the main reasons that the older adults had issues with the interface was because of the highlighting of the tabs. Initially they could not understand that a single tab could display different things depending on the process used to get there. For example, when a programme is chosen, the information for said programme is shown under the TV tab. However, when searching for favourites, most of the older adults were unaware that selecting the TV tab from the home page would give them an overview of the channels and options available as they expected it to only show single programme information. None of the younger group had issues with this.

Discussion also focussed on the on-screen controls of the video player that would pop-up when needed and disappear again when the Wii-mote was set down. In general, the younger adults identified that these controls and their operation was something they were used to when watching DVDs on their own computers or other video players like the iPlayer. Two of the five did indicate that it was annoying that it did not go away almost instantly and that the control had to be set down and rested before it did. One of the five liked that it showed up towards the middle of the screen and that made it more noticeable. Of the older adults, four of the six had no problems with it and did not find it too irritating. One of the six, who was 86, preferred if this was constantly shown on-screen while another, indicated that they did not want anything on the screen when they were watching a programme.

Images to represent programming

The use of images to represent programmes was also observed and brought up during the discussions with the participants. In general, the combination of images and text helped the users when making selections. Four of the younger adults made specific comments about the images. One of these said that they would like to see the images with the list of text in the scroll bar. Another said:

> *"The images give a bigger hint to what programmes are."*

The other highlighted how they found it easy to browse the channels because of the channel icons in the TV tab. One of the younger adults also commented that it was good that there was not too much text on-screen and that they liked the images. Of the older adults, fewer actual comments were made about the images. However, five of the six chose a programme to watch based on the images scrolling through on the

home page. The one that did not was the 86 year old. These images were also accompanied by a text overlay. One of the participants also commented on how they would not have chosen a certain programme because they did not like the person that was shown in the image. One of the older adults did say that they preferred to always have text while another said that they preferred the images as they were easier to see.

Handling the Wii-mote

All the participants who took part used the armrest of the chair or their own body as a way to rest their arm and steady the Wii-mote. In general it was felt that this was easier and less tiring doing this and also most felt that the pointer was more difficult to control without it. A comment from one of the younger participants was:

"Might be easier to put down and use like a mouse."

Another from this group commented:

"I would have to use both hands as it needs some steadying."

One member of the older group felt that it was actually easier to control without the armrest. However, this same person felt the remote was a bit too heavy to keep held out which made it tiring. In the main, most of participants in both groups found the Wii-mote tiring to use, as it was slightly heavy.

Four of the five younger adults liked the Wii-mote as much, if not more, than the remote control that they currently used with their TV. One felt that they could use it in the same way while relaxing. Three others liked the fact that there were less buttons than on their own remote controls at home. However, three of the five did say that they needed more buttons on the remote control, at least for the basic functions of the TV. They were also open to having a control that incorporated elements of both controllers. The older adults had a quite different response to this. They preferred their own remote controls in all cases, although they saw the fact that there were less buttons as somewhat of a benefit. One of the older adults did mention how they felt that their posture might be irritated when using the Wii-mote over a period of time. The main feeling amongst this group was that the Wii-mote was something that they may get used to with more experience of using it.

4.2.4 Conclusion

The overall opinion of the Wii-mote from both the younger and older participants was that it was something that they could get used to using and could see the potential in the set-up. In general, the older adults felt that they would be happy to try the set-up over a longer period of time. They are not presented with too much information and have a simple format to work within.

The younger adults were likely to have a greater level of technical knowledge than the older adults, particularly since they were staff and students from a computing department at the University of Dundee, and since they were more likely to have used the iPlayer on a personal computer. On observation, this did result in them being more efficient in using the system, completing tasks quicker, and making fewer errors when doing so, despite their lack of experience using this particular device. The issues that were identified during the study were common in the majority of cases amongst both the younger and older adult groups. It can therefore be presumed that these issues will impact the majority of the population and must be rectified for using this device in a DITV environment.

As expected in H1, it was apparent that both groups felt that their attention drawn more to the screen than with the traditional remote control set-up, with less concentration needed on the Wii-mote when performing actions. However, it also appears that both groups feel like they have less control over the system because the Wii-mote could not do the basic functions such as adjusting the volume. However, this is a limitation that is imposed with the platform and software being used and is something that can be included in future developments by programming other buttons on the controller to perform these actions, or by providing on-screen controls for this.

H2 was also shown to have substance through the discussions during the study. The older adults did indeed find the Wii-mote heavy, which made it tiring to use, despite the use of the armrest on the chair in most cases. However, this result was not exclusive to the older adult group, as the younger adults also had the same issues with using the device. This was a surprising result to an extent, as it was not considered that the younger adults would experience fatigue in the arm in the same manner as the older adults did.

The on-screen elements were considered to be of the right form factor to allow easy interactions with them, with the exceptions being the scroll bars. The use of images with text overlays to represent programming received mainly positive feedback. This was something that will have to be taken into consideration later in the process when designing interfaces.

There are clearly some benefits towards using a gesture type control in a TV type environment, in particular, the need to switch focus between the screen and controller appears to be reduced compared to a traditional remote control. However, there are also disadvantages such as the lack of control buttons on the controller, and the fatigue associated with using it. These appear to apply to the general population as they are also highlighted by the younger adults, and so must be taken into consideration in the future.

At this stage, it was decided that a larger study would give a direct comparison between a traditional DITV remote control and a gesture control so that the devices could be compared to each other in the same environment. Added to this, a tablet PC as a second screen interface was also to be considered in the comparison as it had the potential to offer similar benefits as those highlighted by the gesture control, such as less need to switch focus between the TV screen and the device, but also more likely to avoid the fatigue issues that were outlined in the Wii Study.

5 Remote Control Study

Based on the literature reviewed, and the previous exploratory research of the focus groups and the Wii study, it was decided that it would be important to test and directly compare different devices for interacting with digital television. The devices selected for this experiment were a tablet PC as a second screen interface, a gesture pointer and a standard TV remote control. The Electronic Programme Guide (EPG) was the particular service that was chosen to test the devices with as it offers a wide range of interaction for the user and is a service that DITV users are likely to use.

5.1 Experimental Methodology

5.1.1 Research Question

This took the overall research question outlined in section 2.5 and adapted it to specifically include the tablet PC as a second screen interface, and the gesture control, as the alternative remote control devices:

Can a tablet PC as a second screen interface and a gesture control be considered as possible replacements for the traditional Digital Interactive TV remote control and why?'

5.1.2 Hypotheses

There were several hypotheses outlined prior to the experiment. These were considered based on the research question. The hypotheses took into account the perceived advantages and disadvantages of the tablet PC and gesture control based on the literature review in section 3 of this thesis, and the subsequent work done with the gesture controller in the Wii study in section 4.2.

H1. The remote control will perform significantly better in all areas of the experiment, producing the:

H1.1 fastest times

H1.2 least errors

H1.3 best usability ratings

This is because it is the device that the participants are most used to using, and most likely to be comfortable using. Also, the experimental interface was optimised to be used with the remote control as it is based on current standard EPGs.

H2. The touch screen interface will produce the faster times for completing tasks than the gesture pointer. With all the buttons and instructions on the same screen, the need to process the on-screen instructions and then switch focus to a second interface is removed completely and therefore the time taken to complete a task should be reduced. There is also direct interaction with the buttons on this device without the need to move a cursor around.

H3. The touch screen interface will produce the fewer errors than the gesture pointer because of the reasons outlined in H2.

H4. The younger adults will give higher usability scores to the tablet PC and the gesture pointer than the older adults. This is due to the likelihood that they have had greater exposure to these newer technologies and therefore be more comfortable using them.

Literature shows that younger adults as a group will perform the tasks faster, and with fewer errors than the older adults. This is due to the fact that they are less likely to have age related declines in physical, sensory and cognitive abilities as well as being more likely to have experience of using the devices that are being used. Because of this, this group will be considered as the control group for this study. This should highlight the results that are specific to older adults and show results that impact the general population.

By testing the above hypothesis, the results will show the extent to which older adults perform with the tablet PC and gesture controller when compared to a traditional remote control when completing tasks on a DITV EPG and therefore if they could be considered as a replacement for the traditional remote control. However, the subjective measures of usability may contradict these results.

5.1.3 Participants

Twenty-four participants were recruited in total, with twelve older adults and twelve younger adults. Twelve participants for each group was decided upon. Hwang and Salvendy argue that only ten plus or minus two participants are required for usability

evaluation (Hwang & Salvendy, 2010). Using the Raosoft sample size calculator[8], the sample size of twelve gives a margin of error of 19%, and a confidence level of 80%.

It was also desired that there be a balance to the number of females and males in each group. In the younger adults group, there were five males and seven females, and of the older adults, there were six of each.

All the participants were recruited from the SiDE user pool at the School of Computing in the University of Dundee. There were no limitations on the computer or television experiences of the participants, although they were asked about this during the study.

All the participants were required not to have any disabilities that may affect the way in which they carry out tasks, apart from those can are associated with the age related decline of physical, sensory and cognitive abilities (not be registered deaf, blind or disabled).

All efforts were made to ensure all the older adults fitted into the age range outlined in section 2.1. This was achieved with all older adult participants aged between 63 and 79. The younger adult participants in the comparison group were all aged between 19 and 30.

Each participant was given a gift voucher the value of £10 for the first hour, and £5 extra for any session taking more than an hour for taking part in the study. Each session lasted between 1 and 1.5 hours. None of the participants had taken part in any of the previous studies in this project work.

5.1.4 Measures of Eyesight

Each participant was required to complete a basic Snellen eye test for both long and short sightedness (Watt, 2003). Participants were encouraged to wear any spectacles that they currently use. This gave an indication of the sight abilities of the participant, taking into account any corrective lenses that they would normally use to watch TV.

[8] http://www.raosoft.com/samplesize.html

The participants were also asked to complete a capability questionnaire (**APPENDIX 5C**), which gave basic information on their cognitive, sensory and motor abilities.

Nine of the older adults indicated that they required spectacles to watch TV, read text on the TV and use the remote control. For the shortsighted Snellen test, none of these participants recorded a reading that was worse than 20/30 and no worse than 20/50 for long sightedness. One of the other three indicated that they needed spectacles for using the remote control, and recorded readings of 20/30 for short sightedness and 20/50 for long sightedness. Another indicated that they needed spectacles for watching TV and reading text on the TV only, with readings of 20/30 for short sight and 20/50 for long. The final older adults indicated that they only required spectacles for reading text on the TV, and recorded 20/50 for short sight and 20/70 for long.

Of the younger adults, five indicated that they did not need spectacles for and of the outlined tasks. The worst recorded reading for short sight of this group was 20/25. Four recorded a minimum of 20/25 for long sight, with one recording 20/50. Six of the younger adults said that they needed spectacles to watch TV, read text on the TV and use the remote control. Four of this group recorded 20/20 for their short sight (no worse than 20/50 for long sight). One recorded 20/30 for short sight and 20/40 for long, and one recorded 20/50 for both long and short sight. One younger participant indicated that they needed spectacles for watching TV and reading on screen text only and recorded 20/25 for short sight and 20/30 for long sight.

The capability questionnaire was somewhat of a self-reflective questionnaire, asking questions about an individual's motor and sensory abilities. In the main, the older adults answered these questions inline with what you would expect from persons of this age, highlighting age related declines in these abilities, especially in comparison to the younger adults.

5.1.5 Devices

The remote controller devices used were:

- **(D1)** A standard Digital TV remote control
- **(D2)** A Samsung Galaxy Tablet
- **(D3)** An air mouse

The standard remote control and the air mouse both used a 28" LG TV as a display for the Electronic Programme Guide (EPG). The Samsung Galaxy Tablet used its own 7" display.

The EPG used for the study was designed using Flash and XML and was based on a standard UK EPG with simple directional navigation of the programme information screen over a 7-day period. The EPG Flash software was running on an Apple Mac laptop that had an Apache server installed. For the remote control and air mouse, the EPG software was running on a standard PC using the Microsoft Internet Explorer browser. The Samsung Galaxy Tablet used its own built-in browser. The EPG functioned in the same way for each device, taking incremental input from directional buttons as well as other buttons for other required inputs (+24hours, -24 hours, access planner and record). In the case of the remote control, these buttons were physical buttons. For the air mouse and the Samsung Galaxy Tablet, these buttons were on-screen.

5.1.6 Design

The experiment followed a 2x3 factorial design. The participant age group was the between-subjects factor with the devices being the within-subjects factor.

Age	**Remote Control**	**2nd Screen Touch Screen**	**Gesture Pointer**
Older Adults (>65)			
Younger Adults (<35)			

Table 5-1 – 2x3 Factorial Design

5.1.7 Procedure

The participant was first asked to complete the participant consent (**APPENDIX 5A**) form and given a participant information form (**APPENDIX 5B**), as well as a capability questionnaire (**APPENDIX 5C**), as well as being asked to take a basic eye test using the Snellen Eye Chart for both long and short vision. The participant was then asked to begin the experiment using the first remote controller device. After using each controller the participant was asked to fill in a usability questionnaire, the System Usability Scale (**APPENDIX 5D**). Once the user had completed each task on

each device, they spent time discussing their opinions about each device with the experimenter.

Each participant worked as an individual during the session time. There was a researcher present during each session, although they had limited interaction with the participant while tasks were being carried out, only stepping in when the participant asked for help or was visibly struggling to complete a task.

The study was conducted in a one-on-one format and recorded with a camera for analysis. The researcher also took notes during the session, but not in a way that distracted the user. Each session was limited to a maximum of 120 minutes, although no participant took longer than 90 minutes:

- 10 minutes to read information and complete consent forms
- 5 minutes discussion about technology experience
- 10 minutes pretesting
    - Basic Eyesight test
- 5 minutes experiment explanation to participant
- 5 minutes getting used to 1st device
- 10 minutes for tasks
- 5 minutes to fill in usability questionnaires
- 5 minutes getting used to 2nd device
- 10 minutes for tasks
- 5 minutes to fill in usability questionnaires
- 5 minutes getting used to 3rd device
- 10 minutes for tasks
- 5 minutes to fill in usability questionnaires
- 10 minutes informal discussion about experiences during study

Initially, several pilot studies were conducted to assess whether this experimental procedure was correct and if the software and devices worked as expected.

5.1.8 Tasks

The experimental interface is shown in **Figure 5-5-1**. Each participant was asked to complete three tasks on each device. These were:

- **Task A**: Find & Select a programme from the EPG
- **Task B**: Use the EPG to find and record a programme
- **Task C**: Find a pre-recorded programme in the EPG planner

Figure 5-5-1 – Experimental Interface

Each participant was given each device in a counter balanced order. This was done in the following way.

There were three devices, D1, D2 and D3. There were six possible combinations of ordering the use of devices:

1	2	3	4	5	6
D1 D2 D3	D1 D3 D2	D2 D1 D3	D2 D3 D1	D3 D1 D2	D3 D2 D1

Table 5-2 – Device Orderings

There were 12 participants per group. Each participant was given a unique participant number (P1 – P12) and assigned a device order as outlined in the table below:

D1 D2 D3	D1 D3 D2	D2 D1 D3	D2 D3 D1	D3 D1 D2	D3 D2 D1
P1	P2	P3	P4	P5	P6
P7	P8	P9	P10	P11	P12

Table 5-3 – Participant Device Assignments

The tasks were always carried out in the same order. There were three different sets of tasks, i.e. programme selections. A counter balance is also applied to this so that the position of the programme to be selected has a minimal effect on the results. This will be done in the following way:

D1 D2 D3	D1 D3 D2	D2 D1 D3	D2 D3 D1	D3 D1 D2	D3 D2 D1
Task (A:B:C)	Task (A:B:C)	Task (A:B:C)	Task (A:B:C)	Task (A:B:C)	Task (A:B:C)

Table 5-4 – Task Ordering

5.1.9 Measurements

As a measure of accessibility, quantitative and qualitative measures were taken during the experiment. The quantitative measurements taken during each task were the:

- Time Taken
- Errors Made

During each session, the experimenter made qualitative notes while observing the participant completing the tasks as well as when the video of the session was analysed. The System Usability Scale (**APPENDIX 5D**), which is a Likert scale, was filled in by the participant after the full set of tasks has been completed on a device.

5.2 Analysis and Results

After all of the participants had completed the experiment, the quantitative results were recorded onto a spreadsheet. Factorial ANOVA was then applied to the data to compare the differences between the groups and between each of the devices.

5.2.1 Quantitative Results

The results of the Factorial ANOVA analysis produced results that fell in line with the fact that older adults in general perform tasks slower than younger adults and are more likely to make errors. This was evident for each of the devices used and for each task performed.

Time Taken

In most cases, the time taken was normally distributed according to a Shapiro-Wilk (Shapiro & Wilk, 1965) test with alpha level of at least 0.01. The normality test did not hold for Task A times for younger adults using the remote control, Task B times of older adults using a tablet PC and Task C times of older adults using a mouse due to outliers. Removing the outliers, the time data was normally distributed.

For all three tasks, there was a significant difference between the times taken by the younger adults and those taken by the older adults **(Task A: $F(1, 65) = 41.01$, $p < 0.05$; Task B: $F(1,65) = 34.17$, $p < 0.05$; Task C: $F(1, 66) = 41.99$, $p < 0.05$)**.

The measured results are shown in **Figures 5-2 to 5-4** with the outliers included.

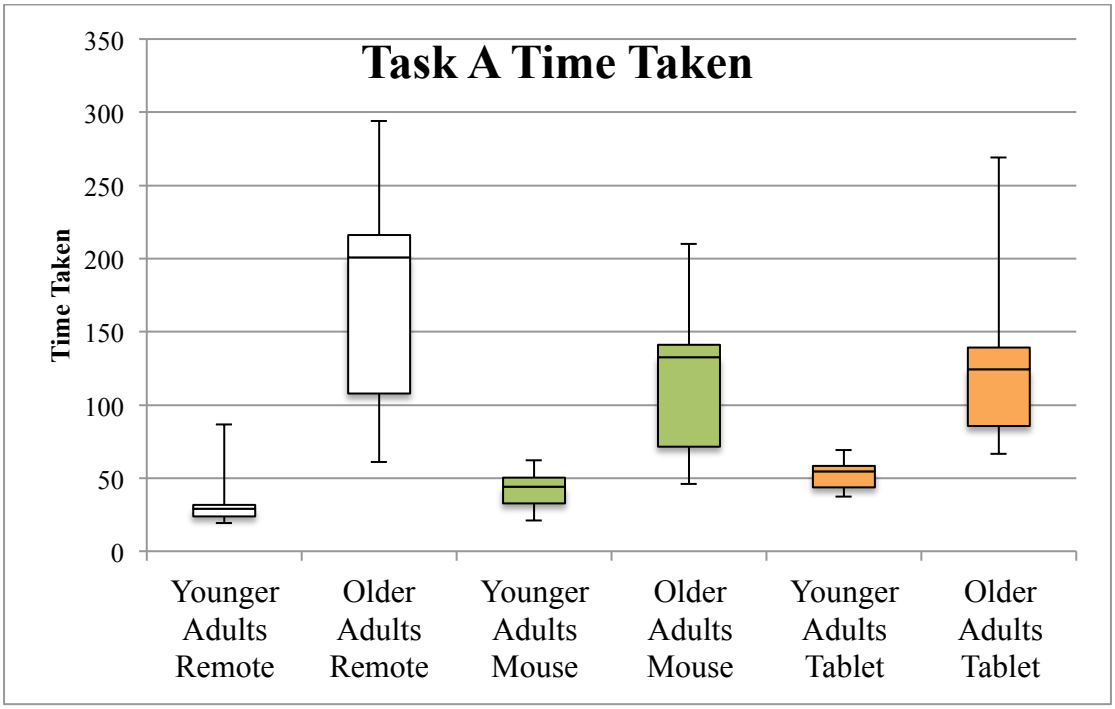


Figure 5-2 – Task A Times

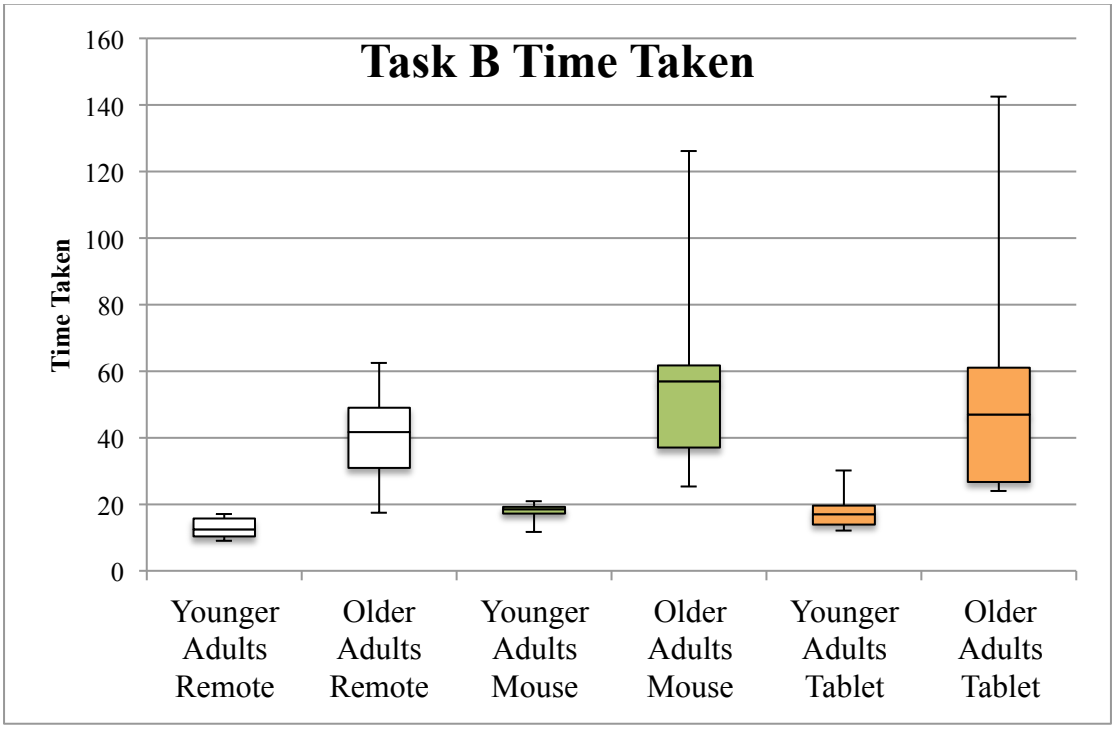


Figure 5-3 – Task B Times

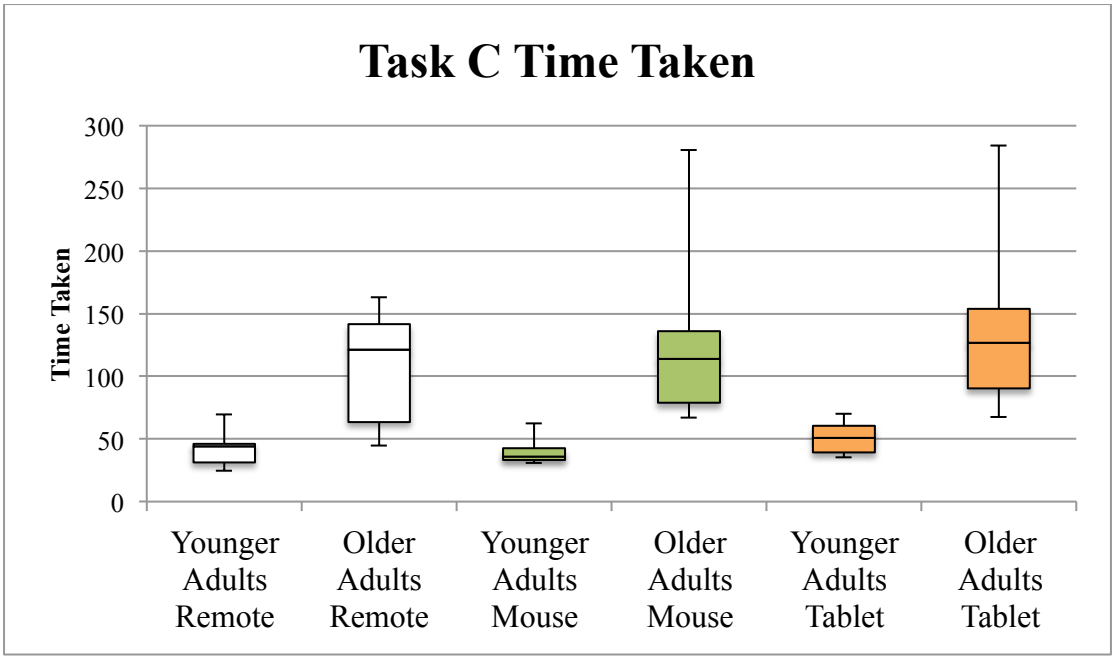


Figure 5-4 – Task C Times

These results support the comment in the hypothesis that younger adults will complete tasks, regardless of the device used, faster than the older adults. However, the results of the factorial ANOVA also show that there is not a significant difference between the times taken to complete each task on each device. This then shows that for the experiment conducted, none of the devices performed better than the others overall in this experimental set up. Therefore, the aspect of hypothesis H1.1 and H2 that suggests this has not been supported.

System Usability Scale

In all cases, the System Usability Scores were normally distributed according to a Shapiro-Wilk test with alpha level of at least 0.01.

In terms of the System Usability Scale scores, the factorial ANOVA again showed no significant difference between each of the devices. This again does not support the element of hypothesis H1.2 that suggested the remote control would get the better usability scores than the other two devices.

The differences between the older adults and the younger adults scores were also not significant, a result which also does not support hypothesis H4 for this experimental set-up.

Errors Made

Due to the discrete nature of the data, the assumption of normality cannot be made. However, the ANOVA tests were still performed.

The errors recorded for each task again produced a significant difference between the younger adults and the older adults **(Task A: (F(1, 66) = 32.3, p < 0.05); Task B: (F(1, 66) = 22.67, p < 0.05); Task C: (F(1, 66) = 35.89, p < 0.05)**. These results are shown in **Figures 5-5 to 5-7**.

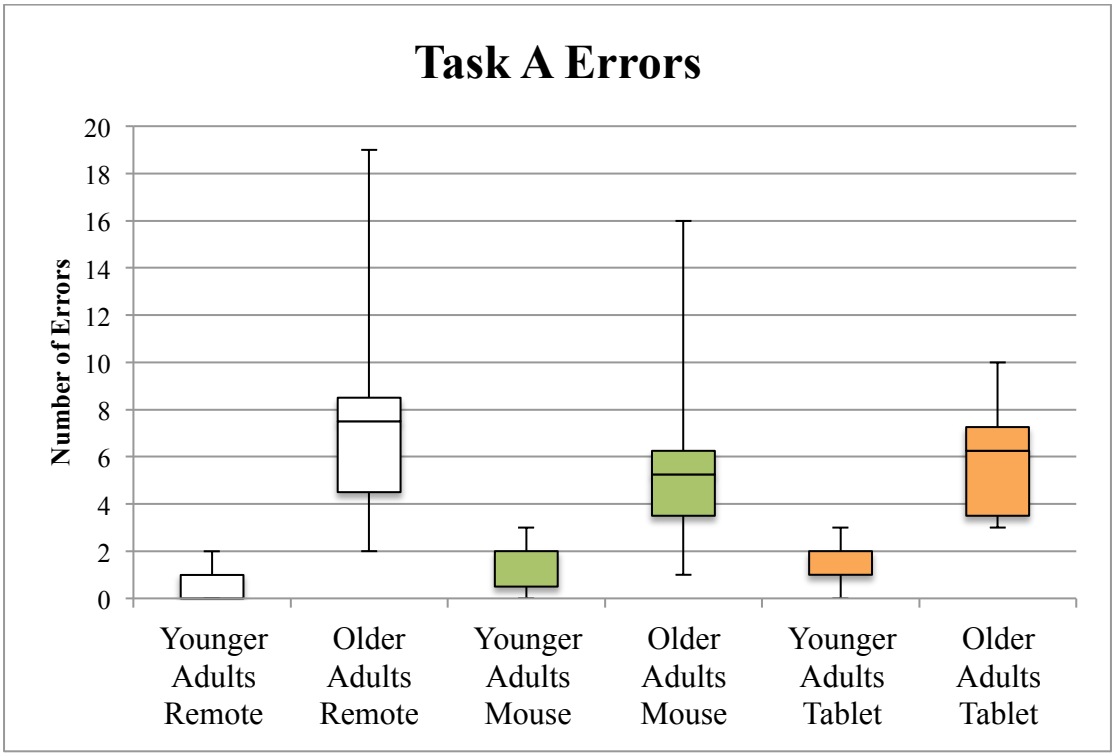


Figure 5-5 – Task A Errors

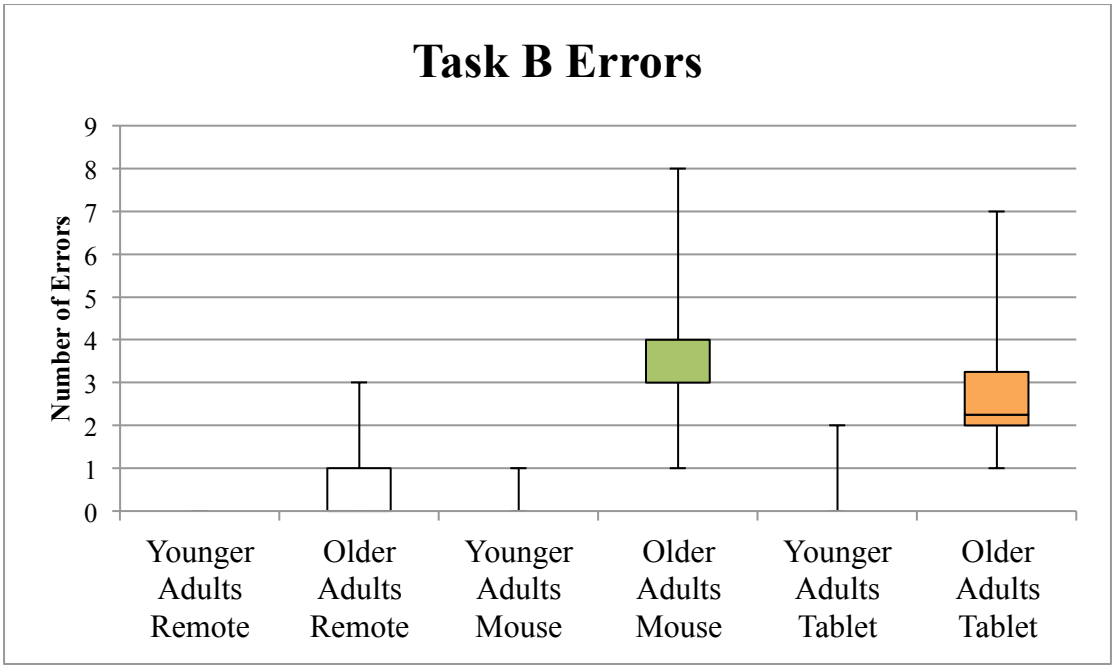


Figure 5-6 – Task B Errors

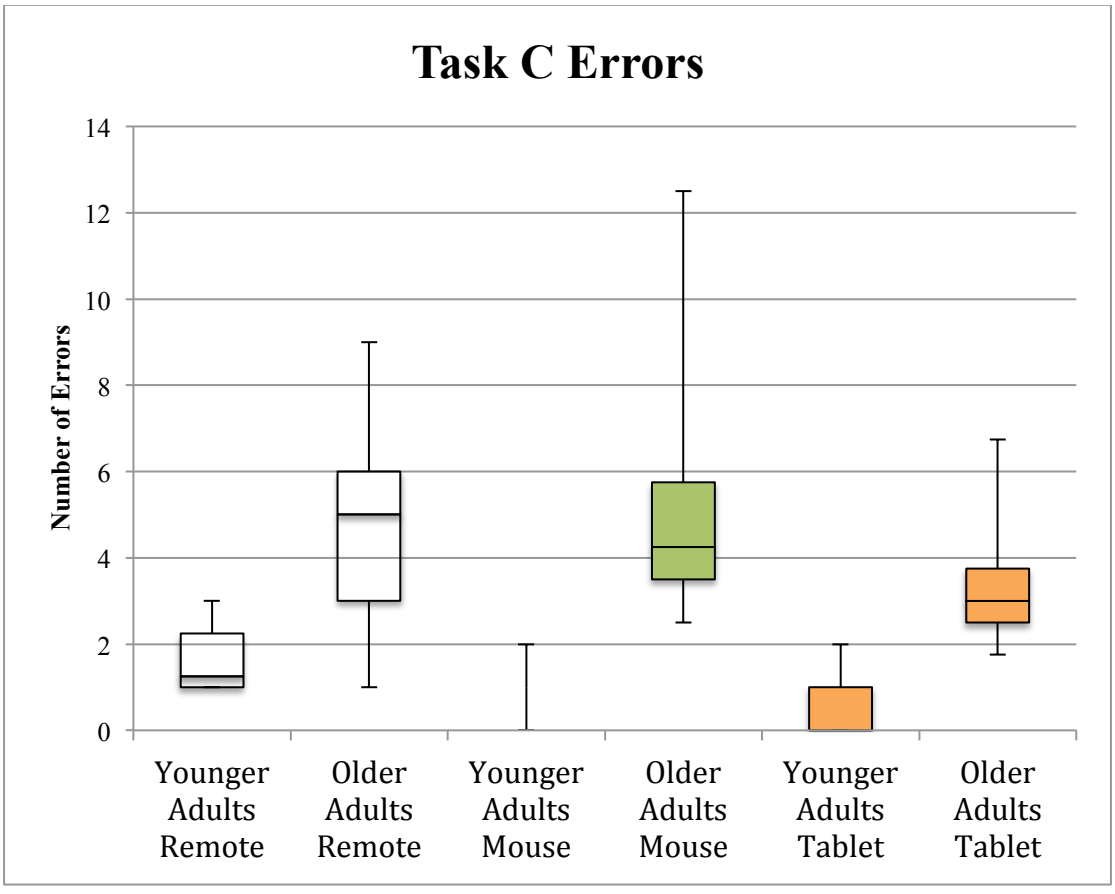


Figure 5-7 – Task C Errors

For Task B, there was also a significant difference between the errors recorded between each device. On further analysis of the Task B errors, by performing a series of T-Tests on the data, it was found that as an overall comparison, the remote control produced significantly fewer errors than both the gesture pointer and the tablet PC **(t (23) = 4.9, p < 0.05 (remote vs. gesture pointer)) (t (23) = 3.45, p < 0.05 (remote vs. tablet PC))**.

For each of the individual groups, the remote control was again the device that produced significantly fewer errors than the other devices **(younger adults: (t (11) = 4.69, p < 0.05 (remote vs. gesture pointer); (t (11) = 4.02, p < 0.05 (remote vs. tablet PC)) (older adults: (t (11) = 3.68, p < 0.05 (remote vs. gesture pointer)) (t (11) = 3.74, p < 0.05 (remote vs. tablet PC))**. The results of further analysis of Task B indicate that the traditional remote control produced fewer errors than the other two devices, therefore supporting this element of hypothesis H1.3 for this task.

For Task A and Task C, the analysis of the error results only shows that the older adults are more likely to produce errors when completing tasks than the younger adults. The ANOVA results for the other tasks therefore do not show any of the devices making fewer errors than the others, and therefore this element of hypothesis H1.3 and H3 are not supported by the results, although in this instance, it must be remembered that the data is not normally distributed according to a Shapiro-Wilk test.

Quantitative results overview

Overall, the quantitative results did not support any of the hypotheses, although it did show that older adults completed the tasks slower than younger adults and also that they were more likely to produce errors when completing tasks.

5.2.2 Qualitative Results

The subjective data recorded, from the formal questionnaires at the beginning and end of each session, was then analysed to get a better understanding of the results as well as any unexpected issues there may have been with the experimental set-up.

TV Watching and new technology Experience

All but one of the younger adults had watched television for their whole lives and all apart from the same one had experienced Digital Interactive Television (DITV) for at least two years. Seven of these eleven had had DITV for at least ten years, two for

between six and eight years and two had had it for about two years. The one outlier had watched TV for approximately twenty-four years but had never experienced any DITV.

All of the younger adults who had DITV used the built in EPG of their own TV systems, but with varying levels of frequency. Seven of the eleven used it for browsing for programmes and to plan programming while the other four said that they did not use it very often. Seven of the younger adults said that they occasionally used paper based TV guides. Four said that they got additional programming information from the Internet and two said that they mainly used the built in EPG.

Four younger adults said that they had never used a smart phone or tablet PC while eight indicated that they had experience of using one or the other. Only three of this group had never used a gesture based gaming system, with the other nine either having used one or owning one.

Of the older adults, they had all watched TV for over fifty years, although many could not identify exactly how long they had watched TV for as it had been so long. Only two could say that they had watched TV their whole life. Interestingly, four of the older adults said that they had DITV for about ten years or more, with two saying they had it for between five and six years and three saying they had it for at least between two and four years. Two had had DITV for at least the last year and one had said they did not have DITV, although they had experience of using it at others homes.

Only one of the twelve older adults said that they used the EPG everyday (they had had DITV for four years), five said that they used it occasionally (two had had DITV for about ten years, one had had it for five years, one for a year and one who only had DITV when visiting others), and six said that they never used it (two for ten years, two for two to four years, one for five years and one for a year). However, two of this group did say that they rarely controlled the TV themselves and their partner did use the EPG. Ten of the older adults also said that they used a paper based guide to get additional TV programme information.

Ten of the older adults had never used a smart phone or tablet PC, with one saying they had tried an Apple iPad and thought about buying one and the other saying they owned an iPad. Six of this group indicated that they had used a gesture based gaming system, with the rest saying that they had not.

These graphs are shown in **Figures 5-8 to 5-10**. This feedback is not entirely unexpected. Both groups have watched and used TV and DITV for a considerable period of time. The differences in experience of using features such as the EPG can be seen between the groups from their feedback, although this is potentially also expected as older adults are less likely to change their routines if the perceived benefits to them are little compared to the effort required to learn new processes (Bhachu, et al., 2008). Also, in general, and again as expected, the older adults as a group had considerably less experience using smart phones or tablet PCs and gesture based gaming systems.

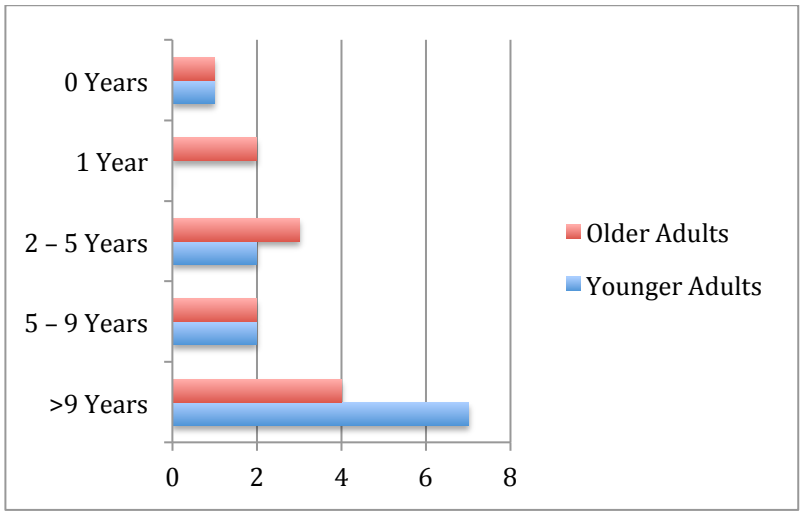


Figure 5-8 – Years with DITV

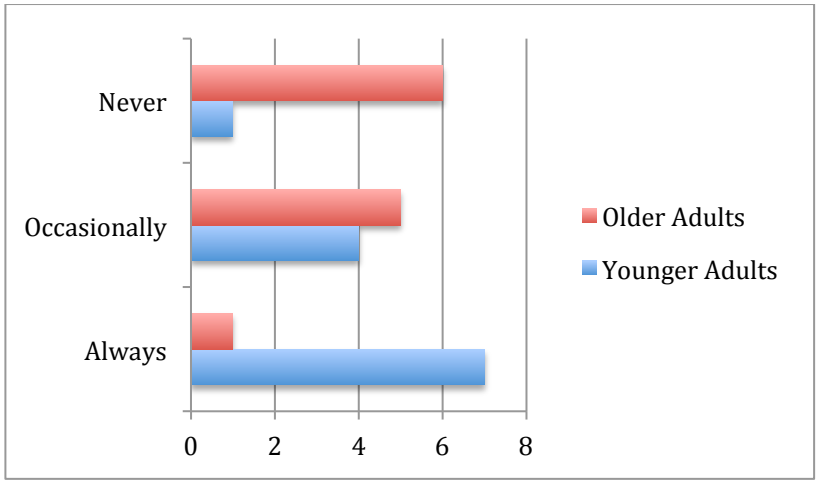


Figure 5-9 – Use of EPG

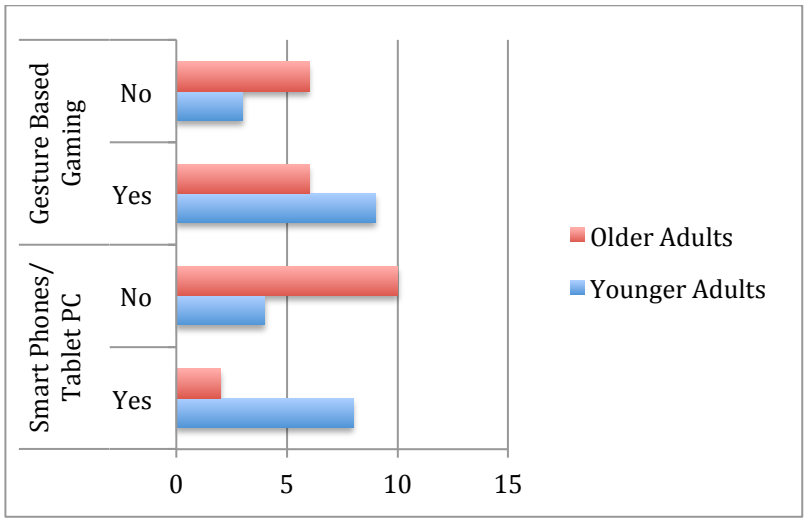


Figure 5-10 – Use of other Technology

Preferred Controller During Experiment

The first question asked in the end of experiment interview was about which device each participant found the easiest to use overall.

Eight of the younger adults preferred the remote control, citing the reason for this being that it was the controller they were used to using and were comfortable using it. Two preferred the tablet PC where they felt it was good to see all the buttons on the same screen in front of them and two preferred the gesture pointer as it was simple and made them feel more in control.

Of the older adults seven of them preferred the remote control because that was what they were used to, with two preferring the gesture pointer and three preferring the

tablet, again because all the information was on a screen in front of them and comments also included the fact that it was a benefit that they could watch the TV at the same time.

This is shown in **Figure 5-11**. These comments appear to lend support to the reasoning outlined in H1 in that when given a direct choice between each of the devices, the majority of participants preferred the remote control over the other two devices as it was what they were used to using.

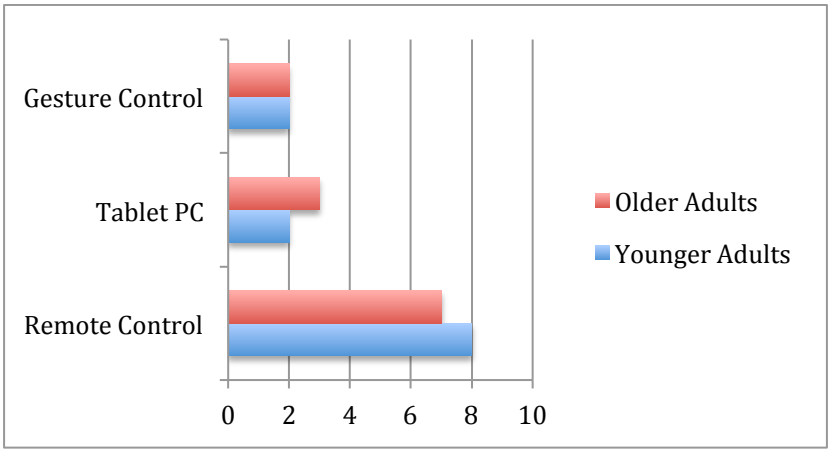


Figure 5-11 – Preferred Controller

Tablet PC Pros and Cons

Seven of the twelve younger adults found the tablet PC comfortable to hold, with three finding it too big to hold, one finding it too heavy and one finding it too light. All twelve said that they had no major problems navigating to the required targets on the screen.

Seven of the older adults also found the tablet PC comfortable to hold, with the three of the other five finding it too heavy and the other two finding it too big. Nine of the twelve older adults found it simple to navigate to the required targets using the tablet PC, with the other three indicating that they felt that the device was too inconsistent to navigate.

When asked about the benefits of the tablet PC, there were many varying responses from both groups.

From the younger adults, comments included that they liked that they could browse the TV guide while still watching TV and that they could essentially do two tasks at once. They felt that in theory, the fact that with direct access to the buttons, without having to figure out what each button does in each mode, on a screen in front of them, that using this device should be quicker than the other two. The fact the tablet could do other things and possibly replace all their remote controls was also seen as a benefit. Another recurring comment from this group was that they liked how they could hold the tablet PC at a distance suitable for them and operate it in a way that was comfortable for them rather than have to point the device at anything else. This was seen as a particular benefit for anyone who may have problems reading text on a TV screen. One of the younger adults saw no benefit of using the tablet PC.

Interestingly, many of these comments were also replicated during the sessions with the older adults, and in particular the fact that the user did not have to 'stare at the TV screen' was a recurring comment amongst the majority of this group. An additional benefit outlined by one older adult was that one person could browse the TV guide while others in the room could continue to watch TV. Two of the older adults saw no perceived benefits of using the tablet PC.

The issues that the younger adults associated with the tablet PC mainly centred around the time lag between pressing a button on the screen and the selected action being carried out. Five of the younger adults identified this as an issue. This time lag was a result of the tablet PC being the only device that was tested using a local wireless network connection to the server laptop, whereas the PC used for the remote control and gesture pointer was connected to the server laptop over a wired connection. Also, the processor and RAM of the tablet PC were inferior to that of the PC used for the other devices. It is also reasonable to suggest that this may have had an impact on the task completion times and error rates of participants as they pressed buttons more than once and went past their required target as they became frustrated with waiting for the tablet PC to react. However, only two of the older adults identified this as a specific issue, with their main problem with the device being its sensitivity to their touch.

Seven of the older adults commented on having issues with the sensitivity of the tablet PC. Although at first it was considered that the issues might have been related to the lag time of the device, on closer analysis of the video recordings, this appeared not to be the case with the older adults. On many occasions the older adult participants had a problem with pressing on the actual button and would often press just off the target area, meaning the button was not being activated. The other observed problem with the older adults related to the sensitivity issue was that some did not fully lift their finger from the button on the screen once they had pressed it, meaning they were waiting for an action to be performed when they still had the button pressed. This is similar to how a remote control is used, as it was observed that users would rarely lift complete contact from remote control buttons when carrying out tasks, and they will rather rely on the tactile feedback of the button press, until they see that the task has successfully been completed. In both of these instances, the automatic response of the older adult to solve the problem was to try and press the buttons on the screen with more pressure, which had no effect on the output. Only two of the younger adults suggested that they had any issues with the sensitivity of the tablet PC, and even then, neither had any great issues with the sensitivity after a short period of time using it. It can therefore be reasonable to assume that the older adults relative lack of experience using such a device compared to the younger adults is one reason for this sensitivity issue. Also, the interface design may not have leant itself to being clear as to the exact boundaries of the buttons on screen. For future developments on this device, these boundaries will need to be made clearer and a delay may be introduced to allow for participants pressing and holding the buttons.

One of the younger adults found the size of the tablet PC to be an issue, with it being too big. Three of the older adults saw issues with the size of it, with two finding too big and one finding it too small and was afraid of damaging it. Four of the younger adults had no issues with the tablet PC, while only one older adult had no issues with it.

The participants were then asked if they would consider the tablet PC as a replacement for their current remote control.

Seven of the younger adults said that they would like it, two answered maybe and three answered no. Of those that said yes, they mentioned how they liked the concept behind the idea and thought it was better than their current remote control. Of the three that said no, one commented on how they did not know why anyone would like this.

Four of the older adults said that they would consider using the tablet PC in place of their current remote control, particularly if the issues could be eradicated. Two said that they maybe would, with one suggesting that the additional functions of the tablet PC may be an influencing factor for them. Six said that they would not consider it because of the issues that they had with it during the experiment (**Figure 5-12**).

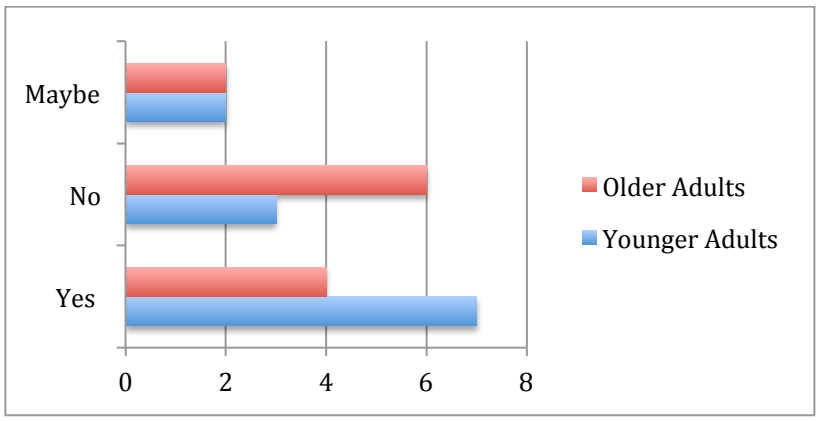


Figure 5-12 – Consider Tablet PC to replace current Remote Control

Gesture Pointer Pros and Cons

The participants were asked the same set of questions about the gesture pointer as they were about the tablet PC.

Five of the younger adults found the gesture pointer comfortable to use, with one likening it to how the standard remote control is used by pointing it at the TV. Three of this group felt that it may become comfortable to use after spending slightly more time getting used to the device while four did not find it comfortable at all, finding the range of movement required to operate the gesture pointer difficult.

Of the older adults, three found the gesture pointer easy to use. Six found it took some getting used to and would be happy with it given more time while three did not find it comfortable at all, again citing the degrees of movement required as the main reasoning behind this.

Six of the younger adults found it difficult to navigate to the required targets, with many finding it frustrating and difficult to select the required targets, often missing it when they thought they were on it. Four of the younger adults found this device easy to use, and likened it to the simplicity of using a mouse. The other two thought it was 'OK' as long as they got used to the actions required.

The older adults were much more positive towards using this device to navigate to the required targets. Seven found it easy to use, with one even saying it was better than the other two devices. Again they likened it to using a mouse with a computer, and that the movements of the cursor were positive. Three felt they would need more time to get used to us but felt it was fairly simple, and two did not find it easy to operate.

There were five younger adults who saw no benefits to using the gesture pointer in this environment, and they preferred to focus on the negatives of the device. Two of the younger adults liked how the interactions were all on one screen unlike with the remote control where they had to continuously switch focus. One of these also felt it was faster than using their own remote control as did one other participant. Two younger adults saw the benefit in the gesture pointer that it performed in a similar fashion to other systems they were used to like their computer mouse and the Nintendo Wii. One younger adult liked how there were less buttons than on a normal remote control to remember which made it easier to use.

Four of the older adults saw no benefits in using the gesture pointer when compared against the other two devices. Two found the gesture pointer quick and positive to respond to actions they were trying to complete. Three found the fact it was comfortable to operate as the main advantage, with two highlighting how it would be easier to use for someone with arthritis in their fingers. Three older adults liked how they could operate the gesture pointer without needing to use their glasses to look down at the controller.

The required movement and coordination was seen as the main issue for five younger adult participants using the gesture pointer. Three younger adults had issues with having to press the trigger on the back of the gesture pointer to move the cursor and two younger adults felt that the required grip of the gesture pointer was the main issue. Two younger adults saw no issues with using the gesture pointer.

Of the older adults, four of them found the gesture pointer's main issue was the positioning of its buttons that made it awkward to operate and required a lot of coordination. Three older adults simply felt that the main issue was that they were not familiar with it and needed more practice using it. One found it annoying moving the cursor around the TV screen with the gesture pointer and one older adult felt that the device was not usable for left handed users because of the button positioning. Three older adults saw no major issues with the gesture pointer.

Five of the younger adults said that they would consider the gesture pointer as a replacement for their current remote control. Another six younger adults said that they would not consider this device as a replacement for their current control, and one younger adult said that they possibly might consider it over time. Half of the older adults said that they would consider the gesture pointer as a replacement, whereas the other half said that they would not (**Figure 5-13**).

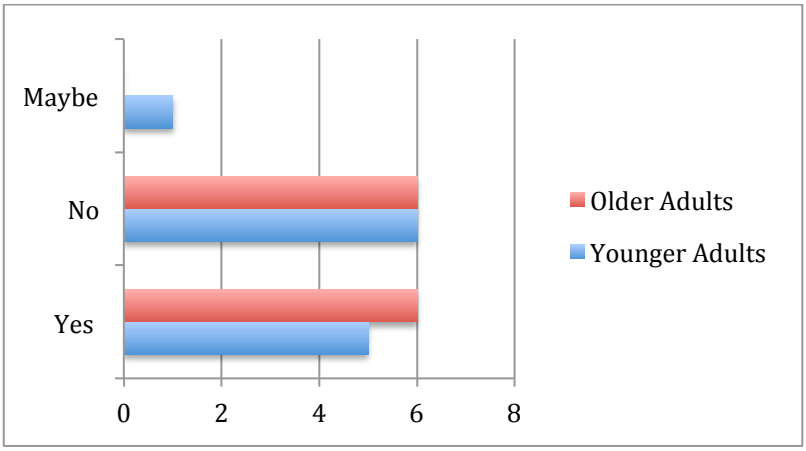


Figure 5-13 – Consider Gesture Control to replace current Remote Control

5.3 Conclusions

This experimental work gave some valuable insight into how DITV is used by older adults in comparison to younger adults, and the potential of other devices replacing the remote control for older adults in a DITV environment.

The quantitative results did not support the hypothesis that the remote control would be the best performing device with the least errors. The outlier to this was the errors recorded for Task B. This may be due to the nature of this specific task and the way in which errors were recorded. During this task, the participants were asked to navigate to a specific programme in the planner, which was displayed in a list format. When using the gesture pointer and the tablet PC, an error was recorded if the participant used the arrow keys to select a programme when it was visible on the screen rather than directly selecting it (which was considered to be the quickest way to complete the task.) However, when using the remote control, the participant could only use the arrow keys to select a programme and so an error was less probable in this instance of the task, unless the participant navigated past the desired programme. This evidence is further backed-up by the fact that the other two tasks did not produce a significant difference for errors between the devices.

This indicates that devices that support gesture interaction or are used for second screen interaction perform statistically no worse than the traditional remote in a DITV EPG environment, for both younger and older adults. These devices can therefore be considered as alternatives to the traditional remote control for older adults in terms of performance. This is somewhat supported by the qualitative analysis.

When asked to choose which device each participant preferred, the majority in each group did choose the traditional remote control. As highlighted in hypothesis H1, the participants suggested that this was closely related to their familiarity with using this device. However, after completing the experiment with each of the devices, at least 50% of the participants were not averse to considering the gesture pointer or the tablet PC as a replacement for their current remote control. The older adults were slightly more cautious when answering for the tablet PC, but still 50% said that they would consider it.

Several issues were highlighted with the tablet PC being used in this environment by older adults that were not foreseen prior to the experiment. These included its touch sensitivity and pressing the right area of the screen to activate a button, causing frustration for the participants. These are issues that would need to be rectified for this device to be considered as a truly viable alternative to the remote control for older adults.

Despite these issues with the tablet PC, the benefits of the device were also highlighted. These benefits included being able to continue to watch TV while completing tasks on the tablet PC such as browsing the EPG. Also, the older adults in particular found that the fact that they could view the content at a distance suitable to them, without having to stare at the TV screen, was a benefit to them. Additionally, the one-to-one mapping of function to on screen button was felt to make the interface simpler in some circumstances, once it was understood what each button did.

The gesture pointer also received many positive comments from both groups of participants. This was something that was not initially expected when outlining the experiment. Again, the fact that most of the required interaction was on one screen and the controller had minimal buttons was seen as a big benefit. The overall coordination required to operate this device appeared to be the main issue with it. This was an issue that was highlighted in the Wii-study and has carried over into this study. It is not something that can be easily rectified due to the nature of the device.

Overall, there is evidence from the experimental results, and in particular the subjective comments, to suggest that developing DITV services that can be controlled by devices such as the tablet PC and gesture pointer has the potential to make these services more accessible to older adults.

The EPG is an obvious service that can be implemented and adapted specifically for these devices. Other potential services that stand to benefit include the Personal Video Recorder and Red Button Services. The tablet PC may also provide a non-intrusive way for recommender systems to be introduced to older adults, as it does not disturb

their actual TV viewing. This may make older adults more likely to explore a greater range of programming than they are currently used to.

5.4 Limitations of the Study

Upon completing this experiment, there are several ways in which it is argued that the method could have been improved.

The standard deviation for the older adults shown in the ANOVA results suggests that a larger sample size would give clearer results, although it is questionable whether the results would be any different. However, participant numbers are obviously affected by time resources to complete experiments.

The experiment was conducted in a lab environment that had been altered to look and feel like a living room environment, but it is argued that this is no substitute for a participant watching TV in their own home. Also, watching television is meant to be a relaxing activity, not based on completing a series of tasks in a specific time. Therefore, it may be more appropriate to test alternate devices while a participant is actually doing their TV watching rather than have forcing them to complete tasks. In this case, the time taken to carry out an activity using menus may not be the paramount deciding factor on if a device is usable or not. Cesar and Chorianopoulos also allude to this (Cesar & Chorianopoulos, 2009).

There was an advantage given to the traditional remote control throughout this study. The participants had a familiarity using this device as is was something that they commonly used with their TV. Also, the interface used during the experiment was optimised to be used with the standard remote control, not taking advantage of some of the unique attributes of the other devices. For these reasons, there is a learning effect put onto the other devices used during the experiment, which may explain some of the issues that the participants had with the devices. A longitudinal study may benefit this type of work to give the participants a longer period of time to learn and get used to new devices in a different environment.

The wireless connection of the tablet PC, and the lower speed specification of the tablet PC compared to the PC connected to the other two devices, was not taken into

consideration prior to the study and therefore was not controlled for. This is likely to have had a slight impact on the results for the tablet PC and must be considered for future experiments.

Finally, the capability questionnaires give a good indication of an individual's self-reflective abilities. However, this is dependent on an individual being open and not withholding any information. Ideally, with enough time, it would be desirable to test participants to get a better idea of their abilities, similar to the way in which vision was tested using the Snellen eye charts.

6 Conclusions

This chapter will summarise the work by reviewing the original research questions in this thesis. It will first describe the overall contributions to knowledge, review the questions asked throughout the research, and then potential future work will be discussed.

6.1 Contribution to knowledge

This thesis identifies and addresses the issues that older adults have with Digital Interactive Television (DITV). Specifically, it has identified the issues that impact the general population when using DITV and how these impact older adults. The relevant literature has been reviewed in chapters 1, 2 and 3 of this thesis. The initial work brings together the literature and highlights the issues that DITV presents to all viewers, and how these issues impact older adults in particular who are likely to experience age related declines in their physical, sensory and cognitive abilities. Potential alternative remote control devices are also reviewed, with the possible advantages and disadvantages highlighted.

The literature outlines studies using devices such as second screen interfaces and the benefits that they offer the viewer in a television environment. The literature review also shows that TV manufacturers sell many of their high-end TV sets with gesture controllers. However, few questions have previously been asked as to how these devices could improve the TV experience for older adults. This work addresses this and looks at the advantages and disadvantages of such devices for older adults, and if they could be considered as alternative controllers for DITV to the traditional remote control for older adults when performance and user feedback is taken into account.

Importantly, the literature shows that older adults watch the most live television out of any age group, but also get less satisfaction out of the television watching experience. With the range of services and features available, and in particular, the programming available, an area that older adults have suggested greatest dissatisfaction currently as identified in section 2.4.2, DITV has the potential to improve the viewing experience of older adults.

This work gives a basis for further research into alternate control devices to make DITV easier to access for older adults.

6.2 Research Questions

The first of the exploratory studies described in section 4.1, the focus group study, aimed to clarify and confirm the issues faced by older adults using DITV that the literature suggested. The issues of the remote control were highlighted during these focus group sessions.

The second of the exploratory studies, outlined in section 4.2, looked at using the Wii-mote, a gesture control, in a TV environment. The question asked at the beginning of this experiment in section 4.2.2 was:

> *'Can the Wii controller be considered as a possible alternative for older adults to the traditional remote control to browse and select TV programming content and why?'*

This small-scale study was conducted to compare the opinions of older adults and younger adults, as well as compare their observed habits when using the device. This study raised the question about fatigue when using a gesture control in a TV environment, not just for older adults, but also for younger adults. Also highlighted by the older adults, as well as the younger adults, was the benefit of drawing the user's attention to the screen with less need to look down at the controller. In general, the older adults felt that they were open to using this type of device in a TV environment, with an opportunity to get used to it more.

The main study in this thesis, section 5, looked at a tablet PC as a second screen interface, and a gesture control as alternatives to the traditional remote control. This study aimed to address the overall question of this thesis.

The overall question was outlined in section 2.5:

> *'What alternative remote control interfaces can be considered as replacements for the traditional Digital Interactive TV remote control for use by older adults and why?'*

This was adapted to take into account what had been learnt throughout the work undertaken and of taking into account commercially available devices. This question was then defined in section 5.1.2:

> *'Can a tablet PC as a second screen interface and a gesture control be considered as possible replacements for the traditional Digital Interactive TV remote control and why?'*

The quantitative results of this study showed no significant difference between the three devices. This was interesting in itself as it had been expected that the remote control would perform significantly better than the other two devices due to familiarity with the it, and even more so looking back, due to the lack of time the participants had to learn to use the other two devices. The qualitative feedback was also positive towards the alternative devices. In all, the evidence from this study suggests that the tablet PC as a second screen interface, and the gesture control, can be considered as alternatives to the traditional DITV remote control for older adults.

6.3 Future Work

Future work must continue to focus on the benefits of DITV for older adults. These go beyond just watching TV.

There are the social benefits of being able to watch and share TV with others not in the same location. Cesar et al mention the ability to share content with others in their work (Cesar, et al., 2009). This would go a long way to helping with social exclusion, particularly when an individual becomes housebound, or loses family and/or friends because of death, which is common as we grow older (Goodwin, 2010). DITV can also be used as part of a telecare system to allow an individual to view their healthcare statistics. This can also encourage the self-management of health by an individual (Bhachu et al., 2012). Revisiting the social element possible through DITV, in a telecare environment, individuals with similar conditions can share stories

through their TV to further encourage self-management of health, as well as allow healthcare professionals to communicate with patients through the TV. This would be particularly useful for patients who live in remote areas. Older adults who have chronic health conditions can benefit more from staying in their own homes for as long as possible. The TV can have a big part to play in this. It is also conceivable that older adults, who are less likely to have access to the internet, can use services offered through DITV to make NHS appointments ("Health advice now live on digital tv ", 2011).

For the above to be easily accessible, particularly for older adults, an alternative to the traditional TV remote control must be used. Trying to carry out the above tasks using this device is likely to be complicated and confusing, not just to older adults, but to all.

The suggested device to focus on is a second screen interface such as the tablet PC. The element of fatigue highlighted in the Wii-study, a theme that was also carried through to the remote control study, make the gesture pointer a slightly more awkward device to champion for older adults in this instance.

The benefits of a second screen interface are outlined in the literature, and the remote control study also highlights these, including the ability to continue to watch TV while doing other tasks, and the ability to adjust the device to a distance that is comfortable to the user. Many will argue that this is an expense that older adults would not go to purchase such a device. However, as has been suggested previously in this thesis in section 2.2, older adults are more likely to take to technology where they see a benefit in using it, and providing it is easy to use.

Focus should first be placed on making current DITV services and menus easily accessible for older adults through this device. The design principles learnt from this process can then be transferred to the design of additional services. Design principals should include button sizes, positioning and, in particular, the amount of information that is acceptable on the screen at any one time. There will be similarities to current second screen interface designs, but the environment in which the device is being used must be taken into consideration.

Future work should also look at the issues faced by older adults using a second screen interface that were outlined in the remote control study. These issues namely centred around the sensitivity of the device and the lack of tactile feedback.

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Appendix 1A: History of British TV

1937 May 12 First outside broadcast: King George VI's Coronation procession

1939 Sep 1 Suspension of TV service because of WW2

1946 Jun 1 TV licence fee introduced

1946 Jun 7 Resumption of TV service after the war

1949 Dec BBC Television service begins to spread outside of London

1950 Aug 27 First cross-Channel broadcast (from France to England)

1953 Jun 2 Televising of Coronation

1954 Jun 6 Britain linked to Eurovision system

1954 Jul 5 Daily news bulletin starts

1954 First on-screen weather presenter - George Cowling

1954 Aug 4 Establishment of Independent Television Authority, a public corporation

1955 Sep 22 Start of Independent (i.e. commercial) Television in London area by Associated-Rediffusion and Associated Television, together with the non-profit-making Independent Television News

1956 Independent Television service begins to spread outside of SE

1958 TV households exceed radio-only households

1958 Apr First videotape broadcast, by BBC (VERA system)

1958 Jun 26 Associated-Rediffusion shows first programme from Ampex VTR, which becomes the established format

1962 Apr First video tape slow-motion replay

1962 Jul 1 Pilkington Report published, recommending 2nd BBC programme, separate BBC service for Wales, change of line standard from 405 to 625 lines, colour on 625-line UHF, and the restructuring of ITV

1962 Jul 11 First transatlantic satellite broadcast

1964 Apr 20 Start of BBC2 on 625 line uhf

1964 Apr 26 BBC2 starts news review programme for deaf viewers

1967 Jul 1 Start of colour transmissions on BBC2

1967 Aug BBC begins using fully electronic, colour, frame-rate standards conversion

1968 Jul 30 ITV franchise changes. LWT replaces ATV London; Yorkshire TV forms new region from part of old Granada area, Harlech replaces TWW; Thames formed by ABC and Rediffusion. ATV takes on all-week Midland franchise. Granada takes on all-week NW franchise.

1969 Jul 21 BBC and ITV night-time audiences watch man's first steps on the moon.

1969 Nov 15 Colour service inaugurated on ITV and BBC1

1972 early Removal of restrictions on broadcasting hours

1973 Feb 2 Teletext system demonstrated by BBC. IBA also developing a teletext system

1976 Colour sets outnumber black and white sets

1982 Jan 1 ITV franchise changes: ATV, Southern and Westward give way to Central, TVS and TSW

1982 Nov 1 Start of S4C (Sianel Pedwar Cymru/Channel 4 Wales), with all Welsh language programmes, both BBC and Independent, moving to this new channel

1982 Nov 2 Start of Channel 4 in England, Scotland and Northern Ireland

1983 Jan 17 Start of breakfast television by BBC, followed by (1 Feb) TVAM on the ITV network

1985 Jan Closure of last 405-line transmitter

1989 Feb Start of domestic satellite services by Sky Television

1989 Sep First official NICAM digital stereo sound transmissions, by ITV

1989 Nov 21 Televising of House of Commons begins

1990 Opening of British Satellite Broadcasting (BSB)

1990 Sky and BSB merge to form BskyB

1993 Jan 1 ITV franchise changes: Thames, TSW, TVS, TVAM give way to Carlton, Westcountry, Meridian, GMTV

1996 Mar 15 BSkyB's first pay-per-view event: boxing match from Las Vegas

1997 Mar 30 Start of Channel 5. Needed retuning of millions of VTRs in order to prevent interference

1998 Oct 1 Digital satellite service starts

1998 Nov 15 Digital terrestrial service starts, including widescreen broadcasts

2001 Jun BBC's first digital interactive programme

2002 May Closure of ITV Digital (formerly ONdigital)

2002 Oct 30 Opening of Freeview digital terrestrial service to replace ITV Digital multiplexes

2003 Dec 29 Regulation of commercial TV passes to Ofcom following merger of ITC with other regulatory bodies

2004 Jan 28-29 BBC Chairman of Governors and Director General both resign in wake of Hutton Report

2004 Feb 2 Merger of Granada and Carlton is complete. Merged company is called ITV plc.

2006 May Start of high definition service

2007 Oct 17 First analogue switch-off: BBC2 signal at Whitehaven, Cumbria

2007 Beginning of BBC iPlayer

Appendix 4A: Focus Group – Questionnaire

Below are several quick questions to give a bit more background information about yourself.

You are in no way being judged or assessed. If information about you is used in publications or presentations, we will ensure no reference is made to your identity. You are free to leave questions that you do not wish to answer.

Thanks
Amritpal S Bhachu

Questions

Name: _____

Age: _____
(if preferred) under 55 55 – 65 65 – 75 75 – 85 85+

Do you live:-

- Alone
- With partner/spouse
- With family
- Other shared

Do you require glasses to:-

Watch TV?	**YES/NO**
Read text on your TV?	**YES/NO**
Use your TV remote control?	**YES/NO**

Appendix 4B: Focus Group Facilitator Questions

What technology devices do you use ‘everyday’?

How many TVs do you have at home?

- Is your main TV relatively new?
- Are the other TVs relatively new?
- In what rooms do you have a TV set?
- Do they all receive digital TV?
  - Do they have DTV built in?
  - Do they require a separate STB?
  - Do you still only use Terrestrial TV?

Do you see TV as a social event (watched with family/friends)?

Do you prefer to watch TV alone?

Why do you watch TV?

- For information (news/stocks/etc.)?
- For entertainment (soaps/sports/game shows)?
- To relax?
- Just in the background?
- Other?

How do you find program information?

- How do you choose which programs to watch?
- Do you use a newspaper magazine?
- Do you use the Digital EPG?
- Did/Do you have a VCR to record programs?
- Did/Do you have problems setting this up to record?
- How do you now record programs you may miss?

Did/Do you use teletext?

- What information did you use to look for using it (news/sport/weather)?
- What do you use to get that information now?

Have you used digitext?

How does it compare to teletext?

Do you ever watch channels dedicated to news/sport/weather/travel/other?

Did you ever use NHS TV?

What kind of information would you like instant access to on your TV?

Has interacting with your TV become more difficult since DTV was introduced?

Switching on multiple devices to view TV?

Different remote controls controlling channels/volume?

Is there anything else that has been made difficult?

Do you ever get frustrated when trying to interact with you TV?

What frustrates you?

Does this make you want to give up/switch off?

How many remote controls do you need to use to watch TV?

Roughly how many buttons altogether on the remote controls?

How many buttons do you actually use?

How many buttons do you not know the purpose of?

Is it a problem when changing focus between the remote control and the TV?
Is this made more difficult when using the DTV menus/EPGs?

Appendix 4C: Participants Information Form – Wii Study

Project Brief

My name is Amritpal S Bhachu, and I am a PhD Student at the University of Dundee. The title of my current PhD research project being undertaken in the University of Dundee in partnership with the BBC (British Broadcasting Corporation) is 'Adaptive Technologies for Enhancing the Accessibility of Digital TV'. The area of my research is focused on enhancing the accessibility of Digital Television. Older adults are a group that it is believed have the greatest issues using Digital Television and the services and features that it can offer. My primary aims in the research are to identify ways in which these features and services can be made easier to use for older adults, as well as identifying possible additional features and services that older adults feel would enhance their viewing experience.

In the UK, we are currently going through the process of switching off the analogue TV transmitters and moving to a fully digital infrastructure. TV watching is also no longer restricted to a single TV set in home and programming is now widely available on our computer systems, gaming systems and mobile devices. This will predictably have a major effect on the way in which we all watch TV.

Study Outline

The Nintendo Wii is one of the most popular current gaming consoles. It differs from other gaming platforms in that it offers the user a unique way of interacting with the environment through the use of gestures.

As with most modern consoles, the Wii does not only offer gaming but also the opportunity to access a range of different widgets such as an Internet browser. On the Wii platform, these widgets are known as channels, and one of the available channels is the BBC iPlayer that was launched as a channel in November 2009. This will be the focus of this study.

The BBC iPlayer was introduced to the Internet on the 25th of December 2007. It allows users to view a variety of BBC programming from the BBC channels after their original broadcasting on TV.

As part of this study I would like to take the opportunity to observe how users interact with the iPlayer using the Wii's gesture recognition remote control. It must be stressed here that the use of a gesture-based remote control by users is the main focus in this study along with the how it interacts with certain interface elements. Issues with the BBC iPlayer itself are not being considered as part of this study. The Wii iPlayer interface offers a variety of onscreen objects that the user can interact with. This includes selectable icons, text and images, vertical and horizontal scroll bars as well as an area to input text during searches.

This will be a qualitative study. Each participant will be working as an individual. They will be asked to experiment with the environment and be encouraged to find their favourite programmes to watch. The researcher observing will have limited interaction with the participant, only giving help when the participant has been given sufficient time and is clearly struggling to complete the actions they wish. After a sufficient period of time has been allowed for the user to experiment in their own way, should the need arise, they will be asked to complete a short task to cover elements that they may not have experimented with.

Participants selected for this study will be adults 18 and above. They will be recruited from older adults from the User Centre in the School of Computing at the University of Dundee, as well as staff and students from this department. There will be a maximum of 5 chosen from the User Centre and 5 other users. There will be no exclusion criteria although attempts will be made to recruit a wide age range of participants. The study will be conducted in a one-on-one format and recorded with a camera for analysis. The researcher will also take notes during the session, but not in a way that distracts the user. Each session will be limited to 30 minutes, but an extra 15 minutes will be allowed if the researcher feels that it is needed.

Participants will be invited to attend a further session once all the data has been analysed and documented where the results will be presented and with the opportunity of discussion as part of their debriefing.

Participants will be asked to sign a form saying that they are willing to participate in the study. The consent form will explain what will be asked and what will happen to any information that is collected. The participants will be given a copy of this form to keep.

If you have any questions about the project then please feel free to contact me on 01382 388115 or abhachu@computing.dundee.ac.uk with any questions.

Thank you for taking time to read through this proposal.

Amritpal S Bhachu

Appendix 4D: Participant Consent Form – Wii Study

Dear Participant

I would first like to thank you for agreeing to take part in this study. Please take time to fully read and understand the attached information sheet and ask any questions that you may have.

During the session today a camera may be used for data collection. This is only to allow for notes to be made after the session. All the information that you give us, and the videotapes (that is all data), will be stored safely and kept separate from information about your identity. Access to your data is limited to the people involved in this research. If information about you is used in publications or presentations, we will ensure no reference is made to your identity. If a photograph or video-clip is used for presentation, your name will be changed. If you do not wish your likeness to be used in any of the material, your image can be blanked from view.

Thank You
Amritpal S Bhachu

I agree to take part in this study and I understand that I can withdraw from this at any time. **YES/NO**

I understand that I am not being judged or assessed **YES/NO**

I understand that I can leave any questions that I do not wish to answer **YES/NO**

I understand that sessions will be videotaped **YES/NO**

I agree for my likeness to be used (i.e. on Video Camera) **YES/NO**

Print Name _____

Signed _____ **Date** _____

Appendix 4E: Wii Study Questionnaire

Below are several quick questions to give a bit more background information about yourself.

You are in no way being judged or assessed. If information about you is used in publications or presentations, we will ensure no reference is made to your identity. You are free to leave questions that you do not wish to answer.

Thanks
Amritpal S Bhachu

Questions

Name: _____

Age: _____

Do you live:-

- Alone
- With partner/spouse
- With family
- Other shared

Do you require glasses to:-

Watch TV?	**YES/NO**
Read text on your TV?	**YES/NO**
Use your TV remote control?	**YES/NO**

Appendix 5A: Participant Consent Form – Remote Study

Dear Participant

I would first like to thank you for agreeing to take part in this study. Please take time to fully read and understand the attached information sheet and ask any questions that you may have. At no time during this research are the participants being tested, rather it is the technology that is being tested.

During the session today a camera may be used for data collection. This is only to allow for notes to be made after the session. All the information that you give us, and the videotapes (that is all data), will be stored safely and kept separate from information about your identity. Access to your data is limited to the people involved in this research. If information about you is used in publications or presentations, we will ensure no reference is made to your identity. If a photograph or video-clip is used for presentation, your name will be changed. If you do not wish your likeness to be used in any of the material, your image can be blanked from view.

Thank You
Amritpal S Bhachu

I agree to take part in this study and I understand that I can withdraw from this at any time.	**YES/NO**
I understand that I am not being judged or assessed	**YES/NO**
I understand that I can leave any questions that I do not wish to answer	**YES/NO**
I understand that sessions will be videotaped	**YES/NO**
I agree for my likeness to be used (i.e. on Video Camera)	**YES/NO**

Print Name _____

Signed _____ **Date** _____

Appendix 5B: Participant Information Form – Remote Study

In the UK, we are currently going through the process of switching off the analogue TV transmitters and moving to a fully digital infrastructure. TV watching is also no longer restricted to a single TV set in home and programming is now widely available on our computer systems, gaming systems and mobile devices. This will predictably have a major effect on the way in which we all watch TV.

During this experiment, I am assessing how viewers interact with a Electronic Programme Guide (EPG) on a Digital Interactive Television (DITV) system using three different control devices. These devices are a standard TV remote control, a tablet PC and a gesture control.

First, you will be asked to do a basic eye test and complete a capability questionnaire. After this, there will be a discussion about your television viewing habits. A set of 3 tasks will be outlined to be performed on each device. The time and the number errors made will be taken during each task. After the 3 tasks have been completed on each device, you will be asked to fill in a System Usability Scale. Once all the devices have been used, there will be a discussion about your experiences during the experiment using the devices.

If you have any concerns before, during or after the experiment, and would like to speak to a member of staff other than myself, then please contact Karen Petrie on 01382 388613 or karenpetrie@computing.dundee.ac.uk.

Thank you for taking time to read through this proposal.

Amritpal S Bhachu

Appendix 5C: Capability Questionnaire

This questionnaire is used with kind permission from the PACT lab at Northumbria University.

Please respond to each statement by circling the appropriate number which corresponds to your answer. On this scale 1 corresponds to not at all able and 7 corresponds to very able.

First could you please answer these questions related to our TV research

Age: _____

Do you live:-

Alone

With partner/spouse

With family

Other shared

Do you require glasses to:-

Watch TV?	**YES/NO**
Read text on your TV?	**YES/NO**
Use your TV remote control?	**YES/NO**

Fine movements

This section addresses the ease with which you can manipulate objects.

To what extent are you able to:	Not at all able						Very able
Make fast finger movements (e.g. rapidly tapping on a table, clicking a mouse button)	1	2	3	4	5	6	7
Make small delicate movements (e.g. doing up a button, pulling up a zip)	1	2	3	4	5	6	7
Hold something steady (e.g. Lighting a candle)	1	2	3	4	5	6	7
Grip an object (e.g. a tin opener)	1	2	3	4	5	6	7
Twist objects (e.g. turning a tap or opening a jar)	1	2	3	4	5	6	7
Squeeze objects (e.g. washing up liquid bottle, toothpaste)	1	2	3	4	5	6	7
Pick up, make pincer movements (e.g. picking up coins)	1	2	3	4	5	6	7
Make tracing movements (e.g. following a path on a map)	1	2	3	4	5	6	7

Use small buttons (e.g. mobile phone)	1	2	3	4	5	6	7

Strength

This section is interested in how strong you are.

To what extent are you able to:	Not at all						Very much
Lift medium heavy items (e.g.) full kettle	1	2	3	4	5	6	7
Lift heavy items (e.g. shopping)	1	2	3	4	5	6	7
Push an item away from you (e.g. a kettle, pushing in a plug)	1	2	3	4	5	6	7
Pull an item/ object towards you (e.g. kettle, pulling out a plug)	1	2	3	4	5	6	7

Feedback/ awareness

This section is about how sensitive you are to pressure information.

To what extent are you able to:	Not at all						Very much
Feel when a key on a keypad is depressed	1	2	3	4	5	6	7
Judge the correct pressure required to, for example turn on a light	1	2	3	4	5	6	7
Judge whether light and /or heavy pressures are required	1	2	3	4	5	6	7

Balance & Flexibility

To what extent are you able to:

	Not at all						Very much
Stand on one leg	1	2	3	4	5	6	7
Bend over	1	2	3	4	5	6	7
Stretch or reach (e.g. for something on a shelf)	1	2	3	4	5	6	7
Tie shoelaces	1	2	3	4	5	6	7
Cut your toenails	1	2	3	4	5	6	7
Stand in queues for periods of time (e.g. in post office)	1	2	3	4	5	6	7
Hold a pen steady (e.g. writing cards, letters)	1	2	3	4	5	6	7
Dance	1	2	3	4	5	6	7
Squat down	1	2	3	4	5	6	7
Move your arms flexibly (e.g. raise your arm above shoulder level)	1	2	3	4	5	6	7
Move your legs flexibly	1	2	3	4	5	6	7

(e.g. have a full range of movement in knees and ankles)							
Overall flexibility	1	2	3	4	5	6	7

Your senses

In this section we are interested in the five senses.

Vision/ Eyesight

If you wear any corrective lenses answer the following as if you are wearing them

Are you able to:	Not at all able						Very able
Hold a steady gaze (e.g. maintain eye contact)	1	2	3	4	5	6	7
Track objects (e.g. a tennis ball across a court, cursor on a screen)	1	2	3	4	5	6	7
Accurately judge how far away something is	1	2	3	4	5	6	7
See objects in the distance	1	2	3	4	5	6	7
See objects close up	1	2	3	4	5	6	7
Distinguish between different colours (e.g. TV, traffic lights)	1	2	3	4	5	6	7
Read small print (e.g. newspapers)	1	2	3	4	5	6	7
Read at an angle from the object or screen (e.g. cash machine, mobile phone)	1	2	3	4	5	6	7
See objects off to the side	1	2	3	4	5	6	7

while you are walking							
Ignore glare (e.g. from car headlights, TV screen)	1	2	3	4	5	6	7
See the flicker on for instance your television screen	1	2	3	4	5	6	7
Accurately judge distances (e.g. driving)	1	2	3	4	5	6	7

Sense of Touch

To what extent are you able to:	Not at all able						Very able
Feel vibration	1	2	3	4	5	6	7
Distinguish between different textures	1	2	3	4	5	6	7
Distinguish between hot and cold	1	2	3	4	5	6	7
Recognise pain	1	2	3	4	5	6	7
Distinguish whether or not buttons are on or off by touch (e.g. a light switch)	1	2	3	4	5	6	7
Feel if there is a draught	1	2	3	4	5	6	7

Sense of Hearing

To what extent are you able to:	Not at all able						Very able
Hear high pitch sounds (e.g. birds tweeting, a flute)	1	2	3	4	5	6	7
Hear low pitch sounds (e.g. car coming towards you, cello)	1	2	3	4	5	6	7
Hear loud noises such as thunder	1	2	3	4	5	6	7
Hear quiet noises such as whispering, the tick of your watch)	1	2	3	4	5	6	7

To what extent are you troubled by:	Not at all						Very much
Sensitivity to loud noise	1	2	3	4	5	6	7

If there is anything else that you would like to add please feel free:

Appendix 5D: System Usability Scale

Instructions: For each of the following statements, please mark **one** box that best describes your reactions to the controller you have *just* used.

		Strongly Disagree				**Strongly Agree**
1	I think that I would like to use this controller frequently.					
2	I found this controller unnecessarily complex.					
3	I thought this controller was easy to use.					
4	I think that I would need assistance to be able to use this controller.					
5	I found the various functions of this controller were well integrated.					
6	I thought there was too much inconsistency in this controller.					
7	I would imagine that most people would learn to use this controller very quickly.					
8	I found this controller very cumbersome/awkward to use.					
9	I felt very confident using controller.					
10	I needed to learn a lot of things before I could get going with this controller.					

Any other comments about this controller:

This questionnaire is based on the System Usability Scale (SUS), which was developed by John Brooke while working at Digital Equipment Corporation.