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A user-centred exploration of the assistive potential of Digital Voice Assistants and Internet of Things technology for People with Disabilities in Ireland.

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Disclaimer

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# Executive summary

## Introduction

This research examines the assistive potential of a range of mainstream, consumer technologies, specifically Digital Voice Assistants and Smart Home, Internet of Things technology, for persons with disabilities and older people.

The benefits that can accrue to people with disabilities and older people through the use of technology have been well established (Enable Ireland & Disability Federation of Ireland, 2016)[[1]](#footnote-1). Research in Ireland indicates that upwards of 192,810[[2]](#footnote-2) people with disabilities are using specialist assistive technologies. However, it has been highlighted that for many more their needs with regard to technology remain unmet (Work Research Centre, 2015). The reasons why these needs remain unmet have been well documented and include the prohibitive costs of specialist technology, its availability and the burden of training and support required for its optimal use (Copley and Ziviani, 2004; Draffan *et al.*, 2015; Boot *et al.*, 2018). Increasingly, digital consumer technologies are building ever-greater functionality in efforts to appeal to as wide a range of users as possible. Mainstream technologies such as smartphones, tablets and digital voice assistants are referred to as accessible technologies as distinct from what has traditionally been referred to as assistive technologies. Aimed at a general market as opposed to being restricted to people with a disability and older people, these consumer products, with their lower cost thresholds, may significantly reduce costs and provide a good ratio of social return on investment.

## Research aims.

This research sets out to establish a more comprehensive understanding of what Digital Voice Assistants and Internet of Things technologies can offer people with disabilities and older people. The research questions are:

1. How do people with disabilities and older people in Ireland perceive the assistive potential of consumer digital technologies?
2. In what ways can people with disabilities and older people utilise consumer digital technologies to support their participation in their home environment?
3. What are the concerns of people with disabilities and older people with regard to the risks in using consumer digital technologies?

## Study participants

There were10 participants in this study, comprising of 2 older people 8 people with a variety of disabilities including a visual impairment, multiple sclerosis and osteoarthritis.

Participants were aged between 26 and 71 years.

The research team installed a range of consumer technology in participant’s homes for a 6-week period from April to June 2022. This included a Digital Voice Assistant (Amazon Echo Show) and Internet of Things technology, such as lights, sockets, and a TV controller.

## Research methods

This research comprised of a literature review and two empirical research studies. Study 1 in this research was a qualitative examination of the experiences of people with disabilities and older people’s use of the range of consumer digital technologies installed in their homes. Data was collected via face-to-face and online interviews with each participant conducted before and after the six-week technology trial. Data was analysed thematically and yielded three themes each with additional sub-themes. These offer insights as to the participants’ experiences using consumer digital technologies and its impact on how they functioned in their home environments.

Study 2 used a mixed methods approach referred to as Q-methodology to examine the perceptions that people with disabilities and older people held about the potential of consumer digital technologies. This study involved the same sample of participants individually ranking a series of statements pertaining to the use of digital consumer technologies by people with disabilities and older people. These statements were extracted from both the literature reviewed and from some of the initial interviews conducted during study 1. Using online interviews, a member of the research team presented each participant with a series of twenty-two statements, and they were asked to rank these from strongly agree (+2) to strongly disagree (-2). The numerical data gathered from each participant was subjected to statistical analysis which aggregated the statements into clusters or factors representing how closely their ranking correlated. This statistical analysis yielded three distinct factors that represented the perceptions and opinions held by study participants. These factors were then considered by the research team alongside qualitative data that was gathered during the online interviews that occurred while the ranking exercise was conducted.

## Collated findings by study

* Participants demonstrated patterns of use for Digital Voice Assistant’s similar to that reported in the literature for the general population, including accessing information, controlling media and entertainment applications, setting reminders (study 1).
* Assistance with set-up and the availability of support throughout the trial ensured that study participants made best use of the technology quickly and efficiently (study 1).
* Participants quickly adapted to using the smart-home functions available to them through the combination of the Digital Voice Assistant and the Internet of Things technologies available to them. As their use of these technologies continued through the trial, the frequency of accessing information and media decreased while the use of smart-home functions increased (study 1).
* The interoperability of Digital Voice Assistants and Internet of Things technology makes setting-up and using smart-home solutions easier for people with disabilities and older people to use than dedicated assistive technologies (study 1).
* Support for using Digital Voice Assistants and Internet of Things technology was often available from participant’s own personal and social networks (study 2).
* The ability to control and interact with technology verbally removes many of the physical barriers to using mainstream technology experienced by people with disabilities and older people. Voice control ensures that a larger portion of the population with diverse needs such as limited mobility, visual-impairment and cognitive disabilities can use these technologies (study 1).
* Voice-controlled technologies offer users of different abilities access to and use of these devices and can be used by multiple people within a household thus offering greater value than assistive technologies that are dedicated to use exclusively by users with specific needs (study 1).
* The patterns of use for Digital Voice Assistants and Internet of Things technologies reported in study 1 reflected the individual routines of each household rather than the individual requirements of specific users (study 1). Participants expressed a preference for using mainstream, consumer technologies instead of dedicated assistive technologies. Factors such as cost, availability and ease of installation were highlighted as impacting upon their choice of technologies (study 2).
* Using Digital Voice Assistants to provide access to web-based information and services removes some of the access barriers using equipment such as keyboards, a mouse or touchscreens that people with disabilities and older people experience getting online (study 2).
* Ethical concerns for people with disabilities and older people that are associated with technologies such as Digital Voice Assistants include threats to data privacy, autonomy, the erosion of consent and the risk of increasing their dependence on the technology they use (study 2).
* Greater attention should be paid by developers and manufacturers to ensure that personal data is managed safely and securely and efforts to do so will increase the confidence of people with disabilities and older people to choose these (study 2).

## Conclusions

The mainstream appeal and broad application offering of Digital Voice Assistants and Internet of Things technologies by people with disabilities is likely to increase over the forthcoming years. The two studies in this research demonstrated that voice-controlled technology provides people with disabilities and older people with ease of access to the in-built functionality such as control over Internet of Things technology and also provides access to web-based information and internet services. People with disabilities and older people participating in these studies outlined the desire to have available a range of mainstream products that were usable and supported their ability to perform a range of tasks in their home environment. Accommodating a greater diversity of users embedding a broader range of functionality, not just on devices such as Digital Voice Assistants but also smartphones may see people with a disability and older people being less reliant upon traditional, bespoke assistive technologies. The mainstream appeal, availability and relatively lower cost of consumer devices offers greater choice and may serve to reduce risk of abandonment of technology solutions by people with disabilities and older people.

Despite the clear benefits that are currently available for people with disabilities and older people and those that may emerge in coming years, participants in this research project suggested some concerns that should be considered. These include concerns with affordability of technology, the availability of support and the fact that some consumer technologies have to collect, store and re-purpose users’ personal data.

Both study 1 and 2 reported here have indicated that extending the functionality of consumer technologies, making it accessible for a larger population of users and increasing confidence in how personal data is used and managed can offer developers and manufacturers increased market share amongst older consumers and those with disabilities. In turn, the flexibility of access and the increasing functionality available with devices such as these offer greater opportunities for controlling one’s home, communication, accessing information and entertainment.

# 1.0 Introduction

## 1.1 Introduction

As the use of digital technology becomes ever more ubiquitous in modern society, access to information, communication and services is increasingly mediated by those technologies. The acceleration of both hardware and software development over the past twenty years has seen the merging of diverse functionality such as telephony, text communication, e-mail, route finding and other functions on consumer technologies. These key consumer devices include computers (Kasulaitis et al., 2015), smartphones (Boulos et al., 2011), tablets (Yoshizawa et al., 2013), smart TV’s (Khan et al., 2022) and smart speakers (Tavares et al., 2022). The adaptive nature of much of these consumer technologies provides greater opportunities for people with disabilities and older people to benefit from access to such opportunities. For example, voice control offers users the ability to control and engage with devices without relying on motor control and dexterity. Similarly, auditory feedback, often available in multiple languages can reduce the need to read information and instructions displayed on screens. Increasingly, manufacturers and technology developers are recognising that people with disabilities and older people are demanding access to the same information and services as others in society without incurring additional costs (Lazar et al., 2015b).

In some instances, technologies that were originally developed for people with disabilities and older people have had traction amongst the general population because of the functionality they offer. One example is voice recognition software which was originally conceived of as a means to provide those with restrictions in upper-limb mobility with a ‘hands-free’ means of typing (Juang & Rabiner, 2004). Such technology is now seen as a standard feature in many digital consumer products. Furthermore, there is an increasing awareness of how much of the mainstream digital technologies intended for use by the general population offer a range of new and previously unimagined opportunities for people with disabilities and for older people (Botelho, 2021b). The uptake of mainstream technologies by people with disabilities and older people has led to the suggestion that accessibility and equality goals can best be met through leveraging the potential of both assistive and consumer technologies (Agree, 2014).

The aim of this research report is to explore the potential of an exemplar range of consumer technologies, namely, Digital Voice Assistants (DVAs) and smart-home technologies otherwise known as Internet of Things (IoT) to support people with disabilities to access information, avail of digital services and live independently in their homes.

## 1.2 Background

Technology developments over the past number of decades have offered new opportunities for people with disabilities and older people. In some instances, developers have sought to produce specialist equipment specifically addressing functional limitations. Such technologies have often been referred to as ‘Assistive Technology’ (AT) a term used to refer to products, equipment, and systems that enhance learning, working, and daily living needs of persons with disabilities. AT includes screen readers, braille output, connections to hearing aids, and alternative access technologies, including pointing devices or switch access. In recent years however, consumer digital technologies such as laptops, smartphones, digital voice assistants and smart TV’s have all featured a degree of functionality that, in the past, may have been described as AT. These mainstream technologies and the functions that they offer to users are increasingly referred to as ‘accessible’ rather than ‘assistive’ so as to distinguish them from AT, a term that remains associated with specialist equipment for people with disabilities. The emergence of accessible consumer technologies has been driven by a greater understanding of the needs of people with disabilities and a recognition of the consumer potential of older people (Global Industry Analysts Inc, 2022). Despite providing features that support the use of people with disabilities and older people, these technologies are aimed at serving a mainstream market. Increasingly, developers and manufacturers are more acutely aware of who makes up the market for their products and consider people with disabilities and older people as constituents of that market. Economies of scale in design, production and manufacture often see these technologies being more widely available on the market and more competitively priced than the more specialist AT that is aimed squarely for a small market of users with specialised needs (Lazar et al., 2015a). Accessible consumer technology includes products, equipment, and systems that can be customized and provide all users, including people with disabilities access to all services and content. Some examples include smartphones with integrated speech-to-text that can be used for dictation, hands-free control or for creating captions. Such devices are widely available and are designed to be used with minimal effort by a broad and diverse population of technology consumers.

## 1.3 Digital Voice Assistant and Internet of Things Technology

Digital Voice Assistants (DVA’s) and voice-controlled digital personal assistants have introduced a new interaction paradigm into the mainstream. Devices such as Amazon’s ‘Echo’ series, Apple’s ‘SIRI’ and Google’s ‘Assistant’ provide a conversational interface in the home that allows users to ask for and save information (e. g. check the weather, ask for the time, add to a shopping list), control smart-home appliances, home lighting, or door locks by voice, and perform a range of online actions (e. g. shopping, banking). A growing number of regular household items such as light bulbs, televisions, plug sockets, intercoms and door locks are becoming ‘smart’. One of the major benefits being that they can be controlled from one central technology hub such as Amazon Echo or Google Home which are typically operated simply by speaking aloud. The technology is increasingly used in conjunction with other commercial technologies that occupy what is referred to as ‘smart home’ market. These include entertainment services such as streaming audio, video and ‘on-demand’ television content. Such technology also encompasses home security and management systems controlling heating and energy use in the home. Although recent research suggests that there is a moderate uptake of this new technology by people with a disability (Malapaschas, 2020; Pradhan et al., 2018, 2020), a full exploration of the assistive potential of this mainstream technology remains in its infancy. The relatively recent emergence of the technology has resulted in much of the research being restricted to dimensions such as design (Chattaraman et al., 2019) usability (Wallace & Morris, 2018) and its potential risks and pitfalls (Schlomann et al., 2021).

Parallel developments in wireless and internet-based technologies, including what is referred to as Internet of Things (IoT), have extended the potential functionality of DVAs and their applicability for people with disabilities and older people. IoT has seen a range of technologies previously referred to as “smart-home technologies” come to the mainstream market at a price point well below that of specialist, disability-specific technology (Lee et al., 2020).

DVAs and IoT undoubtedly present opportunities for many users, including making it easier to access the online world or control other devices. However, there is a growing debate about the seemingly intrusive nature of such ‘connected’[[3]](#footnote-3) devices and the use of the data captured. Questions have been raised about their longer-term disruptive impact on the consumption of information, user profiling, and people’s relationship with technology (Lau, Zimmerman & Schaub, 2018). The potential technology can offer people with a disability has long been balanced against the need to ensure their right to information privacy and security (Lazar et al., 2017). The encroaching use of in-home technologies such as DVA’s requires careful consideration, particularly as general societal concerns seep through to inform the perspectives of people with a disability (Brand et al., 2020). Concerns regarding safety, privacy and autonomy have the potential to erode the confidence people with a disability have in the choice making and control available to them. Thus, a comprehensive appraisal of the concerns of people with a disability is warranted particularly as this may inform future information policy, design developments, and evolving services available for this user group.

Connectivity to the internet and online services, easy market availability and a relatively modest price point for purchase make DVA’s and IoT technologies an attractive prospect for people with disabilities and older people. Furthermore, the ability to control these technologies via voice suggests an accessible option for those who would otherwise find physical interfaces such as keyboards, mice or even touchscreens difficult to use. There remains however a lack of knowledge as to what people with disabilities currently use these products for or what their potential might be.

Considering how the design of technologies such as DVA’s and IoT are not focussed primarily on addressing the specific needs of users with disabilities or older people their potential in terms of how they can benefit this user constituency remains underexplored. There is much that can be uncovered in terms of the degree to which such accessible devices can meet the needs of groups with particular needs. As people with disabilities and older people begin to acquire and use new, accessible technologies it is anticipated that they will discover a range of new and unanticipated ‘assistive’ functionality that meets their needs. The emergence and rapid development of such accessible technologies may indeed provide consumers with disabilities with greater choice and cause disruption to the traditional assistive technology market. This research sought to capture the subjective experiences of people with disabilities and older people as they used these technologies in their own home environments as well as any perceived risks they may have encountered.

# 2.0 Methodology

## 2.1 Introduction

This research aimed to address the following research questions:

* How do people with disabilities and older people in Ireland perceive the assistive potential of consumer digital technologies?
* In what ways can people with disabilities and older people utilise consumer digital technologies to support their participation in their home environment?
* What are the concerns of people with disabilities and older people with regard to the risks in using consumer digital technologies?

Following A review of literature was conducted to identify relevant work that had previously been undertaken in order to establish the context for the current research. Following completion of the literature review, two related research studies were designed, each of which aimed to address the research questions outlined above. Both studies were centred around a field-trial of technology comprising a DVA and IoT smart-home technologies that were installed in the homes of ten research participants for their use over a six-week period. Ethical approval for the study was obtained from the Social Research Ethics Committee at University College Cork. A description of the planning and preparation for this six-week technology trial are outlined in Appendix A of this report.

## 2.2 Literature review

The literature review commenced with a grey literature scoping exercise to determine the range and functionality of DVAs and associated smart home/IoT technologies that were readily available on the Irish market and to appraise these in terms of their fit for inclusion in the fieldwork for this research. This process assisted in the early identification of key research articles and several keywords that could be used to support early efforts by the research team to search a range of databases of relevant, previously published work. During the period December 2021 through to early February 2022 a comprehensive literature search was conducted to inform a state-of-the-art report on the use and application of DVAs and associated IoT technologies by people with a disability and older people. A ‘state of the art review’ seeks to capture the current level of development of a technology or its application (Blessing & Chakrabarti, 2009). Such a review is not limited to research published across academic journals, rather it considers a broad range of published literature from engineering, social science, and computer science alongside sources from grey literature, reports, and web published resources (Paez, 2017).

The process of identifying relevant literature for review and the process by which it was determined to match the research topic drew from the work of Arksey and O’Malley (2008) in their approach to conducting scoping reviews of literature. From this and using the framework developed by Bramer et al., (2018) a protocol was developed that guided the identification of key words matching the study aims, the selection of databases to examine and the process for selecting the correct data (a workflow for this process is presented in Appendix B). Once satisfied with the process a wide-ranging literature search was conducted. This process began with a search of internet available sources using carefully selected keywords pertinent to the topic and research questions. This allowed the research team to quickly identify key articles and grey literature and prompted a review of the common keywords used across these texts. These were then refined and would be used for a more thorough search of databases available. In total, a combination of six databases was used in the search, namely:

* [EBSCO host](https://www.ebsco.com/products/research-databases),
* [Scopus](https://www.elsevier.com/solutions/scopus),
* [Science Direct](https://www.sciencedirect.com/),
* [Pubmed Central](https://www.ncbi.nlm.nih.gov/pmc/),
* [Social Science Citation Index](https://clarivate.com/webofsciencegroup/solutions/webofscience-ssci/) and
* [Google Scholar](https://scholar.google.com/).

Web-based searches were also undertaken to ensure that the relevant policy documents, guidelines, and other grey literature were identified. A final search of the identified databases was conducted yielding a total of 1120 articles (see Appendix C of this report). These were exported to an online software tool[[4]](#footnote-4) developed to support the systematic, collaborative review of literature. Two members of the research team conducted a review of article titles followed by a review of abstracts to determine the applicability of the articles available. Following elimination of duplicates and articles that were not considered relevant a final number of 54 articles remained. A full-text review by two of the authors excluded 10 papers because they were not reporting on research, or they did not report on specific applications for people with disabilities and older people. The final corpus of 44 research articles were examined by two of the principal investigators with a view to extracting a series of concepts, themes and challenges that informed a comprehensive review of current literature which is presented in section 3 of this report.

## 2.3 Study 1: A qualitative examination of the experiences of people with disabilities and older people using Digital Voice Assistants and Internet of Things technologies.

### 2.3.1 Introduction

A qualitative approach in research enables exploration and description of a concept, phenomenon or process as it happens in its natural setting and enkindles understanding on a human level (Carpenter and Suto, 2008). It is conducted when researchers want “to empower individuals to share their stories and to hear their voices” (Creswell, 2007, p. 40). This study aimed to capture the unique experiences of people with functional limitations using DVA and IoT technologies in their homes, therefore a qualitative approach was used. Utilising an interpretive approach, a researcher recognises their influence on the process in that qualitative research can be seen as a co-construction of knowledge between the researcher and the participant (Finlay *et al.,* 2006). In qualitative research the researcher is a key instrument as they play an integral part of data collection and analysis (Creswell, 2018). Researchers use reflexivity as a process of interpreting what they have seen, heard and understand. They also acknowledge and bring their own background, history and prior conceptions to inform the process of collecting, analysing and interpreting data (Creswell and Plano Clark, 2017). Such an approach is suited to research that is focussed on exploring a novel subject that has to date received limited attention. The exploratory nature of this study suggests that a qualitative approach may be appropriate as it is focussed on examining a relatively new phenomenon, that of the experiences of people with disabilities using technologies such as DVAs and IoT.

### 2.3.2 Study1: Methods

There are a range of qualitative methodologies including: phenomenology, ethnography, grounded theory, narrative, and case study design. Phenomenology has been described as “knowledge as it appears to consciousness, the science of describing what one perceives, senses, and knows in one’s immediate awareness and experience” (Moustakas, 1997, p26). Phenomenology raises important academic, intellectual, and procedural issues while simultaneously questioning the basis and standing of knowledge (Carpenter & Suto, 2008). Similarly, Moustakas highlights “any phenomenon represents a suitable starting point for an investigation” (1997, p25). As this study is concerned with the experiences of people with a disability and older people using technology qualitative methods ae most suitable. As such, a range of qualitative methods were used to assist in the collection of data for this study including self-reported short survey, researchers’ field notes and semi-structured interviewing.

As highlighted in the introduction to this section, this study centred around a field trial of DVA and IoT technologies installed in participants’ homes for a six-week period. A full description of the field-trial is outlined in appendix D. Prior to installation of the technology in their homes participants completed a short survey and participated in a semi-structured interview with a member of the research team. Following the field-trial period using the technology all participants were interviewed a second time using a semi-structured approach (see appendix E) for survey and semi-structured interview guides).

### 2.3.3 Study 1: Recruitment and Participants

Purposive sampling was used as a proactive and pragmatic approach to recruiting participants for the study. This involved identifying and contacting gatekeepers[[5]](#footnote-5) who could carry out the role of key-contact or ‘broker’ supporting the process of identifying and recruiting participants matching the inclusion criteria (see Table 2. 1). This approach for recruitment has been used in similar studies (McFadyen & Rankin, 2016).

Table 2. 1: Participant Selection: - Inclusion/Exclusion Criteria

| Inclusion | Exclusion |
| --- | --- |
| All participants to be over 18 years of age. | Those under the age of 18 years by the 1st of April 2022. |
| All participants to be living in a non-institutional care environments in the Irish Republic. | Those living in hospital, residential, respite or other care and support facilities where medical and care services are onsite. |
| All participants must report/declare an ongoing functional limitation (lasting > 6 months) currently impacting their ability to participate fully in a chosen activity. | Those declaring no functional limitation or reporting functional limitations lasting less than 6 months. |
| All participants to maintain full-time residence in their homes for 10 of 12 weeks of the duration of the study. | Those who will reside away from their home for less than 10 of 12 weeks for the duration of the study. |
| All participants’ homes must be equipped with stable broadband connectivity via a home-based Wi-Fi network for the duration of the study. | Those with no access to broadband connectivity or those uncertain that a stable broadband service can be maintained for the duration of the project. |
| All participants’ must be willing to share their home broadband and Wi-Fi credentials and passwords with the research team for the duration of the research project[[6]](#footnote-6). | Those not able to or willing to share their broadband and Wi-Fi credentials and passwords for the duration of the research project. |

A series of brokers were identified across a range of regional and national organisations representing people with disabilities and older people in Ireland. The brokers at each organisation were asked to identify and contact potential participants from their membership base who met the inclusion criteria. Researchers’ contact details were made available alongside if they were interested in participating in the research. The nature of the organisations represented by these brokers ensured a geographical distribution throughout the Republic of Ireland from both rural and urban backgrounds. The research team discussed the profiles of potential participants to ensure that the study included a distribution of ages and gender.

During a first round of recruitment, a total of six participants were identified and recruited using the process above and a further two were identified via snowball sampling[[7]](#footnote-7). In these cases, existing participants were asked to pass the same contact details to other potential research recruits via their own personal networks. A second round of recruitment was conducted with two additional regional organisations. This yielded a further two participants for the research project. All ten participants were provided with the same written information about the project and were offered the opportunity to speak to a member of the research team should they require further information.

Pseudonyms were assigned to participants at recruitment and were used throughout to ensure data anonymity. A master key containing information regarding participant names/addresses/contact details was maintained securely throughout the duration of the research by a single member of the research team and was stored securely in a fully encrypted UCC OneDrive server location. Full details of participants recruited for this study are presented in section 4.1 of this report.

### 2.3.4 Study 1: Data Gathering and Procedures

The first phase of data gathering comprised two elements:

1. All participants were asked to complete a short, survey gathering demographic and personal details and,
2. All participants were engaged in a semi-structured interview.

Based on negotiation with individual participants the interviews were conducted either in-person (in participant’s home) or via video conferencing (using Microsoft Teams). Of the 10 participants, 6 opted for an in-person interview while the remaining 4 chose an online method. The purpose of the interviews was to collect participant data on their:

* Understanding and knowledge of DVAs and other voice-controlled home technologies,
* Previous experience in using technology, specifically DVA or other voice- controlled technologies and,
* Expectations of their use of such technology in their own home environment.

A copy of the interview brief devised by the research team is presented in Appendix F of this report. The interviews typically concluded with a free conversation about the research project and a discussion as to the practicalities of the further stages of the study including technology installation and commissioning. A second round of interviews was conducted between five and six weeks after the original interviews took place. An individual schedule for each of these interviews was designed by the research team following the first round of analysis conducted after the initial interviews.

The purpose of the second round of interviews was to extend the data collected regarding:

* Individual participant’s experiences using DVA and IoT technologies installed for the field-trials.
* The impact using a DVA and associated IoT technologies had on their participation in the home and in community activities.
* Barriers to use, unanticipated benefits and concerns about privacy and security.

The same researcher that conducted the initial interviews acted as sole interviewer for the second round of interviews. In the interests of time all interviews were conducted online using Microsoft Teams and were recorded using the secure recording function of that software. Each of the interviews during the second round of data collection were between 39 and 53 minutes in duration (mean = 46.7 minutes). All interviews were transcribed using Microsoft Teams and Microsoft Stream with all identifiers removed to anonymise the transcripts. All transcription was conducted by two members of the research team who were not involved in the interviews, and they were responsible for preparation of the data for analysis by both lead authors in this work.

### 2.3.5 Study 1: Data Analysis

Narrative data obtained from participant interviews were analysed via thematic analysis. Thematic analysis is a method for identifying, analysing, organizing, describing, and reporting themes found within a data set. A rigorous thematic analysis can produce trustworthy and insightful findings (Braun & Clarke, 2006). Braun and Clarke (2006) argue that thematic analysis is a useful method for examining the perspectives of different research participants, highlighting similarities and differences, and for generating unanticipated insight. Using this approach, six phases are used to analyse and to extract meaning from data gathered: 1) transcription and familiarisation with data, 2) generating initial codes, 3) searching for themes, 4) reviewing themes, 5) defining themes and finally, 6) writing the report.

* Phase 1: Transcription and familiarisation of data.
* All audio-recorded data was transcribed verbatim using Microsoft Teams[[8]](#footnote-8) and Stream. The researcher listened back to the audio recording of each interview to ensure accuracy of transcription and to become familiar with the data. This process of transcription is acknowledged as an important first step in data analysis (Nascimento and Steinbruch, 2019).
* Phase 2 – Generating initial codes.
* Qualitative coding, as described by Savage (2000) is a reflective process in which the researcher interacts with the data and thinks about the data. During this process, the researcher completed line by line coding and attached labels to each, to index them as they related to an issue in the data (Nowell *et al.,* 2017).
* Phase 3 – Searching for themes.
* The third phase of data analysis began when all data had been coded and a list of codes had been developed. Codes were then sorted and collated into a first draft of categories (Braun and Clarke, 2006). Categories were further analysed to form themes. Themes are described by DeSantis and Ugarriza as “an abstract entity that brings meaning and identity to a recurrent experience and its variant manifestations” (2000, p. 362). Therefore, the themes aimed to unite the data into a meaningful whole.
* Phase 4 – Reviewing themes.
* Themes were reviewed by members of the research team to ensure accuracy. This occurred during regular meetings between those conducting the interviews, those responsible for transcribing the data and the remaining member of the team. All these discussions took place online with all team members having access to the data during this time.
* Phase 5 – Defining and naming themes.
* In phase 5, the researcher wrote a ‘story’ that each theme told. Braun and Clarke (2006) suggested that theme names need to be punchy and immediately give the reader a sense of what the theme is about. The researchers then considered how each theme fits into the overall story in line with the overall research question (Braun & Clarke, 2006).
* Phase 6 – Producing the report.
* The responses from participants are used to illuminate the experiences of participants in relation to their perceptions and experiences of using DVA and IoT devices. Pseudonyms were used to ensure the confidentiality/anonymity of all participants.

Due to the time constraints between data collection and reporting a rapid analysis of the data was conducted to identify and extract initial themes. This type of analysis is often referred to as framework guided rapid analysis (Gale *et al.,* 2019) and has been suggested as a mechanism for quickly identifying key themes from qualitative data where there is a limitation in the time available or when it is anticipated that multiple rounds of analysis will be conducted (Neal *et al.,* 2015).

Both sets of data from the first and second rounds of interviews was subjected to rapid analysis by the two primary authors. Initial codes for the data were generated. Both researchers developed these further and used triangulation with the transcripts from both rounds of interviews and the primary author’s field notes to produce emerging sub-themes and themes (Carter *et al.,* 2014; Santos *et al.,* 2020). The themes and sub-themes represent the findings of this study and are presented in Section 4 of this report.

## 2.4 Study 2: An exploration of the perceptions of the potential and risks for people with disabilities and older people using consumer technologies.

### 2.4.1 Introduction

Study 2 used a mixed-methods approach, referred to as Q-methodology, to determine the perspectives of a sample of people with disabilities and older people of DVA and IoT technologies. Originally developed by Stephenson in the 1930’s this method combines both a quantitative and qualitative approach to inquiry (Stephenson, 1936). It provides an opportunity to systematically study participant views of a specified topic, issue, or phenomenon. This research approach is used when there is a requirement to systematically examine the subjectivity of a person or persons’ views, opinions, beliefs or attitudes (Rost, 2021). It collects the qualitative judgements of participants that pertain to the subject of inquiry and presents these to a representative sample of a relevant population. This sample - often referred to as the Q-set - are tasked with ranking the statements from their own perspective, revealing their subjective viewpoint on the given topic.

### 2.4.2 Study 2 Methods

Q-methodology is described as ‘a set of procedures, theory and philosophy’ (Brown, 1993, p. 4). Different definitions of Q-methodology are outlined throughout the literature, however the common theme in all of them is that the process allows researchers to capture and aggregate participant subjectivity. Woods (2012, p892) considers Q-methodology as ‘a methodology developed for small-scale research with the aim of capturing and contrasting subjectivity’. Furthermore, Hughes (2012, p65) illustrates the Q-methodology process as being ‘a method that requires a participant to sort items according to criterion’. These criteria include elements such as the degree to which participants agree or disagree, thus giving the researcher accurate findings that explore their beliefs.

The main disadvantages some researchers have mentioned regarding Q-methodology include validity and reliability issues, which are important elements for any type of ‘R’ methodology study (Watts & Stenner, 2012). In many instances the determination of variables in Q-methodology are reliant on work done by the researcher and because of the prior subject knowledge they possess there is a degree of risk that the study is bound by a certain bias. Interpretation of factors as a process that is reliant on the qualitative subjectivity of the researcher, however, this is acknowledged as findings from Q-methodology studies are considered exploratory, initial, and provisional (McFadyen & Rankin, 2016). As with many mixed methods or qualitative research the reflexivity of the research is a key and vital component in ensuring the overall reliability of the process. Also, iterative, and collaborative consultation between researchers during and after analysis of the data, contributes to the degree of trust that can be made for the outcomes of such research (Watts & Stenner, 2014).

### Study 2: Recruitment and Participants

All ten participants that took part in study 1 were also invited to participate in this study. This ensured that the sample participating in study 2 would have similar experiences of using technology thus increasing the likelihood of consensus being reached during the Q-methodology. All participants were informed that they could withdraw from study 2 while remaining as active participants in study 1, however, none chose to do so. This sampling approach is one of convenience and is often employed as ‘preliminary’ or ‘exploratory’ studies in advance of a larger Q-study to allow researchers to generate findings quickly and to test the utility of the method itself (Gilbert, Turner and Holdsworth, 2021; Rost, 2021). A full outline of the relevant characteristics of each participant in presented in section 4. 1 of this report.

### 2.4.4 Study 2: Data Gathering and Procedures

An important step in conducting a Q-methodology study is spending time developing a series of statements that are referred to as the Q-set. Statements are typically, but not always presented as a series of written text and are presented for the study participants to sort based on guidelines provided by the researcher (Churruca *et al.,* 2021). The next part of the process involved allowing participants to ‘sort’ the statements in order of their own preferences. To support this an online software application Q SortWare™ ([https://www. qsortware. net/](https://www.qsortware.net/))[[9]](#footnote-9) was used by participants to present and rank the statements. Furthermore, this software application arranged the data in preparation for export to a statistical analysis package.

### 2.4.5 Study 2: Data Analysis

Q-methodology studies depart from the usual conventions of qualitative research because Q-data can lend itself to numerical analysis. Using a quantitative approach to examine qualitative data can provide researchers with opportunities to detect patterns and explore connections that would not otherwise be possible using qualitative methods. Data analysis involved calculating correlation and factor analysis. In this way the Q-methodology approach generates results by grouping the expressed perspectives and opinions of participants based on the similarities or differences in which the statements are sorted. All participant’s arrays for statements are then organised into a correlation matrix which is subjected to factor analysis to obtain groupings of data arrays that are highly correlated. This process generates clusters of related statements representing the perspectives of the participants. These clusters are referred to as ‘factors’ and they represent the relative variance in participant’s perspectives and opinions. The level of agreement each statement receives is calculated using weighted averages. Finally, SPSS (version 28) was used to conduct the factor analysis which generated clusters of statements or ‘factors’ which were interpreted by referring to the original Q-set of statements and the qualitative data collected from interviews with participants during the online sorting process. The findings of this study are presented in Section 4.3 of this report.

## 2.5 Summary

This section of the report presents a detailed outline as to the background to and the process and methods by which the research took place. The first study was a qualitative study modelled around a field trial of technology installed in the homes of ten participants recruited through several agencies representing and providing services to people with disabilities in Ireland. The second study used Q-methodology to examine the perceptions held by ten participants who were older or had disabilities regarding the potential and risks associated with using DVA and IoT in their own homes. The findings of this study alongside the findings of study 1 are presented in Section 4 of this report.

# 3.0 Literature Review

## 3.1 Introduction

This review of literature presents a comprehensive overview of the research pertaining to the use of DVA and other voice-controlled technologies and IoT for and by people with disabilities and older people. However, due to the recent and rapid development of these technologies it is important to also present an up-to-date picture of the current state-of-the art of the technology and its application for this population. A review of literature pertaining to the exploration of the assistive applications of such consumer technologies is also outlined. To ensure that this review is comprehensive and up to date the authors draw, as best practice suggests from both traditional published sources and from other grey literature publications (Paez, 2017) to present a picture of the use of DVA and IoT for people with disabilities and older people.

## 3.2 Background and context

The history of DVAs can be charted back to research focussed on an emerging area in computer science referred to as natural language processing[[10]](#footnote-10). These efforts at Bell Laboratories in the 1950’s aimed at developing a mechanism for hands-free operation of a telephone by using a person’s voice. The technology was improved over the next decade with IBM showcasing their ‘Shoebox’, a computer-operated, voice activated calculator which recognised and responded to different voice frequencies (Norberg & Yldirim, 2018). The development of phrase recognition did not emerge until the 1970’s when researchers at Carnegie Mellon University launched Harpy a device that featured not just voice recognition but responsive synthetic voice feedback[[11]](#footnote-11). A giant step in development was taken when a small company called Dragon Systems decided to utilize hidden Markov models in computer-based natural language processing. This was a mechanism by which computers could successfully recognise patterns in natural speech based on identifying specific speech sounds across a short time scale (in the region of 10 milliseconds) and translating these to text (Gales and Young, 2008). The software package, Dragon Naturally Speaking began a new era for people with disabilities using computers and suggested the possibility of a future of human-computer interaction that did not involve a keyboard or pointing device.

Innovations at IBM and newcomer Google in the last two decades including Watson and Google Voice Search[[12]](#footnote-12) demonstrated the value of incorporating artificial intelligence (AI) for natural language interaction and set the scene for the development of home based DVAs. Modern DVAs leverage an AI that is rapidly evolving in terms of complexity and power alongside speech recognition technologies. These, combined with computer processors that are significantly faster than any previous generation, are employed to observe, retrieve, and process data based on user inputs. Moreover, DVAs are designed to respond and interact in more human-like ways compared with prior versions of voice-controlled technologies. This combined computing power provides a platform by which they are enabled to learn from past feedback to enhance their future response performance and facilitate personalisation (Vimalkumar *et al.,* 2021).

Within the context of home environments, DVAs are data-based programs embedded within IoT devices or applications, which can communicate with users and respond to their requests primarily through voice commands (Hoy, 2018). The IoT is a virtual network of physical, real-world objects equipped with sensors and other technologies allowing them to connect with each other and exchange data over networks such as the Internet. The development of the IoT has been accelerated by developments in computer production and advances in processing power, all of which makes more powerful technology available at a lower cost. The advent of cloud computing also facilitates stable connectivity and data exchange between more objects in our environments. Within a typical household the IoT often refers to the connectivity between common household appliances such as kettles, fridges, lights, doors, cookers (Moy Chatterjee *et al.,* 2018). It often refers to devices that support the running and maintenance of the building including alarms, heating, energy management and water (Khajenasiri *et al.,* 2017; Kumar, Tiwari and Zymbler, 2019). It also serves to provide control and access to home entertainment systems and even toys (McReynolds *et al.,* 2017).

Charting the history of DVAs and the advent of what has become known as IoT sets the scene for understanding what the technology is typically used for in home environments and points to its potential utility for older people and people with a disability at home and beyond.

### 3.2.1 The proliferation of DVA technology

The applications for natural language processing and DVA technologies are not restricted to personal, home based devices, rather they proliferate through society underpinning many of the casual interactions that we have with technology (Dutoit *et al.*, 2003; Stefanidi *et al.*, 2018). As the automation of services progresses the use of digital technology to support the interaction of consumers has expanded. Use of digital voice assistant technology has increased, for example, in service encounters such as calling customer support services or accessing dial-up booking services. The service sector in particular has seen significant developments in its exploitation of natural language interaction technology in recent decades, such as the growing adoption of artificial intelligence (AI) applications and automated technologies, including service robots, chatbots or virtual assistants (Gummerus *et al.,* 2019).

Automated technologies are expected to be increasingly adopted in service frontlines (Kumar *et al.,* 2015) and may even replace traditional forms of customer-employee interactions (Marinova *et al.,* 2016). AI-based assistants may soon be able to perform most tasks currently carried out by service employees. It is estimated that by 2025 95% of customer interactions will be supported by AI technology (Huang and Rust, 2018). Applications of DVAs are reported across a diverse range of contexts including; smart office environments (Bogdan *et al.,* 2021) in science labs (Perkel, 2020), in cars (Park *et al.,* 2019). Similarly the versatility of DVAs can be seen as researchers and technologists seek ever new application opportunities across education (Terzopoulos and Satratzemi, 2019, 2020), and healthcare (Laranjo *et al.*, 2018; Campillos-Llanos *et al*, 2020; De Cock *et al.*, 2020).

### 3.2.2 Extending the Use of DVAs – home-based applications.

Although voice assistants such as Siri, Google Assistant and Cortana were quickly embedded in mobile phones their uptake by consumers was slow with general user dissatisfaction due to errors in comprehension and a gulf between expectation and functionality (Luger and Sellen, 2016). However, as the technology moved into people’s homes they offered users opportunities for location-based functionality.

Early applications of DVAs in home environments were mainly limited to daily tasks such as setting alarms, schedule reminders, and playing music. Online retailers such as Amazon quickly grasped the opportunity to extend the use of DVA’s for commercial ends. It has been shown that 88% of consumers support the integration of DVA’s by online businesses if it facilitate consumers’ purchasing decisions[[13]](#footnote-13) (Moriuchi, 2019). A recent study examining consumers’ online purchasing patterns revealed that the items purchased most frequently through DVA’s include homecare and groceries, and making airline and hotel reservations (Poushneh, 2021). Therefore, it has been suggested that the application of digital voice assistants will gradually replace personal and laptop computers for shopping purposes (Dellaert *et al.,* 2020). Despite the opportunities for internet-based shopping and consumer purchasing offered by DVAs recent market level research[[14]](#footnote-14) finds there is not a significant uptake on these. This may be due to consumers’ perceptions of the choices on offer and concerns regarding the algorithmic bias of the devices themselves (McLean etc, Rabassa et al 2022). This is reflected recently in Amazon’s moves to focus on ‘Matter’ a smart-home standard that will ensure greater inter-operation between different technologies and the Echo range of DVA’s[[15]](#footnote-15).

Other uses of DVAs are reported in more recent literature. Several studies have identified accessing music, hands free information retrieval and IoT control as the primary functions for which DVAs are used in the home (Ammari *et al.,* 2019). A more recent study indicates that in home environments selecting and operating media is the predominant application for DVAs, the authors go on to conclude that the applications and uses of these technologies have not been studied enough (Klein *et al.,* 2020). A longitudinal study of DVA use in people’s homes saw that their use to access and play music decreased over time while controlling IoT devices in the home increased over the same time period (Bentley et al., 2018). The same study also identified the top commands issued by users across the same period: these were “stop”, “what time is it?”, “pause” and “how much time is left” (Bentley et al, 2018). This may suggest that the longer they remain in a home environment, the more DVA’s become more embedded in the routines of a household as opposed to promoting new or novel activities. In a similar vein, a more recent study claimed that the success of home-based technology depends largely on the role it plays in supporting existing household routines rather than simply offering new functionality (Voit et al, 2020). These findings mirror similar findings in other studies, which found that within the home environment, DVAs are most commonly located in bedrooms followed by living rooms and then the kitchen, which may reveal a link between the behaviours commonly associated with these spaces and how humans use a DVA (Sciuto et al., 2018).

Despite the emphasis on ‘assistant functions’ across the literature, some studies point to more discretionary use by humans, for example what can be referred to as ‘ludic functions’ (Gaver *et al.,* 2004; Frauenberger *et al.,* 2020), which includes telling jokes, engaging in quizzes, playing word games (Lee, Lee and Sheehan, 2020). Such ‘ludic’ uses of DVAs during the COVID pandemic became a source of entertainment and a mechanism for socialising with people from the confines of one’s own home. The development of new functions that emerged during COVID contributed to younger children and those who had never used this technology before to begin to use DVAs and explore potential uses/possibilities. Much of the literature is focussed on the use of the technology by adults, some of the research pertaining to the interactions children have with DVAs highlights the ease with which they use the technology and novel means of interaction. In a study by Lovato & Piper (2015) children were found to use DVAs primarily for what were described as fun activities, including fact finding and seeking information about their immediate environment. The same study also reported that children engaged with the voice assistant as a communication partner (Lovato & Piper, 2019). Another study extended this analysis reporting that children attributed some mental or social attributes to the devices they interact with (Kuzminykh *et al.,* 2020). Furthermore, young children when using DVAs have a tendency to anthropomorphize the technology, that is to say; assign or attribute human-like qualities to the technology (Lopatovska and Williams, 2018; Festerling and Siraj, 2021a). Such findings suggest that younger children may grow to understand DVA and other technologies as social partners. For example, children will often seek to engage with these technologies using conversational patterns that mirror those that they will use in social encounters with their peers or with adults. However, adult apprehensions about very young children interacting with DVAs were also reported in other studies and highlighted concerns regarding the type of information and content that children might access and the risks that might be associated with making communication with other online users (Sciuto, Saini, Forlizzi & Hong, 2018). A greater understanding of how children assign mental or social attributes to DVAs in particular may potentially inform the development of more sophisticated, conversational models of human and technology interaction (Girouard-Hallam, Streble and Danovitch, 2021).

A growing body of research has focussed on examining the emotional connection that individuals make with DVA devices in their home and the impact such devices have on social and family life within the home (Purington *et al.*, 2017; Beneteau *et al.*, 2019). In exploring how smart speakers are integrated within a household and the resultant social rules that develop. A recent examination highlighted that the capacity to support ‘experimentation’ and ‘rapport building’ also ensured its long-term use in the context of a family home (Voit *et al.*, 2020). Furthermore, it would appear that the more a technology allows users to interact using typical social patterns the more accepted they are and the more they are used in home environments (Wagner, Nimmermann and Schramm-Klein, 2019).

## 3.3 Applications of DVA & IoT technologies for people with disabilities

There is an increasing number of studies focusing on the applications of DVAs in healthcare, rehabilitation, and education, for example, a study that sought to use a DVA as an element of a music-guided stress reduction programme where the functionality of a DVA could allow participants to personalise their own intervention (Siegert et al, 2022). The use of DVAs as a therapeutic tool for autistic children is also well represented, for example Safi et al’s recent study identifying their use as a tool to improve verbal and social interaction skills (Safi, Al Sadrani and Mustafa, 2021). Other studies have examined ways to exploit DVA technology to develop social-communication skills for autistic children (Tanaka et al, 2017; Porayska-Pomsta et al., 2018) and to maintain engagement in speech and language therapy during events such as the COVID pandemic (Kulkarni et al., 2022).

The time efficiencies that voice-based interaction offers over keyboard-based text entry also suggests that this technology may emerge as an alternative to voice-guided virtual keyboard commonly used by users who are blind or visually impaired (Bai et al., 2016; Bouteraa, 2021). Furthermore, the interoperability of DVAs with home based IoT technologies offer the potential to make hitherto inaccessible devices such as touchscreens usable and within the sphere of control of people who have a visual impairment (Vtyurina et al., 2019). One such study examined the use of DVAs to support individuals who are blind and also identified a number of outstanding barriers to their use including synchronizing the presentation of both visual and non-visual cues and challenges in recognizing names and interpreting complex commands (Abdolrahmani, Gupta and Vader, 2021). Further studies report on the development of bespoke DVA applications for those who are blind or have a visual impairment (Marvin, 2020). Similarly, McNally et al (2017) reported on the development of an educational DVA application supporting access for people with visual impairments to study texts, listening content and addressing basic queries. The literature draws attention to the fact that most of the currently available DVA technologies on the market were not designed with users with visual impairments in mind. They do however offer a platform for developers to continue developing and deploying specialist apps that offer functions that may be of benefit to users with specific needs including those with visual impairments (Weeratunga *et al.,* 2016).

The prospect of voice input and control of technology is of interest for anyone (including people with intellectual disabilities) who might have difficulties engaging with technology via keyboard or text entry or who might find reading text presented onscreen challenging. Feng et al (2008) highlights that young people with intellectual and learning challenges get less opportunity to use technology and as a result are often less likely to develop digital skills. Indeed, completing online tasks such as finding a recipe, booking a restaurant, or purchasing a concert ticket may be challenging for many people who have difficulty with remembering and understanding. Equally there those who may have difficulty spelling the words to enter a typical search bar (Lussier-Derochers, 2017).

A limited number of studies have examined the potential of DVAs for people with intellectual disabilities to access information and services from the web (Balasuriya *et al.,* 2018, Schloman et al., 2021). These explore the general potential of DVAs and the advantages that could be accrued through having access to internet-based information resources and to services (Chadwick et al, 2013). Other studies have looked at DVAs as a tool to help those with intellectual disabilities complete particular productivity tasks, for example, helping with concentration and attention (Mechling, Gast and Seid, 2010). Bespoke development of DVAs to provide assistive functions include a system to support voice-based information retrieval for those living with intellectual disabilities and declining cognitive functions (Baldauf *et al.,* 2018). Despite an absence of published evidence suggesting benefits that can be accrued by people with dyslexia by using DVA’s there are a number of web-based resources that suggest some practical ways in which these can serve as a functional support tool[[16]](#footnote-16).

Supporting older people is a feature of several studies. For example the development of a DVA app that uses the Amazon Alexa conversation agent to support information retrieval and control of smart televisions (Meliones and Maidonis, 2020). Amazon’s Alexa has also been used to support the well-being of older adults (Duque *et al.,* 2021) and as a cognitive assistant for those with dementia (Wolters, Kelly and Kilgour, 2016). Other novel applications of the technology for older people include helping support their management of Type II Diabetes (Balsa *et al.,* 2020) and assisting them avoiding sedentarism through monitoring and prompting for regular physical activity (Román *et al.,* 2021). Although some questions are raised across the various sources listed here as to the general accessibility of DVA technologies, a recent study did conclude that the devices most commonly found on the market can be used effectively by those with motor, linguistic and cognitive challenges given specific levels of residual cognitive and linguistic skills (Brewer *et al.,* 2018; Masina *et al.,* 2020).

Finally, the examples of the use of DVA or IoT technologies for those managing their mental health are more limited across the literature. In their systematic review of voice-based technology interventions for addressing chronic and mental health conditions, Berube et al (2021) found that three of the studies they reviewed used DVA’s to deliver interventions. These interventions centred on using DVA technology to provide those managing their mental health (Cheng, 2019) with opportunities to monitor symptoms (Maherjan, 2019) or provide up-to-date information about their condition (Ooster, 2017).

### 3.3.1 Smart Home Technologies

Much of the reported research pertaining to the use of DVAs and IoT technologies for people with disabilities and older people examines and explores its application in smart-home solutions. However, the application of technology, more specifically, natural language processing to control items’ domestic functions in a household pre-date the emergence of the IoT and DVAs. [[17]](#footnote-17)

Descriptions of how DVAs and IoT technologies are purposed and configured for use by those with different challenges have increased over the past number of years. [[18]](#footnote-18) For example, several studies report on how technology can solve common problems faced by people living independently in their home environment including safely closing, locking, unlocking and opening doors across a range of different conditions (Tajadod, Li & Hadaegh, 2021; Hannan *et al.,* 2022). Other work has focussed on the usability of DVAs and IoT technology when configured as a smart-home solution (Hugo *et al.,* 2021; Yadav *et al.,* 2021) and how to extend the technology to provide users with remote control of their system (Elçi, Yalçın & Ünaldı, 2021).

Studies examining what older people saw as their priorities for smart-home technologies found tasks like calling for help in emergencies, staying in touch with relatives and friends, monitoring their health status and controlling lights and home temperature as key (Ghorayeb, Comber and Gooberman-Hill, 2021). For people with disabilities and older people, connecting everyday objects and changing how we as human operators interact and engage with these offers a broad scope for future development of applications in several domains. This includes accessing information and services, manufacturing, logistics and transportation, eHealth, and smart-homes and cities. A review of IoT projects funded by the European Commission summarised some potential areas where emergent, networked technology might support people with a disability. These include:

* Seeking assistance and help from outside.
* Monitoring health conditions and identifying emergent health issues.
* Supporting the delivery of medication.
* Space automation – automatically adjusting the immediate ambient conditions, e.g., light, heat, ventilation etc.
* Intelligent transportation (Vasco Lopes, 2020).

However, developments in DVA and IoT technologies have not been universally positive. Criticism in the literature has highlighted that emergent IoT technology is being led by the emerging functionality of the technology rather than the expressed needs of users (Domingo, 2012; Ulloa, Prado-Cabrera and Cedillo, 2021). Designers and developers of smart-home technology are reported as taking a ‘utilitarian’ approach rather than actively focussing their design process around addressing the needs of people with disabilities (Turner et al, 2022, p. 4). Furthermore, a recent study has drawn attention to the fact that much of the research must be considered Anglo centric, in so far as many of the published sources are reporting on studies done with technologies that only provide English language conversational agents thus limiting their use by non-native English speakers (Saleh, Ahmed and Chyad, 2022). It has also been suggested that a more sophisticated leveraging of space and location awareness by technology would greatly improve the functionality and uptake of DVAs as a smart-home device. An example of this has been given as better integration of recipe information and hands free engagement in cooking routines resulting in increased uptake of devices in a kitchens (Sciuto et al, 2018).

Despite some of these concerns the literature highlights the potential consumer technology such as DVAs and IoT offer people with disabilities and older people. Research focussed on the assistive features and functionality of such devices appears to be increasing and offers manufacturers a potential roadmap for further expansion of their consumer reach amongst people with a disability and older people.

## 3.4 Ethical considerations

Despite the potential of technology for people with disabilities and older people there are many ethical concerns relating to the use of commercially available DVAs or IoT as assistive devices. The most prominent of these issues is privacy, which is our starting point; but discussions around privacy by no means exhaust the scope for ethical research. It is worth bearing in mind that the use of DVAs, such as Amazon Echo or Google’s Assistant, as assistive devices take place in a political and economic context. DVAs are designed for commercial reasons by massive corporations such as Amazon, Google/Alphabet or Apple. Such devices form an important element of the development of “surveillance capitalism” in which large companies compete for people’s data to better attract, keep, and direct users’ attention. The extent of the data gathered and the uses to which it is put is not easy to determine. This broad point applies to DVAs too: “the big tech firms are coy about exactly what they are planning to detect in our voices and why, but Amazon has a patent that lists a range of traits they might collect, including identity (*“gender, age, ethnic origin, etc.”),*health*(“sore throat, sickness, etc.”),*and feelings,*(“happy, sad, tired, sleepy, excited, etc.”)”*(Cox, 2019).

This section provides a brief overview of some of the most pertinent ethical issues relating to the use of DVA’s by persons with disabilities, beginning with privacy.

### 3.4.1 Privacy

To function, DVAs must be able to listen to users, thus introducing the circumstances whereby an individual’s privacy may be subject to threat. People have a right to privacy. This right is reflected in a number of international documents that enshrine privacy as a basic right by the United Nations (United Nations, 1948: art. 12; UNESCO, 2005: art. 7) and by the European Union (Council of Europe, 1997). As a result of DVAs’ capacity to continuously listen to users and to events in the users’ homes they can also record, store and possibly re-use a broad range of a person’s data. The data gathered by DVAs could be revealing of habits, preferences (political, cultural, sexual), psychological well-being, and physical health. The presence of DVAs with the capacity to gather huge amounts of aural data (all of which can be used to make further inferences), ensures that protection of informational privacy (i.e., concerns control over the amount of information available about the person, confidentiality, secrecy, data-protection, anonymity, and accountability) becomes a new burden on the user. Simultaneously, states, institutions, and individuals have a general obligation to respect privacy, which may generate duties (to regulate to protect privacy rights) on behalf of users of DVAs.

### 3.4.2 Informed Consent

Obtaining informed consent from users will be central in the widespread use of DVAs, or other such interactive technologies that actively collect user data. Whilst the value of informed consent has been recognised in medical ethics over the past few decades, it has recently entered debates around big data, data mining, and novel technologies (Eyal, 2012; Novitzky et al., 2014; O’Brolcháin & Cohen, 2019). There have been countless academic debates regarding the threshold of being sufficiently informed. However, a person has not been sufficiently informed when they have been deceived, lied to, or not been given full disclosure about their new circumstances. Beauchamp and Childress (2009) have written extensively on medical ethics and define informed consent as “an individual’s autonomous authorization of a medical intervention or of participation in research” (Beauchamp & Childress, 2009; p 122). Informed consent “is usually understood as informed, voluntary, and competent consent (Ahlin, 2018, p. 46). Depending on the data gathered from DVAs and the way in which that data is used (e. g. to gather medical information) informed consent is central in considering the use of DVAs. However, some persons with intellectual and developmental disabilities may have cognitive deficits meaning they cannot provide informed consent without additional supports, i.e., it might be impossible for them to understand aspects of what is being explained. For instance, a user might not fully grasp that the data they generate in using a DVA is going to be used by third parties. As is the case with terms and conditions associated with services such as online commerce, banking and other services the procedures around informed consent for commercially available DVAs may need to be adapted to accommodate these requirements.

The procedures around informed consent for commercially available DVAs may need to be adapted to accommodate these requirements.

### 3.4.3 Autonomy and DVAs

By offering a new paradigm for interacting with digital technology, DVAs present us with a capacity to influence their users, as such it can impact on their autonomy. Autonomy is often understood as the capacity for self-rule, the capacity of a person to make decisions for themselves (Cardol, 2004; Christman, 2011; Burch, 2017). DVAs can function to provide users with reminders (for medicines, appointments, exercises and so on); to make suggestions (things to do, purchases they might make, events to attend); and to organize aspects of a user’s life (Lindqvist et al., 2018; Smith et al., 2020). The data gathered can be utilized by the DVA to refine and improve the suggestions etc. offered to the user. In this sense, DVAs can be said to increase a user’s autonomy. Such convenience can be helpful and thus liberating – freeing up a person to spend more time pursuing their interests, allowing the user to be more efficient. Such information about health, habits, preferences and so on is extremely useful for those who can access it and those capable of utilizing it. This includes the very companies that currently lead in the development, manufacture, and commissioning of commercially available DVAs.

However, data gathered that can be attributed at an individual level to any person can also create the conditions by which it may become easier to manipulate and “nudge” them. Data gathered over a prolonged period because of a user’s interaction with home-based technology offer those with motive to manipulate, influence, or nudge the user in a variety of ways. Moreover, this can be tailored to be extremely effective at an individual level (Marteau et al., 2011; Robichaud, 2016; Simkulet, 2019). These issues are more prominent for users with Intellectual and Developmental Disabilities (or, indeed, cognitive decline) as people with intellectual disabilities have an increased risk of being manipulated by other persons (Patel et al., 2020). Such users may have a reduced capacity to query or ignore suggestions or nudges from the DVA. Increasingly, newer iterations of such devices offer ever broader mechanisms for presenting the user with such suggestions or nudges (e.g., smart nudges) (Karlsen and Andersen, 2022).

### 3.4.4 Bias

That a DVA might bias a user to make certain decisions or adopt certain positions regarding their lives by making suggestions, interpreting needs, and framing options for the user has been discussed under the heading of autonomy (Blumenthal-Barby, 2016). There is a further issue of bias that needs to be addressed: DVAs will be run by algorithms that may themselves be biased or may become biased due to being built using biased datasets. Specifically, in relation to disability, the possibility that a DVA will exhibit societal biases relating to people with disabilities must be guarded against (Wilson & Scior, 2015; Blumenthal-Barby, 2016). Alongside these risks of course is the possibility that widespread use of DVAs by people with disabilities will provide the commercial developers with opportunities to build more inclusive technology solutions through the collection of better data about the lived reality and diverse needs of this cohort (Smith et al. 2020). However, the heterogeneity of persons with disabilities will require great flexibility, adaptability, and understanding of the diverse needs and capabilities of this cohort. A theoretical solution would be to use data sets that did not contain such biases to develop the algorithms running DVAs (amongst other systems). Alternatively, algorithms could be screened for biases in a manner like checks on health products. Within the European context there is a legal impediment to certain types of data gathering. The General Data Protection Regulations (GDPR) prohibits the processing of special categories of data, i.e. processing of personal data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation (General Data Protection Regulation [GDPR], 2016: art. 5(1)). Given information about a person’s disability can overlap considerably with information pertaining to an individual’s health, it will be difficult to for commercially available DVAs to gather such data, while the cost of screening for potential biases may be prohibitive. A resolution to the issue of bias is not easily discernible.

### 3.4.5 Anthropomorphising and Deception

It has been suggested that groups, such as people with cognitive impairments are at risk of being deceived by social robotics (Sparrow & Sparrow, 2021); a similar risk likely exists for DVAs, as people with intellectual disabilities have been found to mentally model voice assistants as people (Balasuriya et. al. 2018). As has been highlighted earlier in this report (see Section 3. 2. 2 for further elaboration) users may come to anthropomorphise interactive technology such as a DVA, to the extent that they may come to view it as a companion or friend. This may mean that the user is less likely to protect information that in other circumstances they would keep private. Users might find themselves more inclined to trust DVAs than they would when dealing clearly and directly with a private commercial entity. This issue is again raised in both the literature review and in the discussions with participants who talk about the DVA in personal terms (see above). More broadly, there is a risk that users are being encouraged to deceive themselves regarding the nature of something like a DVA (Coekelbergh, 2012; Seymour & Van Kleek, 2021) i.e., they may be encouraged to view it as a “friend” or “companion” rather than simply as a device. This is in turn will raise issues around care, companionship, and friendship, i.e., is it possible to be “friends” with a virtual entity? Is a person’s need for companionship truly met via interactions with a virtual assistant? Such issues are extremely pertinent where cohorts at risk of being marginalised by mainstream society are concerned. There exists a scenario where a DVA begins to function as a friend or companion, to the extent that a user who, due to unchosen impairments and social conditions, struggles to participate fully in society, reduces their participation.

### 3.4.6 Justice

Questions of justice also arise in relation to DVAs. Justice is of course a complex idea with applications in ethics, public policy, and law. There is not space to outline all the varied theories of justice; instead, we will focus on the justice as being concerned with how people are treated, where justice is the basis by which conflicts amongst people with competing claims are resolved. Equality has become a major focus here, with some arguing that justice requires equality of some kind (Rawls, 1971; Nozick, 1974; Dworkin, 1981b, 1981a). This is particularly germane to people with disabilities, many of whom need atypical social arrangements if they are to live integrated and productive lives (Nussbaum, 2006; Richardson, 2006; Nussbaum, 2009; Harnacke, 2013; Wasserman et. al., 2015; O’Brolcháin & Gordijn, 2017). As such the fair treatment of people with disabilities might require additional resources raising issues of distributive justice. Additionally, fair treatment requires that all people are treated as morally equal, which may in turn have practical implications. If it is the case that a DVA or similar can play a positive role in helping people with disabilities live integrated and productive lives, there exists an argument from fairness that they should have access to such a device. Given the continuously increasing importance of the digital world, DVAs are likely to be an important aid to people with disabilities and older people (for instance, bridging the digital divide). That DVAs might have practical real-world benefits for people with disabilities (in terms of setting reminders for appointments, socialising, playing games and quizzes, etc.) and practical digital world benefits (helping those with disabilities access the digital world) raise issues of distributive justice. Those with access to DVAs might gain significant benefits (i.e., greater autonomy); carers will also experience benefits (potentially in terms of reduced workloads). If DVAs are only available to those who can afford them extant inequalities amongst persons with disabilities will be exacerbated.

### 3.4.7 Technological Dependency

All people are vulnerable to the risk of technological dependency, but the risk increases the more a person is reliant on a device for helping with daily tasks and routines. Take for example the importance of routine and habit for successful activity performance by a person who may have experienced a cognitive disability because of a brain injury (Lamontagne et al, 2013). Old habits and routines (e. g. navigating a house in order to lock doors and windows) can easily be lost if new technologies (such as DVAs) make such activities obsolete. But recovering such habits in the event of even a temporary loss of the DVA is difficult. On a societal level, there may be a risk that collectively we come to rely on DVAs (or technology more broadly) instead of other means of achieving independence for people with disabilities or older people. As such, while we should celebrate and maximise the potential of DVAs and assorted technological innovations, we should guard against dependence on them.

## 3.5 Summary

This review serves to provide a background to the overall examination of the application of consumer technologies such as DVAs and IoT for people with disabilities and older people. It also details how the functionality inherent in this technology is currently being leveraged by not only people with disabilities but also manufacturers, the research community and service providers. The application and functionality of DVAs and other technologies including IoT, and smart-home technologies has been accelerated by developments in the wider technology ecosystem. An examination of the current literature reveals the complex role-played consumer technologies as assistive technology. Analysis of the most recently published sources suggests that consumer devices such as DVAs offer features that fall within the scope of the functions of assistive products and services. In many cases the features and functions are classified as only contributing to ensuring that the device is accessible to users or have been developed with a prescribed set of pre-determined functions. A clear trend that emerges from this review is that development of bespoke solutions for specific segments of the user market (such as those with specific disabilities) are waning as a greater understanding of the usability of such devices by broad sections of the population emerges. Extending the scope and potential of DVAs through the addition of third-party products, including emerging technologies and innovative software such as IoT offers the potential for more comprehensive assistive solutions to support the participation of people with disabilities and older people in their homes is emerging. There are market-driven and commercial factors fuelling the continued development of the technology and an increasing focus on engaging as broad a range of consumers as possible. The ethical issues associated with the manner in which more and more consumer devices harvest, store and re-use personal data does require further consideration, particularly in determining if there are additional threats for people with disabilities and older people. As technology systems become ever more complex it is likely that this ethical landscape will become less clear and will require ongoing debate. Issues such as algorithm bias, artificial intelligence and recent developments in large-language modelling such as the ChatGPT[[19]](#footnote-19) chatbot look set to challenge those who seek assistive solutions for people with disabilities and older people. Nonetheless, researchers continue to exploit the functionalities proffered by these devices for people with disabilities, older people and those with functional restrictions that limit their participation in chosen activities. There is an expanding range of applications emerging to support the participation of people within their own home.

# 4.0 Study 1: A qualitative examination of the experiences of people with disabilities and older people using Digital Voice Assistants and Internet of Things technologies.

## 4.1 How the study was conducted.

As outlined in Section 2 of this report a total of ten participants were identified to participate in Studies 1 and 2 reported here. Each participant was contacted by telephone and was asked to complete a short, online survey gathering demographic and personal details about each participant and their home environment (see appendix F). A link to this online survey was sent to each participant by a member of the research team following conclusion of the introductory phone call. During these phone calls arrangements were made to visit six of the participants in their homes with a view to conducting a semi-structured interview and to install the equipment identified for the field trial. The remaining four participants indicated that they could not accommodate a visit to their home in the time available and as such, were contacted by telephone in order to arrange a time to conduct a semi-structured interview via Microsoft Teams. This phone call was also used to discuss arrangements for the delivery of the technology for the trial period and installation arrangements[[20]](#footnote-20). These ‘first round’ interviews aimed to collect participant data on their:

* understanding and knowledge of DVAs and other voice-controlled home technologies.
* previous experience in using technology, specifically DVA or other voice- controlled technologies and
* expectations of their use of such technology in their own home environment.

The interviews typically concluded with a free conversation about the research project and a discussion of the practicalities of the further stages of the study including technology installation and commissioning. Researcher field-notes were recorded throughout and are maintained securely and confidentially. The typical duration of interviews was between 35 and 65 minutes (mean = 51. 7 minutes) and were recorded using the researcher’s secure audio software. Audio to text transcription was conducted using Microsoft Stream with the research team checking for accuracy and correcting mistakes made during the automated transcription.

Each participant was called by telephone approximately one week after completion of the pre-trial interview to ascertain if all technology was functioning correctly and where necessary to provide telephone support. These calls were not recorded but field notes were kept by the researcher. A further, scheduled phone call was made to all participants during the six-week trial period with field notes recorded by the research during these. Over the course of the trial participants were encouraged to contact the research team in the event of any challenges or difficulties. During the course of the trial three participants made contact by e-mail and a further one participant telephoned a member of the team. All of these contacts were either to make an enquiry to clarify times and dates for scheduled phone calls or to ask about moving technology from one room to another in their homes.

Following conclusion of the field-trial period using the technology all participants were interviewed a second time using Microsoft Teams. An individual schedule for each of these interviews was designed by the research team following the first round of analysis conducted after the initial interviews. The purpose of the second round of interviews was to extend the data collected regarding:

* Individual participant’s experiences using DVA and IoT technologies installed for the field-trials.
* The impact using a DVA and associated IoT technologies had on their participation in the home and in community activities.
* Barriers to use, unanticipated benefits and concerns about privacy and security.

As with the first-round interviews, these ‘second round’ interviews took a semi-structured approach aimed at collecting each participant’s experiences and their perspectives of using the technology installed during the six-week trial period. The same researcher that conducted the initial interviews acted as sole interviewer for the second round of interviews. In the interest of time all interviews were conducted online using Microsoft Teams and were recorded using the secure recording function of that software. Each of the interviews during the second round of data collection were between 29 and 53 minutes in duration (mean = 46. 7 minutes). All interviews were transcribed using Microsoft Teams and Microsoft Stream with all identifiers removed to anonymise the transcripts. Transcription for the second-round interviews was conducted by two members of the research team who were not involved in the interviews, and they were responsible for preparation of the data for analysis by both lead authors in this work.

## 4.2 Who participated in the study?

All participants met the inclusion criteria that guided recruitment for this study, therefore all participants are reported as adults living in their own home.

Table 4.1: Summary of Environmental Context for Participants

| Participant Number | Pseudonym | Age | Gender | Context[[21]](#footnote-21) | Dwelling Type[[22]](#footnote-22) | Numbers in the Household[[23]](#footnote-23) | Broadband[[24]](#footnote-24) | Home DVA in situ prior to field trial |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | Paul | 44 | M | URBAN | APPT | 2 | 100Mbps | NO |
| 2 | Henry | 36 | M | RURAL | HOUSE | 2 | 100Mbps | YES |
| 3 | Jim | 51 | M | URBAN | HOUSE | 4 | 355Mbps | NO |
| 4 | Sam | 26 | M | URBAN | HOUSE | 1 | 500Mbps | YES |
| 5 | Colin | 28 | M | URBAN | APPT | 1 | 100Mbps | NO |
| 6 | Jack | 31 | M | RURAL | HOUSE | 1 | 24Mbps | NO |
| 7 | Mary | 71 | F | RURAL | HOUSE | 7 | 100Mbps | NO |
| 8 | Geri | 49 | F | URBAN | APPT | 5 | 100Mbps | NO |
| 9 | Joanna | 30 | F | URBAN | APPT | 2 | 100Mbps | YES[[25]](#footnote-25) |
| 10 | Jackie | 67 | X[[26]](#footnote-26) | RURAL | HOUSE | 1 | 50Mbps | NO |

There was a mixture of rural dwellers (n=4) and those living in urban centres (n=6). The ten participants represent a total of nine homes or dwellings[[27]](#footnote-27). Similarly, four of the participants lived in apartments or in an independent dwelling within a larger housing complex. The remaining six participants live in houses ranging in size from one-bedroom, single storey dwelling to a five- bedroom, two storey home. Of the participants, four reported living alone predominantly while six were sharing their home with others. These others included spouses (n=2), siblings (n=3), their children (n=2), grandchildren (n=1) and one other reported that they have a rota of paid, formal carers staying with them on an ongoing basis. All participants had broadband coverage with the majority (8/10) reporting service of up to 100Mbps as per their contract with their internet service provider. Three reported that they have or had a DVA in their home for their own use. Of those participating, six identified as male, three as female and one did not identify as either male or female. The average age of participants was 43.3 years, and the median age was 40 years. Seven reported that they were in employment, three of which were determined to be part-time or short-term employment. Of the remainder, two indicated that they were retired and one reported that they were working in the home. As part of their self-completed survey participants were asked to complete an exercise to indicate if they perceived themselves to have a functional limitation such that they are aware that it impacts or can impact their ability to perform certain tasks or participate in activities.

Table 4. 2: Participants Reported Activity Limitations

| Participant Number | Mobility | Vision | Hearing | Self-Care | Communication | Interpersonal Skills | Work Skills /Tolerance | **Memory/**  **Thinking/**  Cognition |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 |  | **√** |  |  |  |  |  |  |
| 2 | **√** |  |  | **√** |  |  |  |  |
| 3 | **√** |  |  |  |  |  |  |  |
| 4 |  |  | **√** |  | **√** | **√** |  |  |
| 5 |  | **√** |  |  |  |  |  | **√** |
| 6 | **√** |  |  |  |  |  |  |  |
| 7 | **√** |  |  |  |  |  | **√** |  |
| 8 |  |  |  |  | **√** |  | **√** |  |
| 9 |  | **√** |  |  |  |  |  |  |
| 10 | **√** |  | **√** | **√** |  |  | **√** | **√** |

Table 4.2 presents a visual representation of this exercise and highlights that half of the participants indicating they had a limitation in mobility that hindered their activity participation. Three self-reported that they had a visual impairment while two participants separately considered that difficulties with hearing, communication, and their memory, thinking and cognition impacted their participation in activities. Finally, two participants indicated that their activity participation was limited by their self-care with one highlighting interpersonal skill as the issue.

## 4.3 Findings

This section presents the findings of analysis of data gathered during the first round of interviews conducted before the technology trial in their homes and a second round of interviews conducted following completion of the six-week trial period. The findings also incorporate data gathered via survey with participants prior to their initial interview which has also be used for the purposes of triangulation.

### 4.3.1 Study 1: Overall themes and subthemes.

The thematic analysis yielded three major themes with several associated subthemes that will be discussed through the next sections of this report. All extracted themes and subthemes are presented in the table below. The table has been structured such that the major theme is presented in line with its associated sub-themes. Each of the sections describe the major themes alongside the sub-themes that make up each of these. Pseudonyms are used and no personal details are identified throughout this report.

Table 4. 4: Extracted themes and sub-themes

| Major Theme | Sub-theme 1 | Sub-theme 2 | Sub-theme 3 |
| --- | --- | --- | --- |
| 1. What happens when we bring technology into homes? | 1. 1 “Keeping a home a home” | 1. 2 “Owning technology; different things to different people” | 1. 3 “Feels like we always did it like this” |
| 2. All the things we can do | 2. 1 “The power of discovery” | 2. 2 “The unexpected uses that emerged” | 2. 3 “It’s not just me: how technology fits in household routines” |
| 3. Finding a role in a household and family | 3. 1 “Talking about talking to technology” | 3. 2 “A strong sense of presence” |  |

4.3.2 Theme 1: “What happens when we bring technology into homes?”

Participants in this study expressed opinions regarding the ‘place’ that DVA and IoT technology took within their home environments. These discussions revealed a broader series of the factors that impact the decision making that people with disabilities and older people have regarding decisions to purchase, install, use, and continue to use technology in their home.

#### 4.3.2.1 Sub-theme 1: “Keeping home a home.”

Participants demonstrated how they valued their homes and how important it was for them to take time to make clear and considered decisions about what technology to “bring into” (Jim[[28]](#footnote-28): Interview Round 2) their home. Some participants talked of a long history of using technology, in particular reference was made to the size of assistive technologies previously used (Jim: Interview Round 1). It was interesting to note that the reports were in the main, negative, and highlighted a dislike for technology that was large, took up a lot of space or was not to the person’s aesthetic tastes:

“…it used to take up most of the room, I had a large box as well that had all the bits in it that took up the whole corner of the room. I was very conscious of it and just thought it looked terrible and that for anyone visiting it was all you could see and was just embarrassing….” (Jim: Interview Round 2)

In their descriptions about using the DVA and IoT technologies, participants’ reports revealed a shared understanding that technology is getting smaller and their expectations that it should fit unobtrusively within a family home. They mentioned that this was of particular importance if your functional limitations were such that you required additional technologies that, by their nature took up space in a home:

“…. if you have a house full of wheelchairs and hoists, the last thing that you want is anything else taking up space, we always worry here that it will just become clutter” (Henry: Interview Round 2).

#### 4.3.2.2 Sub-theme 2: “Owning technology; different things to different people”.

The issue of owning technology or being in possession of technology emerged as a common theme for participants. They spoke of the importance of having the technology, having the right to have it in their home and of having the agency to do with it as they desired. They also spoke of how, regardless of the technology in question that the value of technology was in how you could choose to use it in a way that mattered to everyone. In general, there was a sense across the participants that using technology in a highly prescribed way, particularly if that way was recommended by the person supplying the technology. Participants valued the choice that was offered via technology and were also aware of how those choices were seen or valued by others including those outside of their home:

“. . . there is no way that a [technology prescriber or supplier] would ever think about providing someone in a wheelchair with something to change the channels on the TV, they prioritise the more basic things. Sometimes all you want to do though is change the channels on the TV, at any minute in my day that might be the most important thing to me….” (Mary: Interview Round 2).

This sub-theme also highlighted participant’s views on challenges with ownership of technology and in particular issues with cost and affordability.

“…doesn’t matter that you can buy it out of Argos, it’s still expensive for people, not as expensive as it was, but that doesn’t matter to you if you haven’t worked or can’t work” (Geri: Interview Round 2).

They also reported on what they considered challenges for people with disabilities and older people using these technologies. They communicated their concerns that the fact that the technology was considered a ‘mainstream’ technology (in some instances several participants referred to the technology as ‘high-end’ or ‘luxury items’) that there would be difficulties for traditional health services to fund the purchase of such technology for people with disabilities and older people.

“…many of us still depend on the equipment to be provided to us, we know it is our right so why would we have to pay for it, the trouble is that it is someone else that decides if and what we need, but no, I wouldn’t be rushing out to buy one of them just to have it” (Sam: Interview Round 2).

The challenge with cost, ownership and affordability also highlighted the previous experience of technology use those participants brought with them to this study.

#### 4.3.2.3: “Feels like we always did it like this”.

Despite many participants highlighting their lack of experience using new technology in their homes during the course of the first round of interview, some expressed a collective sense that the technology installed in their homes established some routines that became familiar very quickly. Performing tasks like switching on/off lights in a room using voice was described as “effortless” (Paul: Interview Round 2) and “incredibly easy” (Joanna: Interview Round 2) such that the routine of doing that task changed quite quickly.

“…it was only after a couple of days that I was so used to saying, “Alexa turn on the living room light’ that I really forgot that I used to have to hit the switch, I think I might even forget where the switch actually is, there’s no going backwards” (Joanna: Interview Round 2).

They elaborated on the point about how new ways to do tasks and activities incorporating the technology very quickly replaced the way they had done the same tasks over many years.

“I was never a fan of the routine at night of going around checking the plugs, but it was a habit. I’m doing it now without stooping down and it’s as easy before bed just to shout out to Alexa and check, you get used to that very quickly when you get the better way, don’t you?” (Sam: Interview Round 2).

This sub-theme suggests that the ways in which the suite of technology allowed participants to modify the ways in which they performed existing tasks and activities in their home allowed new, easier routines to emerge and consolidate patterns by which they performed activities at home.

### 4.3.3 Theme 2: “The things we can do.”

The second major theme to emerge “the things we can do” reflects not only the feedback from participants as to the new opportunities for engaging with tasks and activities using voice, but also it reflects the playfulness that they expressed in getting to know and use new technology. This theme highlights not only what study participants found that they could do with DVAs and IoT technologies but also the enthusiasm that they had for learning to use the new technology and uncover its boundaries and limitations as well as its possibilities.

#### 4.3.3.1 Subtheme 2. 1 “The power of discovery”

This sub-theme reflects the journey described by participants as they got to know their technology, what it did and how best they could adapt to its presence in their homes. Participant’s spoke of the nature of using voice as a means of accessing and using the technology:

“…. It does feel strange at first, my initial reaction was to look for a button that I should press or something…” (Geri: Interview Round 1).

During the first round of interviews participants who had previous experience using a DVA in their homes described during the first round of interviews using their voice as; “very natural” but required “a bit of getting used to” (Henry: Interview Round 1).

The process of ‘getting used to’ using their voice to control their technology was echoed in the responses gathered during the second round of interviews after participants used the DVA in their homes during the trial period. Some participants described their initial impressions as “sort of embarrassing” (Joanne: Interview Round 2) and making them feel “very self-conscious” (Paul: Interview Round 2). Participants who were new to controlling technology using their voice described the process of learning to use it as “a matter of getting used to it” (Jackie: Interview Round 2) and a process that “didn’t take too long” (Paul: Interview Round 2). Other participants were more specific stating that “a day or two and I was definitely used to it and think I knew what I had to do” (Jackie: Interview Round 2).

Despite initial reservations however, many within the group clearly stated that using voice to use technology aided their ‘discovery’ (Jim: Interview Round 2) and provided a novel means of ‘learning’ (Paul: Interview Round 2) how to use the technology. Some stressed that the conversational nature of the interaction was such that it was like having a “training partner” (Mary: Interview Round 2) or an “on-site teacher” (Mary: Interview Round 2) as they became accustomed to using the equipment provided and began to consider the use of their voice as “intuitive” (Paul: Interview Round 2). Participants highlighted the novelty of finding new functionalities in the technology and an enthusiasm for finding it themselves:

“…it sounds silly, but I was so chuffed with myself that I had figured out how to find and install the skills that I wanted to use, mainly because it was completely new and nobody ever had to tell me what to do, it was wonderful really…” (Sam: Interview Round 2).

Participants who had previously used similar technology spoke of the value of rapid updates and newer iterations of the same technology and how this provided them with more opportunities for discovery:

“…. It changes so fast, even though the [previous technology used] is only about three or four years old, what it can do now is very different, that’s the value in this tech, companies the size of Amazon don’t sit still, they’re changing products up all the time and mainly for the better….” (Jim: Interview Round 2).

#### 4.3.3.2 Sub-theme 2.2 “Unanticipated uses”

This subtheme represents the descriptions by participants to the ways in which they discovered that they could use the DVA and IoT technologies in their home that they had not considered previously.

During the first round of interviews the participants expressed a range of functions and activities that they hoped the technology would serve, much of which was general in nature including “just making things easier about the house” (Geri, Interview Round 1) and “give me more independence” (Mary; Interview Round 1). Those that had previously used the technology were somewhat more specific with some expressing the hope that “I’ll learn how to get the best out of [the DVA]” and to “get my head around how all the home-tech can help” (Sam, Interview Round 1). In the first round of interviews those that had previous experience using DVA’s expressed an interest in exploring the smart-home functionality that would be available to them. Despite this in their follow up interviews they tended to focus more on the additional uses of the DVA rather than the IoT installed for the trial. During the second round of interviews following the trial participants, in general, appeared more interested in sharing some of the novel, quirky uses of the technology rather than what one would imagine are the most ‘functional’ (Henry: Interview Round 2) in a home environment. Participants’ described ways in which they found uses in their home routines for functions they encountered with using the DVA. For one participant who discovered that they could remotely control their living room lights by linking their smartphone app with the DVA in their home, he described how he would then switch the lights in his home on and off when his family visited relatives. The reason for doing this was explained as; “…it’s better than having and alarm on the house, anyone thinking of breaking in will think again if the lights are going on and off…” (Mary: Interview Round 2). In similar fashion, another participant spoke of how the timer function was employed with her teenage son who had challenges concentrating on school-work and other tasks that require a degree of focus and attention skills. She described how they would both agree a time for tasks, how they would agree a reward (a music track from Spotify or YouTube) and they would set the timer accordingly. Once the task had been successfully completed, the DVA would check that it was and would then play the reward as anticipated.

There are other examples of how participants and others in their household used the technologies available, these were focussed mainly on the DVA such as a ‘hub’ for family entertainment. One participating household reported that they were informed by friends of themed quizzes that they could download as Amazon Skills. [[29]](#footnote-29) For those that discovered the extensibility of the device when the relevant ‘skills’[[30]](#footnote-30) were downloaded there was a sense that they began to think that the possibilities in terms of using the technology were “endless” (Joanne: Interviews Round 2) or restricted only by one’s “imagination” or “what it is that you can do at home” (Joanne: Interviews Round 2).

#### 4.3.3.3 Sub-theme 2.3 “It’s not just me.”

A strong sub-theme that emerged, particularly through the second round of interviews was of the group communicating a shared belief that the technology presented benefits to others within the household and that people with disabilities or older people may not necessarily be the primary beneficiaries. One participant who lived alone and quite a distance from other family members described how his daughter felt the benefit of being able to speak to him via the DVA:

“…once her husband set it up that my Alexa could talk to her Alexa it was like a load lifted off her shoulders, she said being able to talk to each other just like that was like ‘we’re in the same room’…. That’s what she got out of it”. (Paul: Interviews Round 2).

Similarly, participants described that benefits they accrued were shared, particularly for other family members:

“…. I do know that using Alexa for the lights is mainly for me being able to stay in bed at night and not have to call someone to switch them off, but it really works for my carer [name removed] who gets me up in the morning, she just says it and they go on……” (Sam: Interview Round 2).

One participant spoke of using the DVA to play games and quizzes with their family:

“…Harry Potter is an obsession in this house and not just for the kids, so we do this pub-quiz thing from the Alexa, and she asks the questions and keeps score…it’s been a bit hit and miss. The first time for me that anything has come into the house for me that is of any interest to the rest of them….’ (Jack: Interview Round 2).

Participants also reported that as the devices provided a functionality and utility to others within the household it made them less conscious of the ways in which they used the technology to address some of the functional limitations that they experience in their home.

The opportunities afforded by the DVA specifically those that provide access to information was highlighted as a benefit both to the person with a disability or older person participating in the study and others in the household who might fill the role of carer. One participant described how he would work with a new carer to find information online about medical issues that he experienced:

“…. It’s a lot easier to just say ‘Alexa tells me about… [a specific condition] … and then the two of us can listen together and chat afterwards. Before I would start to explain once a new person started, and it was boring for me explaining and boring for them listening. When Alexa says it, it has some authority!” (Colin: Interviews Round 2).

This function of using the DVA to access information also highlighted the value of such technology for a whole family beyond just a member with functional limitations. One participant who used a wheelchair to support their mobility described how when he goes out to visit a new location with his daughter that she used to become anxious about how accessible a venue might be. He described how using the DVA to ask questions and gather information about a venue could “at least put her mind at ease a little bit”. (Henry: Interviews Round 2). However, other participants commented that some information that might be of relevance to others in the family might not be readily available:

“…well, an example might be about whether or not there is a toilet that I can use, which is great for me, but for [name removed] who has to do the driving, there’s nothing about parking spaces that we can throw the van in, he hates that.” (Jack: Interviews Round 2).

Nevertheless, these findings demonstrate a utility for the technology for those with functional limitations living in the home. Moreover, analysis of the data further recognises that these provide opportunities for other household members as well as presenting a more holistic system for supporting the person diagnosed with a condition or disability.

### 4.3.4 Theme 3 “Finding a role in a household and family.”

The third theme captures the opinions and perspectives of participants about how they understood technology such as a DVA or IoT’s would fit within a home environment and within the realities of living in a household with others. Most of the participants in this study lived with family or others some of which had functional limitations and others who did not. They spoke of the challenges in the past in making a home and the process of differentiating the space from others that they had used and experienced, particularly for those that had spent time in hospital or other care facilities. They spoke of introducing technology in a home environment that; “is homely, not just grey and medical, no to beeping boxes” (Mary: Interviews Round 2) and how the technology should help a household function and not just focus on assisting one household member. They spoke of the positives of when they felt the technology had become integrated within their home life, while also expressing some concerns with its long-term use within their homes.

#### 4.3.4.1 Subtheme 3. 1 “Talking about talking to.”

Many participants described how they felt that the DVA and associated IoT’s had become integrated and accepted as useful in their homes. There was a sense that household members had to get beyond seeing the ‘novelty’ (Jackie: Interviews Round 2) in the technology and focus on the functions that it offered. Some described how they became aware that the novelty with which they viewed the technology had somehow passed when, as a family they ceased to have conversations about what they might have said to the device and what sorts of answers were presented back to them. Participants reported how much of the time-period in which they considered that the technologies were ‘bedding into’ (Colin: Interviews Round 2) a person’s home was taken up by checking and double-checking what was asked of the device, what feedback was provided by the device and how accurately it may or may not have responded to requests for information or to instructions given. Some of this was explained as a process by which everyone in the household built a collective trust in the device and understood how it might fit into the routines that they performed. Some, however, reported that this process of household members talking about the use of the devices, the DVA helped to ‘find a place for Alexa in the family’ (Paul: Interview Round 2). They stressed the importance of this process and how they anticipated it contributing to the longer-term use of such technology:

“…you work out quickly what it might do, but then you’ve to figure out together how best it can do that, and it changes as well, for example, we figured out quickly that Alexa had to be in the kitchen during the day to be of any use to everyone….”. (Paul: Interview Round 2).

Furthermore, participants reported speaking to each other about “how we use the Alexa” (Geri: Interview Round 2) as a way of building their collective knowledge about how the devices could be used. It is this social dimension of discussing new devices and learning how to use these that contributed to:

“…. All of us getting used to having it in the house and getting the benefit out of having it there” (Jim: Interview Round 2).

During the second round of interviews, once participants had lived with the technology for a few weeks, they began to describe the technology, specifically the DVA as “something you get used to very quickly” (Joanne: Interviews Round 2). Two participants went further to say that the DVA soon came to be understood as “…a member of the family, almost like we got a pet” (Colin: Interviews Round 2). This highlights a growing sense from participants as to how technology can establish a ‘presence’ within a household. This will be elaborated upon further in the next sub-theme.

#### 4.3.5.2 Sub-theme 3.2 “A sense of presence.”

During the first round of interviews participants who had previous experience with DVA technologies in their homes tended to describe their devices in terms of the functions that they performed. However, following the trial period in this study most participants commented on the ‘presence’ of technology such as a DVA within a home environment and how they perceived this presence to be. Some participants reported they just; “know that she’s there and available” (Sam: Interviews Round 2), while differentiating DVA’s from other technologies in the home:

“…it’s different, not like things like the hoist or things like in the bathroom or the kitchen, even the remote control, I think it is the fact that she talks back to you….” (Sam: Interviews Round 2).

Interestingly, several participants described the multi-dimensional nature of this presence. Firstly, it was almost entirely referred to in a gendered fashion as ‘she’ (Paul: Interview Round 2), ‘her’ (Joanne: Interview Round 2) even, ‘herself’ (Jack: Interview Round 2), it was only with one participant that the DVA was ever referred to as ‘it’, or ‘that’ (Geri: Interviews Round 2). The DVA was never referred to in the masculine, which should be of no surprise as all participants used the technology with the standard female voice feedback option. Secondly, all the technology together was described in terms of having ‘power’. This power referred to a quality described by most participants that the technology as a whole could ‘just do things’. Even though participants were aware that they were controlling the device via their voice, they still attributed a degree of agency to the device particularly for smart-home functions such as turning household items on/off or controlling things like entertainment:

“. . . you could easily get dependent on it for plenty of things like switching on the TV at the mains and getting started on whatever it is you want to watch…” (Henry: Interviews Round 2).

Similarly, participants described the technology in terms of having a personality or perhaps having particular ‘states of mind’ (Jim: Interview Round 2) that determined how effective it might be at any time. For example, one participant reported how: “sometimes she’ll only do what you want if she’s in the mood for it” (Paul: Interviews Round 2) or “depending on how you ask her, please and thank-yous are important….” (Joanne: Interview Round 2).

Some participants spoke of a comfort in knowing that the technology was in their home and their awareness that it was there:

“…. Once you get used to it, you know that it’s there when you need it, you might not talk to it all day, but if you want something you know where it is”. (Paul: Interviews Round 2).

Similarly, others mentioned the ‘on-demand’ (Jim: Interview Round 2) nature of the devices:

“…. Mostly you don’t need to switch on lights until the night-time, but it’s still a good thing to have the choice that if you needed to, you’re not just restricted to using it at particular times of the day, like we were when we used timer and things like that…” (Jim: Interview Round 2).

However, participants’ perceptions of the ‘presence’ they experienced with DVAs and associated IoT technologies was not consistently positive. Some spoke of concerns about “what she might be listening to” (Colin: Interviews Round 2) and described being alone in a room with the technology as “unnerving” or “a little weird” which they ascribed to the device “always being on” and “always listening in” (Jack: Interviews Round 2). Some participants did go on to say that this was something “that you get over after a while” (Mary: Interviews Round 2), but did leave them with a long-term, unresolved sense that: “…. You never quite know do you, is she listening or not, I guess that she has to be if she’s waiting for commands, but you wonder don’t you? It’s not something that I ever thought too much about, but the longer it is here, the more you wonder” (Paul: Interviews Round 2).

Despite no substantive concerns about the technology being expressed by participants during the first round of interviews, participants did, following completion of the technology trial, communicate their concerns with the privacy and security implications of the always on nature of the DVA technology:

“I think the longer it [the DVA] was there I had more chance to think about it listening in, particularly sometimes when she’d light up for no reason, I’d say “that’s her now, we’d better keep quiet” or something” (Geri: Interview Round 2) and “I wondered about the camera on them, they could just be in record mode all the time or someone could take control of it, like you’ve heard of it happening” (Jackie: Interview Round 2).

Further examples of the participants’ concerns post technology trial included additional costs associated with using the technology, including “what the bills will look like” (Jack: Interviews Round 2) highlighting the ease with which electrical items in the home can be switched on and operated. Participants, in the main, described practical concerns with the technology such as what the impact of “electrical faults” or “changing service provider” (Jack: Interviews Round 2) might have on their continued use of the solution rather than on any issues that might pertain to the security of information or the harvesting of their personal data.

## 4.4 Summary

Study 1 was a qualitative study that examined the experiences of a group of people with disabilities and older people as they used a range of consumer digital technologies comprising a DVA and IoT devices. From analysis of the data gathered including recorded interviews collected, before and after the installation of DVA and IoT technologies in participant’s homes, a series of themes and sub-themes were extracted. A total of three themes with eight sub-themes emerged from the thematic analysis of the data gathered during the two rounds of interviews. These themes and sub-themes are discussed further in section 6 of this report.

The themes and sub-themes have highlighted how the technology that featured in the trial quickly became integrated within peoples’ homes and households. Participants reported that the ‘mainstream’ nature of the products and the fact that they were not specifically a product for people with disabilities contributed to the ease with which they were integrated into homes. The findings suggested that this, mainstream appeal contributed to device aesthetics that focussed on fitting into the home rather than to a specific person. Another feature that appears to have supported how the technologies were accepted by participants was the relative ease with which installation occurred and the fact that the DVA in particular provided an easy way in which new functionality could be discovered or uncovered simply by using the technology.

Further analysis highlighted the importance of voice control, not just for those with a disability or older people, but for others in the household as well. It was felt that communicating with technology also meant that more people in the household could use the technology. In this study different members of a household used the same technology, but for different reasons. These experiences, however, equipped them to better support each other in continuing to discover new ways in which the technology might be used. The findings also indicated that people with a disability and older people are drawn to use these technologies based on the options provided to easily control items within the home, namely using the DVA to access the smart-home functions offered by the IoT technologies. However, these were not the only functions participants were interested in and it became clear that the patterns by which the technology was used was very much dependent on the existing routines and behavioural patterns in a home or household.

These findings will be considered further in Section 6 of this report and examined alongside the findings of the second study in this report and with the literature previously reviewed

# 5.0 Study 2: A Q-Methodology exploration of the perceptions of people with disabilities and older people as to the potential and risks associated with using consumer technologies.

The second study in this research project used a Q-methodology to examine the perceptions of people with disabilities and older people about the potential and risks associated with the use of consumer technologies. This facilitated an examination of the opinions of the 10 participants in this study and aggregated these into related clusters also referred to as factors.

## 5.1 Study preparation: development of Q-set

The development of the Q-set for this study was guided by the process outlined by Sheldon Gen (Gen, 2020). This involved starting with a series of statements that could be included in a Q-set. These statements were extracted from the literature examined and reflected some of the key issues that emerged from the analysis (see Section 3 of this report). Another source from where statements for the Q-set were drawn included the grey literature pertaining to the growth in use of DVAs and IoT and opinions as to the benefits or otherwise to people with disabilities and older people. A final source from which the statements were extracted were the anonymised transcripts of the first round of interviews in Study 1 (as described in section 2.2.4). A total of 27 statements were generated during the research workshop scheduled at the end of the first round of data gathering in Study 1. See Table 5.1 below for a list of the original twenty-seven statements that were used to make up the final Q-set used in this study.

Table 5.1: List of Q Statements Generated

| Number | Statement | Source |
| --- | --- | --- |
| 1. | I worry that companies will be able to listen in on me in my home | First Round Interviews: Study1 |
| 2 | I believe that DVA technology collects data from those who use it | Grey Literature/Internet Resources |
| 3 | Companies should respect the privacy rights of individuals | (GDPR, 2018) |
| 4 | Ensuring the privacy of people with a disability should be of paramount concern to technology developers | (Cobigo *et al.,* 2020) |
| 5 | It is my right to decide what data I share about myself with others | (GDPR, 2018) |
| 6 | People with a disability should be afforded additional data protection rights than the general public | First Round Interviews: Study1 |
| 7 | Individuals should take greater responsibility for the personal data they share online | (Hargittai and Marwick, 2016) |
| 8 | Large corporations are not interested in a single individual’s data | First Round Interviews: Study1 |
| 9 | The data of people with a disability may be more susceptible to breach | First Round Interviews: Study1 |
| 10 | The developers of internet technologies such as DVAs are motivated by the opportunities offered to collect user data | Grey Literature/Internet Resources |
| 11 | Technology such as DVAs offer affordable assistive functions for people with a disability | Grey Literature/Internet Resources |
| 12 | DVAs will play a role in supporting the participation of people with disabilities | (Purington et al. 2017) |
| 13 | There is less stigma associated with using DVAs for people with disabilities | First Round Interviews: Study1 |
| 14 | Controlling technology using your voice is beneficial for those who have disabilities | (Park et al., 2019) |
| 15 | The cost of technology is a significant barrier for people with a disability and older people | First Round Interviews: Study1 |
| 16 | Corporations such as Amazon and Google consider the needs of people with disabilities when designing technologies | Grey Literature/Internet Resources |
| 17 | There is a risk that using voice-controlled technology will be replaced by new technology in the medium term | First Round Interviews: Study1 |
| 18 | New technologies for people with disabilities are likely to emerge from the development of commercial, mainstream technologies | Grey Literature/Internet Resources |
| 19 | Using a DVA and other Smart-home technology helps me control my home and live independently | First Round Interviews: Study1 |
| 20 | Using technology at home will help people with a disability depend less on others | First Round Interviews: Study1 |
| 21 | People with a disability will be more secure in their homes if they have an accessible means to control that home and communicate with others | First Round Interviews: Study1 |
| 22 | DVAs and IoT technology offer affordable assistive technology for people with disabilities even if they have limitations | First Round Interviews: Study1 |
| 23 | Using internet-connected technologies poses risks to the security of people with disabilities | (Schlomann et al., 2021) |
| 24 | There is a need for more information specific to how people with disabilities can use mainstream technologies such as DVAs or Smart-home technology | (Schlomann et al., 2021) |
| 25 | New technologies such as DVAs are not yet reliable enough for people with disabilities to depend on | Grey Literature/Internet Resources |
| 26 | People with disabilities do not feel safe using the voice interface technologies | Marzin (2019) |
| 27 | Support from others is required to set up technology in their home | (Smith et al., 2018) |

During this workshop the statements were devised by both main authors from the resources mentioned, however researchers’ field notes were examined for elaboration of each of these. Through discussion amongst the research team statements that were deemed too alike with merged with others or excluded. All researchers discussed the generation of statements and were satisfied that statements represented the information represented on the topic in the sources. Furthermore, statements that were confusing or contained too many elements for a reader to consider were also adjusted or if this was not possible, they were removed from the final Q-set containing 22 statements.

Once the Q-set comprising the piloted statements were finalised they were prepared for sorting by the study participants. To streamline this process and support remote data collection an online software application Q Sort Ware™ ([https://www. Qsortware. Net/](https://www.qsortware.net/))[[31]](#footnote-31) was used by the research team to upload and arrange the 22 statements so these could be presented to participants for ranking. The final Q-set presented to participants for ranking is outlined in Table 5. 2.

## Table 5.2: Final Q-Set presented to participants for ranking

Table 5.2: Final Q-Set presented to participants for ranking

## 5.2 Who participated in the study?

This study utilised the same sample of people with disabilities and older people as was the case in Study 1. As this study aimed to examine the perceptions and beliefs that this group held with regard to the use of DVA’s and IoT technologies by people with disabilities and older people the experience that they had gained during the technology field-trial (described elsewhere in this report) was considered invaluable. Participants were informed of the nature of the study prior to the commencement of the field trials and were told that they would be contacted to schedule an online, semi-structured interview where they would be given the opportunity to rank a series of statements pertaining to the use of the technologies that they were trialling.

## 5.3 How the study was conducted.

As detailed in the previous section, the final Q-set comprised a total of twenty-two statements extracted from sources and represented perceptions and beliefs about the use of DVA and IoT for and by people with disabilities and older people. The next stage of this study required that each participant rank these statements in a manner that best represented their own perceptions and beliefs.

To do so, all participants were contacted after four weeks of trialling the DVA and IoT technologies in their own homes. Each participant was offered a date for an online interview. It was explained that this interview would involve ranking a series of 22 statements and discussing some issues pertaining to the use of the technology they had on trial. In each online interview a researcher presented the Q-sort to participants using the Q-sortware™ software and asked that they rank each of these based on whether they 1) strongly agreed, 2) agreed, 3) disagreed, 4) strongly disagreed or 5) they felt ‘neutral’ about each statement.

In each interview the Q-Sort was displayed on-screen shared between the researcher and participant using Microsoft Teams[[32]](#footnote-32). All statements were read to participants by the researcher, and they were asked to rank each one. Once the participant had indicated their preference for ranking the researcher selected the appropriate rank displayed on the Q-SortWare[[33]](#footnote-33). This ensured that the process of ranking each statement with participants was more efficient and less prone to error. By selecting each participant’s rank-orders for the statements the Q-SortWare software transformed these to numerical data by placing each statement along a scale from Agree Strongly (+2) to Disagree Strongly (-2). Neutral perspectives on each statement are ranked as 0 (zero). This data was then exported as CSV file and exported to SPSS ver. 24 statistical analysis software.

Furthermore, participants were asked, if possible, to describe why they ranked each statement in that way. These interviews were recorded using Microsoft Teams and were transcribed using the transcription facility in the software and Microsoft Stream which were further supplemented by the researchers notes.

## 5.5 Findings

Data analysis was conducted using the SPSS Version 24 software and all quantitative data gathered using Q-SortWare™ software was uploaded by a member of the research team. Using the statistical software data from all 10 completed Q-sorts were firstly correlated with each other to create an intercorrelation matrix. Using SPSS, the correlations between ranked statements were calculated from this matrix providing insight as to how statistically similar each of the variables (in this case the ranking of each statement) are to each other. This yielded that a significance of p<0.05 could be used to further identify other statements that could be determined to be closely related.

The matrix was then analysed using factor analysis (Principal Component Analysis, PCA), a statistical technique which groups the statements and by extension the opinions of participants into smaller clusters based on the similarities in how they were ranked by the participants. PCA sorts the correlated data into ‘families’ or statements where the Q-sorts or rankings are similarly correlated. These ‘families’ of statements that have been determined to be ranked similarly by participants are referred to as factors. In using SPSS with the data from the correlation matrix a total of three factors or clusters of statements were extracted.

Table 5.4: Factors and Statements following PCA.

| Factor | Statement |
| --- | --- |
| Factor 1 | 12, 13, 14, 17, and 18. |
| Factor 2 | 1 ,2, 6, 9, 10, and 18 |
| Factor 3 | 3, 4, 6, 11, 18, 21 and 23 |

The three factors accounted for 18 of the original Q-set of 22 statements with the remaining 4 not demonstrating significant enough correlation to any of the others. Table 5.4 below outlines the overall weighted-average rank position of each Q-statement for each of the extracted factors:

Table 5.5: Calculation of variance across factors

| Extracted Factor | Variance (%) |
| --- | --- |
| 1 | 26. 1 |
| 2 | 8. 21 |
| 3 | 12. 69 |

### 5.5.1 Findings: Interpretation of Factors

Factor analysis of the completed Q-sorts yielded three factors or clusters of statements. Interpretation of these clusters was finalised using qualitative analysis of the discussions conducted with participants during the sorting exercise while considering the positions of the various statements across the three factors.

#### 5.5.1.1 Factor 1: The appeal and benefit of DVA and IoT for people with disabilities

Several statements featured in this cluster focussed on the participants’ general opinions of the benefits of using DVA technology alongside IoT. It should be noted that the representation of statements in this factor is lower than the other two, however they are best clustered together rather than with either Factor 2 or 3 below. The qualitative data analysed also indicated that the participants as a group communicated the benefits, they accrued in using the technology. Furthermore, qualitative data indicated that participants were keen to highlight that their positive experiences could also be generalised to others with disabilities.

12. DVAs will play a role in supporting the participation of people with disabilities

13. There is less stigma associated with using DVAs for people with disabilities

14. Controlling technology using your voice is beneficial for those who have disabilities

17. Using a DVA and other smart-home technology helps me control my home and live independently

#### 5.5.1.2 Factor 2: Concerns with privacy and the motivations of technology manufacturers

This cluster of statements highlighted participants’ concerns with privacy and the risk that their data was being gathered by third parties while they used the technology. Moreover, there was a sense communicated in the rankings of individual statements that there was a general mistrust of large corporations and their motivations to develop and place consumer products on the market that could be of benefit to people with disabilities. Statements that featured in this cluster included the following:

1. I worry that companies will be able to listen in on me in my home

2. I believe that DVA technology collects data from those who use it

6. People with a disability should be afforded additional data protection rights than the general public

9. The data of people with a disability may be more susceptible to breach

10. The developers of internet technologies such as DVAs are motivated by the opportunities offered to collect user data

#### 5.5.1.3 Factor 3: Balancing risks with benefits

The third factor that emerged following analysis highlighted participants’ consideration of the benefits and the risks associated with using these technologies. This included an understanding that the affordability of the technology provides more opportunities for people with disabilities. However, there remains a requirement for support and training to ensure it is used successfully. Two participants suggested the technology might work better for people who co-habited with others and highlighted the long-term benefits of having such support at hand. One participant highlighted a concern with an over-reliance on technology in situations where a person’s safety may be at risk and suggested that this must be considered in situations where a persons living circumstances were at risk of changing. The following statements featured very positively in this factor/cluster:

11. Technology such as DVAs offer affordable assistive functions for People with a Disability

18. Using internet-connected technologies poses risks to the security of people with disabilities

21. People with disabilities do not feel safe using the voice interface technologies

23. Support from others is required to set up technology in their home

## 5.6 Summary

The three factors emerging from this, small-scale, Q-methodology study represent exploratory findings regarding the perceptions held by participants in this study regarding the benefits and risks they associate with using technologies such as DVAs and IoT in their homes. They highlight the awareness that participants had as to the appeal of using the devices made available to them during this research. Participants articulated those technologies such as DVA’s and IoT present opportunities for increased autonomy and safety in their homes at a lower cost than traditional AT. Moreover, they also recognised the continued need for support that is required to maximise the benefits that can be accrued. The mainstream nature of these technologies and their availability for the general market was seen as less stigmatising than using other forms of specialist technology. However, concerns were expressed by the participants in this study that the benefits of using these technologies must be weighed against the potential risks to their privacy. Finally, this group of participants expressed a concern that the developers and manufacturers of these technologies may not be giving adequate attention to the needs of people with disabilities and older people, particularly when it comes to the securing of personal information.

# 6.0 Discussion

## 6.1 Introduction

This section presents a detailed synthesis of the findings from the literature review in this research project alongside the empirical findings for studies 1 and 2. The overall aim of this project was to explore the assistive potential of a range of digital consumer technologies currently available as mainstream products aimed for use by the general population. Studies 1 and 2 aimed to examine the perceptions of people with disabilities and older people with regards their use of exemplar technologies in their home, including a DVA and IoT smart-home technologies. Furthermore, the studies that comprised this research explored some of the concerns that people with disabilities and older people held with regards the risks they may experience in using such a range of technologies.

## 6.2 Benefits for all, but not all equally

The review of literature presented in section 3 of this report provided a glimpse of some of the benefits that can be accrued by people with a disability and older people using DVA and IoT technologies. Findings from both studies reported in sections 4 and 5 echo many of those in the literature, in particular how these technologies support participation in home-based activities such as entertainment, information retrieval and control of their environment. Furthermore, the findings in study 1 and 2 suggest that for those who experience limitations of function in their homes such as people with disabilities, the benefits gained from using these technologies is amplified relative to the general population. For example, study 1 highlighted how the presence of a DVA and some IoT extended the activities participants engaged in within their homes. This is explained by the findings from study 1 that pointed to how existing barriers for using many home-based technologies may be overcome by configuring technology for control by voice. In study 1 the benefits that voice control technology offers everyone in a household are clearly evident, however, the benefits to those who previously found it difficult or indeed impossible to use existing technology controls was found to be greater. As such efforts to make technology more usable by the general population yields greater dividends for those who are currently most challenged in terms of using these technologies.

Much of the literature to date has focussed on examining the application of smart-home technologies for particular categories of user, for example those with intellectual disabilities (Balasuriya et al., 2018), for older people and those with progressive cognitive challenges (Schlomann et al., 2021) or those who are blind and have visual impairments (Marvin, 2020; Murugesan & Balajiraja, 2019). For research examining how technologies work together, particularly the combination of mainstream voice control with IoT, findings from study 1 presented in section 4 of this report has shown that inquiry focussed on the interaction between a single individual and the technology may overlook the complex nature of the relationships users in a household have with technology, with each other alongside the variability of need that different members will have at any time. Some of the themes emerging from the qualitative data in study 1 highlight how technology offered different opportunities for different members of a household. Findings from Study 2 showed that the value of people with disabilities and older people using mainstream, consumer technologies is that they present a flexibility of function for different users. This flexibility of use and function would appear to contribute to what can be described as the ‘cross-over’ success of these technologies. For people with disabilities and older people both study 1 and study 2 indicated that there are additional benefits to be accrued from leveraging the assistive potential of these mainstream products. In particular the very fact that they are not intended solely for use by people with disabilities offers that very group a less stigmatising experience and does not serve to highlight or reinforce their sense of having a disability.

## 6.3 The place of DVA and IoT in the home

A finding in this study that does not appear to feature across other studies is the way in which the presence of a DVA in a home became the focus for social engagement between members of the household. Descriptions of discussions of ‘Alexa’ almost as another member of the family or household may be similar to the ‘personification’ that Purlington et al described in their work (Purington et al., 2017). Although in other studies the anthropomorphizing of the device was seen as characteristic of children’s engagement with these technologies (Festerling & Siraj, 2021), this study would seem to suggest that it is a more nuanced, social process. In this study, it appeared that the ‘personification’ of the device emerged naturally from the social conversations about using device. Participants in this study described a series of meta-social explorations where they spoke to each other about what they spoke to the device about. In this study participants described how many of these meta-social explorations involved understanding how questions were answered, how accurate information was, how commands were executed. Such conversations could be suggestive of users of DVAs first and foremost understanding these devices in terms of what it was that they did with users engaging in a process of checking or validating if the device is indeed doing what it is supposed to do. As such, it is important to recognise that although users view devices as objects that act on their behalf, they differ entirely from other technologies and other assistive technologies in that they also perform as social agents. This undoubtedly is an outcome of the nature of engaging with a device that is structured to provide a conversational experience. It could be speculated that not only is it the personification of the device that contributes to its acceptance in the home and its continued use (Wagner et al., 2019) but rather it’s the complex social discourse that it promotes and encourages. Similarly, Zhang et al (2021) in a recent work highlighted how trust in the technology encourages and facilitates its continued use.

This process of ‘talking about, talking to’ a device in the home environment may also contribute to another feature described by participants in this study; that of attributing a sense of presence to the device. This can be considered a further expression of the process by which users personify an inanimate device, in this situation, an interactive digital technology. It was interesting to note in the study that participants described a very tangible ‘presence’ once with which they reflected that they responded to at an emotional level. For example, for some participants the associated feelings and emotions about this presence were negative and focussed on their discomfort with not knowing exactly if or when the device was or was not listening to them. On the contrary, some participants, those that had set up their device for hands free voice calling or room to room communication described feelings of reassurance that the device provided them with the opportunity to engage with others without feeling that it needed to be acted upon. This reflects somewhat, the findings of Gummerus et al (2019) when exploring the emotional consequences of engaging with technologies that use conversational agents for interaction. Further, recent work (Zhang et al., 2021) also highlights the social and emotional dimensions of engaging with a device but stops short of further exploring users’ relationship not only with the device itself but with the abstract representation they form through using it.

For older people, people with a disability or those living alone there may well be hitherto un-recognised opportunities to design technologies that will not only provide functional support in domestic, home situations, but might also serve to provide that social support that long been the ambition of those charged with developing new generations of care-technologies (Koh et al., 2021).

## 6.4 Making Life Easier

The most significant benefit of using DVA and IoT together was simply that it made using smart-home technology easier. Participants were less concerned with what it was that they could do but were more interested in describing the ease with which household tasks could be performed. For the most part, participants highlighted the value of the DVA in this regard, considering the IoT technologies as part of the infrastructure of their home. The ease of operation of the devices opened possibilities for doing activities on a repeated basis without concern for effort, fatigue, or risk. These opportunities to engage in different ways to control home-based appliances via the connectivity and control afforded by the DVA and IoT technologies installed were lauded for the novelty that they provided. An example of this included describing the pleasure that ‘channel surfing’ with one’s voice presented.

Participants described an inherent pleasure not just in completing a task that might previously have been difficult or impossible, rather they described the value they accrued from simply doing the task. It should be stressed that the reduction in activity effort that was ascribed to using the smart-home solution was not limited to the physical domain, rather, participants identified reductions in cognitive effort through not having to remember particular sequences for using multiple television remote controls and in one case where the benefits of keeping lists of shopping as the week progressed removed a range of both requirements to memorize items, write them down, find notebooks and organise the list ahead of shopping. Reducing activity effort constitutes an important element of activity performance for people who may have limitations that present performance challenges. It has been reported elsewhere that in some circumstances efforts to make activities possible far outweigh efforts to make activities easier (Elgendy et al., 2019). Study I highlighted the capacity of people with disabilities and older people to ‘discover’ new functionalities and options when presented with technology that offered accessible means of control such as by voice, as is the case with DVA’s.

Despite the positive regard with which participants in these two studies held the DVA element of the smart-home solution there was criticism of the feedback provided with individuals with different functional needs expressing a desire for better status information to be provided by the device. For example, two participants with visual impairments suggested that perhaps the reason they were not given feedback as to when lights were on or off was because there was an assumption that they would not require control of lights. A simple solution they suggested was that the control system provide voice feedback indicating that the lights were on or off. This, however, was an issue that was more generalized and not restricted to one area of functional limitation and highlights the fact that the feedback from technology may be as important as how it is controlled. Further exploration of how technology developers build user feedback within systems as has been highlighted in the studies here and elsewhere as factor in ensuring greater use of technology (Peña Novoa et al., 2022).

## 6.5 Not quite ‘out of the box’

The findings across both studies conducted as part of this research reflect some of the concerns and issues that have accompanied the uptake of consumer technologies by people with disabilities and older people. Many of these concerns raised by participants in the studies reported here are similar to those that have emerged in studies of specialist AT as well. For example, challenges with setting up the technology (Smith et al., 2018), the need for support and maintenance (Cruz et al., 2016) and training in ensuring that the device or devices are used to their optimum (Scherer & Federici, 2015). Findings from study 2 highlighted that maximising the benefits that any technology can offer requires a degree of support with set-up, ongoing use and maintenance. The degree to which this support is required for consumer technologies however is less than is typically required with specialist AT and can often be sourced from a person’s personal and social network. As indicated elsewhere, people with disabilities and older people who use technology rely on a network of enablers and supporters who facilitate not only their immediate use of the devices they have but also provide a platform for the development of skills which serves to further improve their use (Bennett et al., 2018). Furthermore, the proximity of support emerged in this current work as participants perceived that home-based technologies such as DVA’s and IoT could work better in busier households where a broad range of skills and supports is more immediately at hand. Once study participants overcame installation and set-up of the DVA and various IoT technologies, participants in this study fell into a similar pattern of usage as has been reported for the general population.

## 6.6 Exploring new opportunities with home-based technologies.

These patterns of overcoming initial concerns and early challenges with set-up before becoming accustomed, relatively quickly to the presence of the technology in the home featured in the findings of Study 1 are similar to those described in a recent study of using commercial, mainstream technologies as alternatives to AT (Ding et al., 2021). Although early reporting in this study described patterns of use that were primarily focussed on the DVA for accessing short, fact-based information and services such as finding out the time, news, weather in their area and the time participants’ interests quickly shifted to the IoT technologies. Interviews with participants in study 1 highlighted the value participants place on using the smart-home functionality and how their attention quickly focussed on this range of functionality for them. Starting with access to entertainment such as music, television and downloading content from service providers such as YouTube.

Patterns of using the technology to control home-based items such as lights and plugs were very much influenced by where the technology was originally located. Despite the size and portability of these devices, it was interesting to note that for the most part participants did not move these devices from room to room. Instead, they quickly became associated with a particular room and with the functions of that room. For example, some participants asked that the smart plug sockets be placed in their bedroom to control a bedside light alongside a smart lightbulb in the room as well. Over time participants tended to choose one over the other, typically favouring the smart lightbulb but then not moving the smart socket to another location or function. The relationship between the perceived functionality of a device and its location is echoed in other studies (Bentley et al., 2018; Terzopoulos & Satratzemi, 2020). This suggests a potential direction for further developments with DVAs in particular that would see functions optimized based on location information.

Findings from study 1 in particular, also highlight how the technology came to be embedded within the existing routines of a household. In many services, delivery models are designed ensure that a single user is equipped with the technology to perform a specific range of pre-determined tasks. The findings in these studies suggest that finding a technology that reflects the routines of a household may be as important as identifying what the best fit for a single user might be.

## 6.7 A question of definition – what makes assistive technology or technology assistive?

It is worth noting from the outset that the literature describing what it is that people use DVAs for is focussed on what has been described as the ‘assistant’ functions. Although these also feature in the findings from this study, participants did provide a valuable context for these ‘assistant’ functions. Functions such as setting alarms provided insights as to the routines of a household and the patterns of how participants occupied particular spaces at different times. For busier households alarms were tied with functions such as cooking or doing homework and reflected the balance for families of managing a busy household. Older participants described alarms for helping to wake up in the morning or to serve to remind them of events or activities during the day. The alarm itself often highlighted where a person might spend the most time during the day, whether it was in their bedroom or the kitchen or other living space depending on what the perceived function of the alarms might be. A suggestion that revealed quite a bit about how participants perceived the value of such assistive functions was that alarms could or should be personalised. Extending this technology in such a way would open opportunities to further assimilate the routines of the day in a household within the technology. Suggestions that some alarms could be associated with voice messages providing reminders for taking medication, arranging appointments, or preparing for visitors to the home could serve to add a further layer of cognitive support to those who may require such. Although this is a suggestion that emerged informally through this study, it hints at a broader perspective that if adopted could potentially guide the direction of future development for home based DVAs. While not specific to DVAs, a study from 2018 suggested a model by which Information and Communication Technology could be used to promote well-being in families (Trilar et al., 2018). The artificial intelligence capacity could be harnessed to support individuals and families to off-load a degree of the cognitive load required to function successfully in domestic situations. Such ‘cognitive sharing’ with objects in the environment is in the tradition of work on human-computer interaction by Ed Hutchins and Gavriel Solomon (Hutchins, 2006). In these circumstances, however, it could be that this distribution of functional cognition that the ‘assistant functions’ of DVAs offer could also provide a degree of mitigation for those with intellectual disabilities and for those with progressive deterioration in memory or executive function.

Much of the literature features the ‘assistant functions’ with less focus on the ‘ludic functions’ that may be offered through using DVA technologies. In study 1 in particular, such ludic uses featured richly in the descriptions of how participants spoke about exploring and using the technology as well as understanding its functions. Many of what could be described as ludic functions took the form of playful ways of pushing the boundaries of what participant’s expected a technology to do. Participants discussed how they would challenge themselves to find questions or tasks that they could set for the DVA that might generate answers or responses that might be considered by the user as incongruent or unexpected. There was a comic element to these interactions, insomuch as users responded to the DVA responses relative to how outlandish or at times how inappropriate they might be considered. This function did appear to contribute to users’ acceptance of the DVA and could be a feature in ensuring the long-term use of such technologies. This appears to be an area of study for human-computer interaction hitherto overlooked and could be worth consideration for future work examining the design of technology for use across different usage situations and conditions (Benazzouz & Boudour, 2021).

It is certainly worth considering from this study if we, as a community of professionals and users of assistive technology, have perhaps focussed too much on the functional benefits that can be leveraged for use by people with disabilities and older people. This study provides a glimpse of the benefits that can be accrued through a more playful approach to the functions of technology and how it can serve to engage and maintain interest in its use. Although this study was of a short duration, a longer consideration of the ludic functions of technology such as with DVAs may unearth new ways in which design can be informed. This may also provide an insight as to how future assistive technologies can be designed in such a way as to offset the risk of its abandonment by users’ (Sugawara et al., 2018).

## 6.8 Do the benefits of consumer technologies come at the cost of privacy?

Findings for the Q-methodology in study 2 of this report make it clear that people with disabilities and older people are aware of concerns that are held by the general population with regards the capacity that technologies such as DVA’s in particular have to collect, store and re-use personal data. In exploring the perceptions held about the potential threat to a person’s privacy while using such devices responses by participants in this study suggested that they believed that people with disabilities and older people could be considered a more vulnerable group than others in the population. The also made it clear that they perceived that manufacturers and developers were not motivated by a willingness to be aware of or meet their specific needs. Qualitative data gathered during study 2 suggested that there may be an expectation by people with a disability and older people that manufacturers of technology, even that developed for a mainstream market should do more to address the specific privacy issues of this group. This raises ethical issues similar to those already highlighted in some of the literature reviewed and presented in section 3 of this report. The clear benefits that mainstream consumer technologies can offer must be considered alongside some of the risks that may be posed for all users of the technology and careful consideration given to how issues such as privacy, justice and autonomy are understood and responded to (Kuo, 2015).

## 6.9 The relativity of affordability

In exploring the perceptions that people with disabilities and older people held with regards to the consumer devices they trialled, study 2 highlighted how participants acknowledged the value of having technology at a price point that is significantly more affordable than specialist AT. The barriers to technology use that are brought about due to cost are well acknowledged as is how affordability constrains not only the services and technology that are available but also limits the full and optimal utilisation of that technology (Federici & Scherer, 2017). Participant responses recorded as part of study 2 reported here acknowledged that their perceptions about the affordability of DVA’s and IoT was in some part informed by their experience using technology over a number of years and their dependence on statutory funding to access such technology. However acute the issue of technology affordability is in developed, industrialized nations, when considered in a global context it appears that the debate about cost has not even begun. For many of those in developing nations the prospect of being able to afford such technologies as are referred to in this study is not a realistic prospect in the short or medium term and ways must be explore by which this gap can be bridged (de Witte et al., 2018).

Despite calls by the Chief of the World Health Organisation for all countries “to fund and prioritize access to assistive technology”[[34]](#footnote-34), it remains to be seen what efforts will be made to address the acknowledged gaps in knowledge and awareness, policies supporting availability and affordability that exist to varying degrees across high-, low- and middle-income countries (Botelho, 2021a; World Health Organisation & United Nations Children’s Fund (UNICEF), 2022). Notwithstanding these challenges, some suggest that the changes required will be brought about by developments in new technologies and the evolution of function and operation that reflect an awareness of a population with broader, more diverse needs. Others suggest that how we use technology and what we use it for will be determined primarily by the functionality offered rather than any legislative or policy-based approach (Raja, 2016)[[35]](#footnote-35).

The point has been made that the availability of smartphones, tablets and other devices such as DVAs and IoT technology that are discussed here do indeed “offer features that allow them to function as assistive products” (de Witte et al., 2018, p. 408). In this work however, the point is made that despite the relatively low prices of such technologies they often remain outside the affordability reach of people with a disability and others who may benefit from the features they offer. Many of the participants in study 1 discussed the cost of technology and raised interesting questions about the place for mainstream consumer products within traditional medical device provision systems for people who may benefit from these.

Considering how recently technologies such as Google’s Hub or the Amazon Echo have entered the market it is likely that those features that do serve to function as assistive products will become a more apparent selling point for the device. As this happens and as awareness of their utility to segments of society such as older people and those with disabilities increases, questions will emerge as to how they can be made available to those that serve to benefit the most from using them. Recent work on using a concept referred to as an Assistive Technology Passport that began in Ireland in 2016 has started to gain traction on an international scale as a possible mechanism for bridging the affordability gap for technologies for people with disabilities and older people (Long et al., 2017; Maalim et al., 2019).

## 6.10 Conclusion

Despite the rapid acceleration of functionality of DVAs and its increasing availability for people with disabilities and older people, significant ethical concerns remain. This summary exploration of the ethical issues likely to arise from widespread use of commercially available DVAs in disability contexts suggests that there are several areas that should concern interested parties, as well as some significant benefits. To maximise the benefits and minimise the harms associated with DVAs, these areas need to be explored in more detail. A fuller ethical exploration of the issues could serve to inform future recommendations that will benefit users, institutional policymakers, manufacturers and legislators.

Nevertheless, as is evident from the two studies that make up this report, there is a need for more research to be conducted in this area. As such, this research offers a platform for further work in this important area of interest. In a European context an ongoing evaluation of the economic costs, benefits, and liabilities of technology use for people with disabilities and older people appears set to continue for the foreseeable future (Albala et al, 2021). In a changing consumer context where people with disabilities and older people have choices to supplement, augment or indeed replace specialist AT with consumer devices, research that considers these processes from an economic perspective will be welcomed by funding agencies and service providers alike. This research also highlighted some of the benefits that can be accrued by people with disabilities and older people beyond simply meeting the needs that are associated with their own circumstances. Additional uses for technology such as DVA’s emerged in these studies, for example the playful, entertaining, and ludic activities. These additional uses further demonstrate ways in which people gain additional pleasure from engaging with technologies that they have available for use in their proximal environment. Such uses merit further examination and consideration and may offers opportunities to explore mechanisms by which designers can find new means by which long-held challenges such as technology abandonment could be addressed and overcome.

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# Appendix A: Technology ‘Configuration Report’

Planning Document 2: Final Technology Profile for Fieldwork

January 2022

Study Title: A user-centred exploration of the assistive potential of Digital Voice Assistants for People with Disabilities in Ireland.

## Introduction

The purpose of this short report is to outline the technology configuration and the resultant research questions that will underpin the fieldwork component of the above-named project. Both researchers would like to extend their gratitude to the Cliona Doherty, James Hubbard, and Donal Fitzpatrick of the National Disability Authority for reviewing and discussing the various options outlined in the “Planning Document 1: Technology Profiles for Fieldwork” (January 2022). Following a thorough discussion and consideration by both researchers it is proposed that the focus for the research be fixed on.

1) exploring the assistive potential of Digital Voice Assistants in supporting information retrieval and communication tasks for People with Disabilities,

2) examining the assistive potential of Digital Voice Assistants in providing Smart Home solutions for People with Disabilities and

3) increasing our understanding of the privacy concerns specific to People with Disabilities using Digital Voice Assistants.

## Selection considerations

Based on the revised research aims above, it was clear that the technology required for installation would comprise both a Digital Voice Assistant device and a range of compatible Smart Home technologies.

A further set of constraints however were considered in planning regarding the final fieldwork configuration, namely:

Cost: an upper limit of approximately €200 per participant was the working budget identified at the outset considering that this would allow a total of 10 fieldwork sites to be included.

Assessment of Need: the provision of an assessment of need prior to installation was considered but ruled as outside of the scope of the project and had the potential to incur risks and additional work for the assessment team including the need for additional documentation such as individual assessment reports.

Ease of installation: technology was selected based on ease of installation, thus reducing the travel demands made of the research team and minimised the ongoing maintenance and support requirements of the participating People with Disabilities.

## Revised fieldwork technology

Each installation will comprise the following technology:

Amazon Echo Show Version 8

The Amazon Echo Show 8, originally released in 2019 it comprises an 8-inch touchscreen that could be used to display visual information to accompany its Alexa generated audio output as well as to play streaming video and make video calls. Amazon updated the Echo Show 8 in mid-2021 to the improved 2nd generation version which includes an integrated camera. This device typically retails around €149.

2 Philips Hue Smart Light Bulbs

The Echo Show range of smart displays has a built-in Zigbee smart-home hub, meaning that it can be configured to set up several smart-home devices that aren't Wi-Fi-enabled, such as Phillips Hue's smart bulbs. And it’s much easier to set up devices, including Smart Mains Plug Sockets with the Show than it is with some other hubs, such as Philips Hue’s Bridge.

2 Amazon Smart Mains Plug Sockets (Tapo P100 Mini Smart Wifi Socket or equivalent).

A smart socket works with any WiFi network. Paired with Amazon Alexa or Google Assistant it can be controlled using voice commands. Management can be shared beyond the Digital Voice Assistant for use by other members of a household with the Tapo app. The socket and app feature an Away Mode to provide additional security and safety where it automatically turns devices on and off at different times of day.

It is anticipated that the cost of one installation of the presented technology will be under the budgeted €200 and will provide a degree of Smart Home functionality for participants including switching on/off lights across two locations in their home and managing the power supply to plug-in electrical appliances. Although not a bespoke Smart Home installation that has been individualised for participants, it has been determined that this will serve to provide participants with functional exemplars of how commercial technologies may be configured for use by People with Disabilities.

## Revised participant sampling

The inclusion/exclusion criteria for this phase of the research were revisited further based on the discussions with the review team at the NDA.

Although the partnership with the Community Hub for Assistive Technology would be leveraged to support recruitment to this research it was determined that a purposive sampling method would be required to ensure that a representative sample of functional need could be ensured across the participant sample. This approach will allow the research team to maximise the needs diversity across a small sample. To ensure this is the case the World Health Organisation International Classification of Function (ICF) will be used to inform the inclusion and exclusion criteria for this phase of the research. Further considerations will be included to ensure ease of participation for participants including some of the technical requirements including participant’s having existing wi-fi connectivity in their homes.

## Summary

This report presents an overview of the commercial technology selected for the fieldwork proposed as part of this overall research study. It is anticipated that the technologies will be purchased before the end of March 2022 to facilitate installation and the commencement of preliminary data gathering in early April 2022. The technology will then be in-situ for the various rounds of participant interviews and data gathering through April, May and early June with the final review interviews scheduled for June 2022. Progress will be reported in the monthly reports that will be provided to the NDA team over the next few months.

Again, we would like to thank all of those at the NDA who contributed to the reviews and discussions that have informed this report. Further discussion and comment are welcomed and will be incorporated by this research team.

Bryan Boyle & Fiachra O’Brolchain on behalf of the UCC/DCU Team

*Revised February 2022.*

# Appendix B: Workflow Diagram – Literature Review

Workflow Diagram – Literature Review

# Appendix C: Search Criteria – State of the Art Literature Search

* Databases/Catalogues Used:
  + Science Direct
  + EBSCO Host
  + Pubmed,
  + SCOPUS
  + Social Science Citation Index and
  + Google Scholar
* Initial Search Terms (Internet Search)
  + “Digital Voice Assistant” and/or “DVA”
  + “Digital” + “Voice” + “Assistant”
  + “Digital Voice Assistant” + “Disability”
  + “Alexa” and/or “Disability”
  + “Digital Voice Assistant” + “Voice Control” + “Disability”
  + “Digital Voice Assistant” + “Access” + “Disability”

Secondary Search Terms

” Digital Voice Assistant,” “DVA”, “Disab\*”, “Voice Technology”, “Natural Language Processing”, “NLP”

Search Parameters & Result Filters

The image below is a screenshot detailing some of the keywords used in the final search alongside some of the search parameters used and the filters applied to limit the results to the most relevant.

Image C1: Screenshot of Search – Literature.

Screenshot from a computer capturing a database search using the UCC library portal.  The keywords Digital Voice Assistant is visible in the search bar and is in parentheses alongside the word Disability.  The right of the image shows the Filters used including “peer reviewed”, “journal article”, “5 years, “psychology” and approximately 12 others.  There is also a partial list of other criteria used.  The Centre of the screen shows the 1120 results in summary form and the right of the screen then displays other links to non-related content.


# Appendix D: Installation Report

## Installation & set-up for technology field-trials determining the technology configuration.

Following a review of the available technologies along with a risk and benefit appraisal by the team a final configuration of technology was determined to install in the homes of participants for the fieldwork element of this study. The final configuration comprised of a single DVA with two Smart Plug Sockets (Amazon Socket); two Smart Bulbs (Philips Hue) and an Amazon Firestick. All the technologies in this package were operable by voice via the DVA hub. A description of the anticipated functionality that each element of the configuration package offered are in Table D. 1 alongside a breakdown of the final cost.

Table D. 1: Description of technology, function, and cost

| Technology | Anticipated Function | Unit Cost (in Euro) |
| --- | --- | --- |
| Amazon Echo Show 8 | Information retrieval.  Control of provided third party devices.  Access to online shopping/purchasing. | 108 |
| Philips Smart Hue Light Bulb | Control of ambient room lighting | 26 |
| Amazon Smart Sockets | Voice control of ON/OFF; Function of third-party plug-in devices, such as lights / fans /etc | 32 (for a pack of two) |
| Amazon Fire Stick | Voice control of entertainment.  Control of on-demand services such as video | 44 |

### Preparation for installation

* All participants were contacted by a member of the research team prior to provision and installation of the equipment list. Contact was made by phone-call and each team member sought to collect information that would support the installation of the technology including questions such as: Do you or have you used similar technology in your home before?
* Please provide details as to the Wi-Fi provision in your home, network details, number of devices/users etc.,
* Do you have anyone who could provide support or assistance with installing the devices?
* Is there anyone that can provide immediate support to you if there are issues with the operation of any of the devices provided.

The information collected on each participant was reviewed by the team to determine who might require a visit and what households might be best placed to complete the installation and set-up of the equipment themselves. Follow up telephone calls were made to further discuss with participants when equipment would be delivered and/or to schedule a visit by a member of the team.

### Challenges arising during installation.

Many of the installations were completed easily, however there were some difficulties noted. These difficulties were recorded as field notes and were resolved through discussion by the wider team. Examples included visit appointments made by telephone and no household member at home at the scheduled time and issues finding locations due to inaccurate Eircodes.

* Broadband password had been changed and no-one in the family in a position to provide the correct one.
* WiFi coverage not adequate to locate the Amazon Echo Show in the desired location within the home.
* No smart TV in the home when equipment delivered.
* Smart TV located in a different room to the Amazon Echo Show (e. g., bedroom)
* Difficulties configuring the Amazon Fire Stick with certain models of Television including, Walker, Normende, Bush and Tevion.
* Difficulties switching on/off audio description function on Netflix using the Amazon Echo Show.

Many of the issues were resolved in-situ during the installation but some solutions were identified after the installations and support personnel contacted participant’s by telephone.

### Support through the Field-Trials

Telephone support was provided on a Monday to Friday basis for the six weeks of the trial period. Participants were provided with the mobile number of one of the researchers who had agreed to serve as the initial point of contact for queries or issues that participants might have across the duration of the field trial. Scheduled calls were also made by the team on a weekly basis to check in with participants and discuss any issues that may have arisen over the course of the week. It was during these scheduled calls that most issues were reported and dealt with. Many of the queries were focussed on ways in which individuals’ use of the technology could be extended or enhanced.

Three of the research team met on a fortnightly basis to report and discuss any issues, brainstorm solutions, and identify positive ways in which each participant could be supported to make better use of the technology. One participant required a follow up visit due to persistent difficulties with connecting the DVA to their home broadband that could not be resolved over the course of several phone-calls.

# Appendix E: Data Gathering Tools: Study 1 – survey and interview schedules.

## Study 1 Assistive Potential of Digital Voice Assistant Survey

Online, self-complete survey created using [www. supersurvey. com](http://www.supersurvey.com).

This survey captured the following details from participants:

Name

Date of birth

Gender

Description of home

Which of the following best describes your home?

Insert options here.

Description of location of home

Which of the following best describes where your home is situated

Insert options here.

Household composition

A picture containing graphical user interface: Page 1 of the Assistive Potential of Digital Voice Assistant Intro Survey




Image E.1: Name page of Survey.

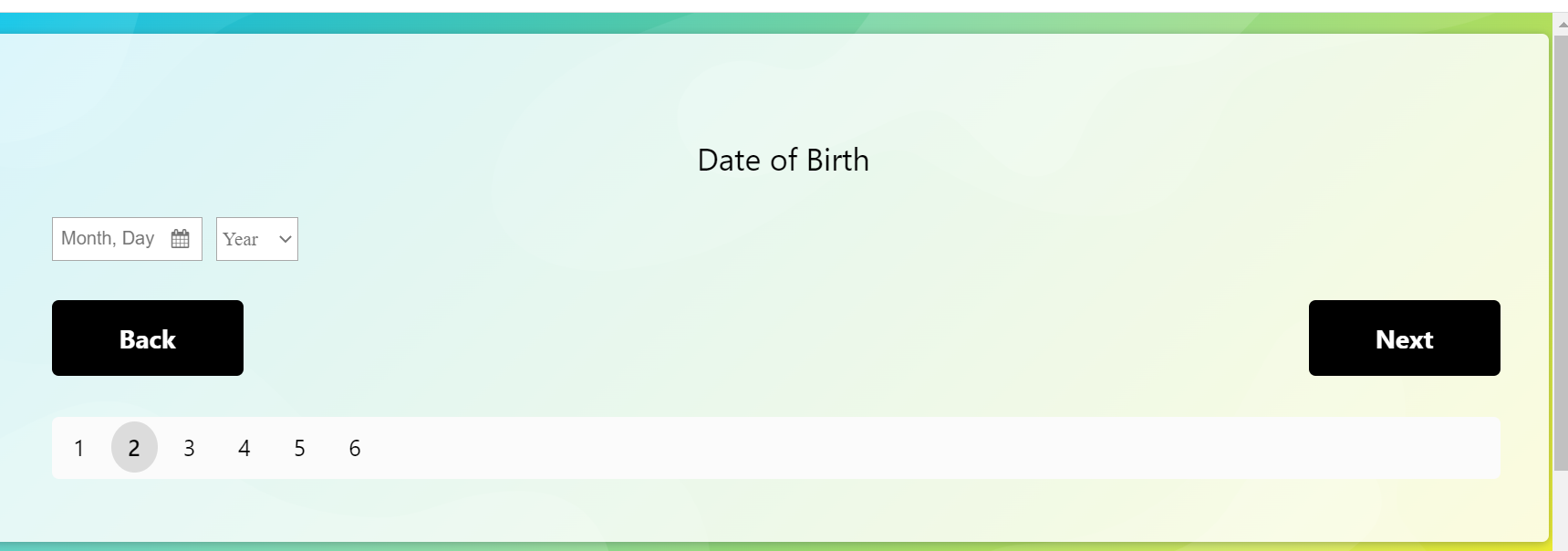


Image E.2: Date of Birth.

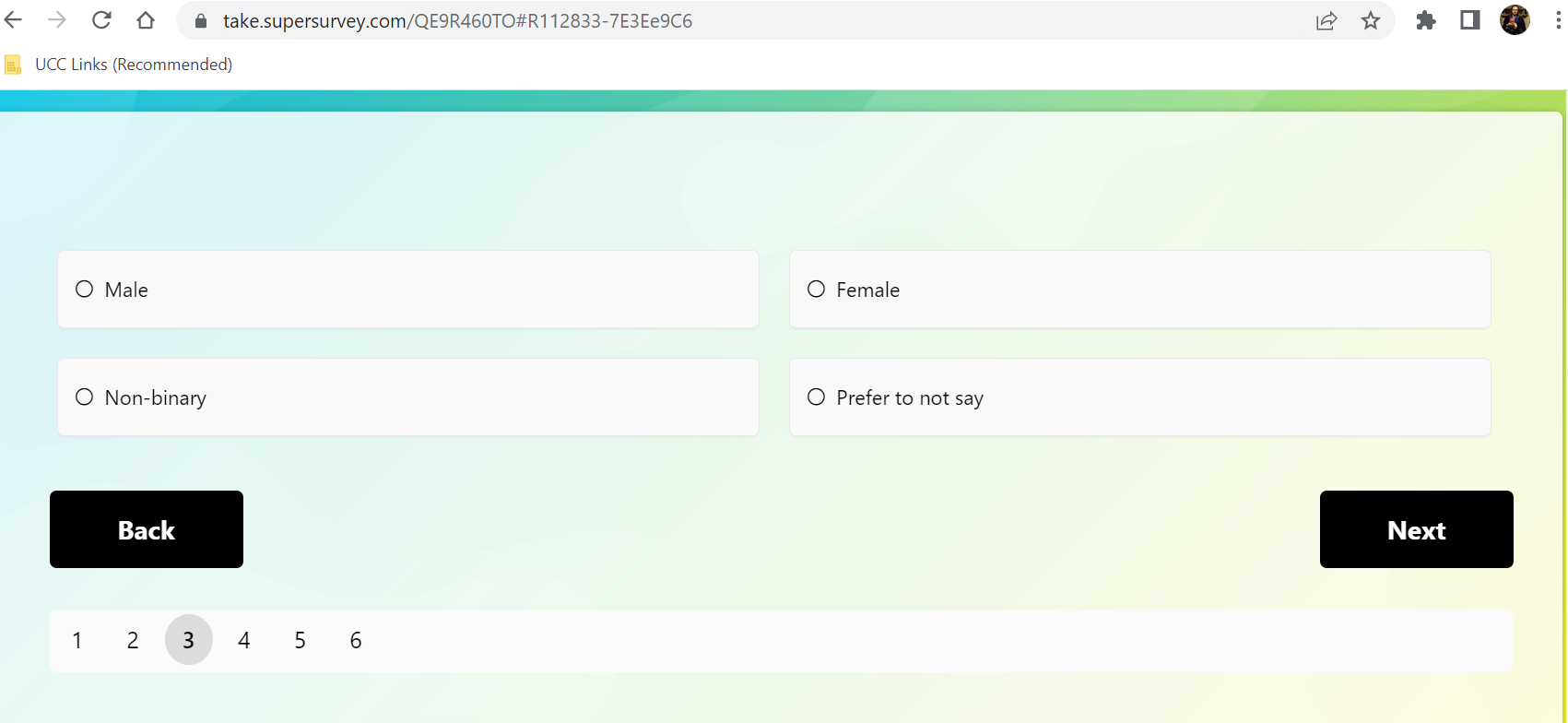


Image E.3: Gender



Image E.4: Describing your home.

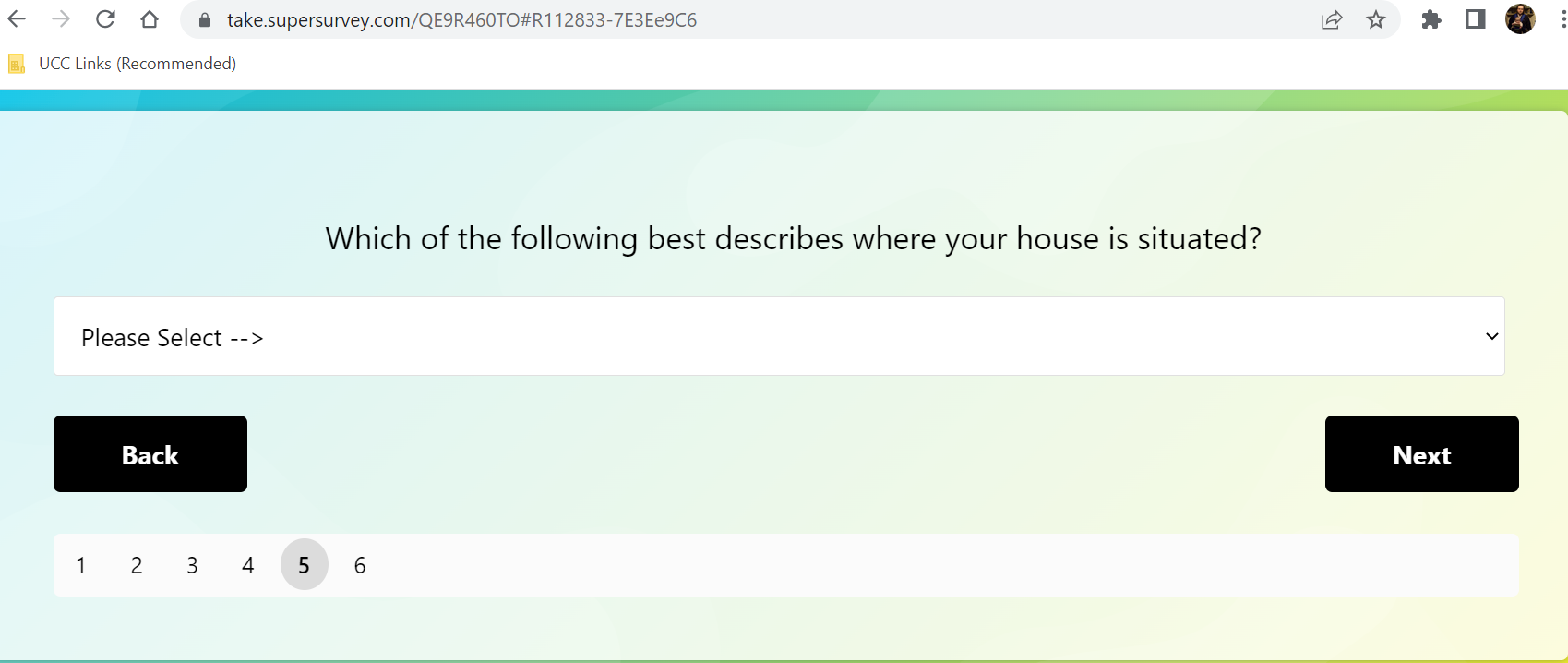


Image E.5: Describing home location.

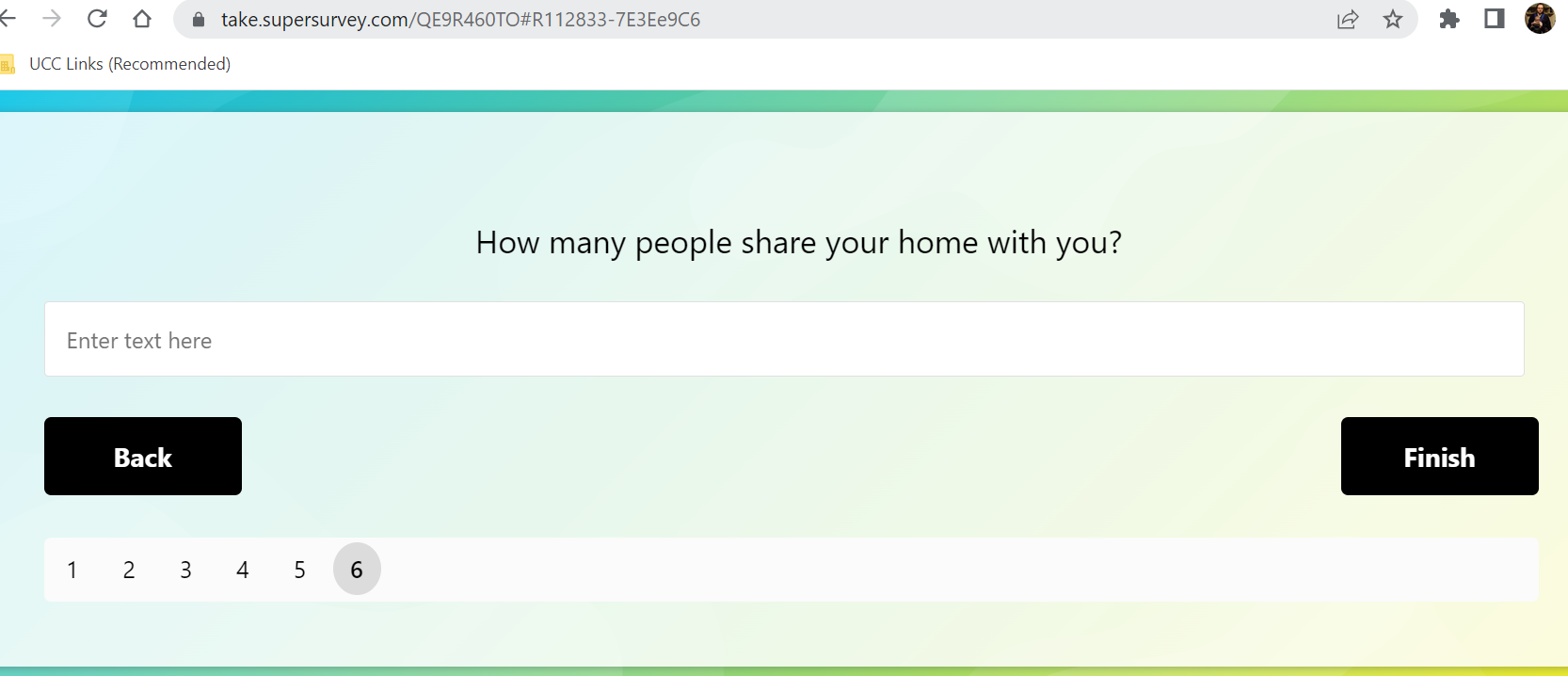


Image E.6: Household composition.

## Study 1: Data Gathering: Semi-structured interview Round 1 – (pre-field-trial) Interview Guide

To be used to support initial interviews with all participants – all responses to be collected as ‘field-notes’.

* Record pseudonym
* What gender do you identify as?

Male Female Other Prefer not to say.

* What is your age?
  + 18 – 30
  + 30 – 45
  + 45 and over
  + Rather not say.
* Where is your home located?
  + RURAL CITY TOWN (>5,000 people) VILLAGE (<5,000)
* What is the highest degree or level of education you have completed?
* What is your current employment status?
* Are you married/cohabiting?
* How many children do you have?
* How many people live in your household?
* Describe your relationship with those living in your household?
* How long have you lived in your current home?
* Approximately, how many rooms are regularly used in your home?
* What parts of your home do you and other family members use most? In what ways do you use these rooms?
* Tell us a little about any functional limitations that you experience, how would you describe these?
* Tell me a little about using home-based technologies such as Amazon Alexa, Google Home etc.?
* Do you have or have you used SmartHome technologies in the past? Can you tell us a little bit more about that?
* What are your expectations of using Digital Voice Assistant technologies such as the Amazon Alexa and Google Home etc.?
* Can you describe any functional limitations that you (or household members have)?
  + Can you describe how this/ these impact your day-to-day functioning in your home?

## Study 1: Data Gathering: Semi-structured interview Round 2 (post field-trial) – Interview Guide

* Record pseudonym
* Can you tell us a little about your experience(s) using your technology over the past few weeks?
  + Can you tell us a little about the installation, were there any difficulties/challenges?
  + In terms of the use of the devices over the last few weeks – can you let us know what problems you had? (If any)
* How did your use of the technology change over the course of the weeks that you had it in situ?
  + What did you use the DVA for?
  + What sorts of experiences did you have with the DVA?
  + What were the benefits of using it in your home/what were the highlights for you/your family?
  + What challenges did you experience using it?
  + What sorts of things did you feel it helped you with?
  + What sorts of things do you wish it could do?
* What were your experiences of using the IoT technologies?
  + Tell us a little about how this worked in your home?
  + In what ways did it benefit you/your family using these?
  + What challenges did you experience using it?
  + What sorts of things did you feel it helped you with?
  + What sorts of things do you wish it could do?
* What sort of concerns did you have used the technologies in terms of privacy/security?
  + What sorts of fears did you have when using these technologies?
  + How did these fears/concerns/challenges change over the course of the trial?
  + What are your concerns about having and using this technology and/or other technologies in your home?
* What changes did the technology provide in your own/family lives?
* Are there ways in which your household changed because you had this technology installed?
* What would the implications be if you removed the technology from your home?
* Can you tell me any experiences that you/your family had that you would consider were unexpected/unusual?
* What advice would you have for others that might choose to use DVA’s and/or IoT in their homes?
* What would you say the advantages are compared to other Assistive Technologies that you are aware of/have used?
* What would you say the disadvantages are compared to other Assistive Technologies?
* Have you any other experiences that you would like to share?

# Appendix F: Data Analysis Workshop Samples – May 2022

## Workshop summary

The outputs of the initial framework-guided rapid analysis were discussed by the research team, primarily with a view to gaining initial insights that would inform the immediate progression of the research and guide the next stages in the process of the study. The recorded outputs of this workshop meeting are reflected in the points below:

* Concerns held by the research team as to the support and training requirements of participants may not be as extensive and onerous as had previously been assumed.
* Opportunities whereby participants might support each other across the fieldwork should be explored.
* Capturing participants’ experience on an iterative basis throughout the study provides the best chance of capturing rich data.
* Mechanisms for supporting communication between participants should be explored:
  + In terms of the ethics of extending the research in this way
  + In terms of how it may impact upon the data generated and fidelity to the research aims and process.
* Focus groups may offer a valuable mechanism for collective sharing of experiences and may support further collection of rich data from participants.
* Research team to explore the viability of remote versus face-to-face focus groups.
* Further discussion merited with FreedomTech to explore opportunities for sharing knowledge gained (for researchers and participants) and whether there are events/activities that can offer opportunities for focus groups to be held.
* Considering changes to data gathering may impact the instruments used and protocols for collection.
* This issue needs to be resolved as a priority. Further discussion with David Banes Solutions to be scheduled to allow decisions regarding the planning of future data gathering rounds to be determined as quickly as possible.

# Appendix G: Rapid Data Analysis Round 1Interviews for Study 1– Preliminary Findings

A rapid analysis guided by the Braun and Clarke thematic analysis framework was used to identify dominant themes emerging from the data gathered. The four themes extracted are listed here with a brief description and some codes allocated to each theme and presented by way of bullet point.

1. Familiarity
   1. Nothing to be afraid of

Collectively, most participants expressed an eagerness to try new technology and understood that using such technology may yield positive dividends even if they were unable to pinpoint what these might be.

* 1. Just like your phone

Participants expressed the opinion that modern mobile phone usage, particularly smart phones served to prepare people for using technologies such as DVAs. Several references were made to other voice technologies and a sense that this approach to interacting with technology may indeed become ubiquitous in the near future. Most participants did not see challenges in transitioning to using DVAs with those with previous experience highlighting that:

“Once it’s there for a while, you forget about it, until you want something” (Jim: Round 1 Interviews)

* 1. Voice control as natural control

Using their own voice as a means of engaging with technology and by extension their home environment was something that participants saw as both practical and attractive to them.

“Well, one thing we can all do is talk, or well, most of us like to anyway” (Geri: Round 1 Interviews)

Participants expressed their own visions of how engaging or interacting with technology might change as voice control becomes more ubiquitous:

“it’ll eventually come around to you can talk to anything even your kettle and boil it” (Colin: Round 1 Interviews)

1. Associations with Branding

The brands associated with the more common DVAs have instant recognition with the participants and evoked strong opinions as to their perceptions of the quality and potential of the technology.

* 1. Trust in recognised brands

There was a clear confidence expressed by participants in the fact that the technology was made by companies that were also household brands such as Amazon, Apple, Microsoft, and Google. There was a sense communicated that the fact that the devices had such named brands behind them assured them of the quality that they could expect in the device:

“They don’t make bad technology, it’s against their ethos”.

(Paul: Round 1 Interviews)

* 1. The validation of recognition

Participants reported that the fact that devices made by brands such as Amazon and Google provided functionality specifically aimed at People with Disabilities was recognition of their needs and individuals and of their importance as a community:

“it’s not for nothing that they’re making devices that we can use” (Mary: Round 1 Interviews)

* 1. Image and identity

The brands associated with DVAs had a strong resonance with participants with some stating clearly that they are “an Apple family” or that they’ve “steered away from Apple products up until now”. For some, DVAs represented a technology that is used to “make a statement” in your home that you are “modern” and “connected”. (From Geri: Round 1 Interviews)

1. Unexplored Potential

During the interviews, many participants discussed what it was or might be that they could use technology such as DVAs and other related technologies.

* 1. Exploring new opportunities

Many of the participants expressed an enthusiasm for their engagement in the research and, found the exploratory nature of the process appealing. There was a sense of excitement communicated that “it won’t be boring or won’t be like work” (Henry: Round 1 Interviews) taking part in the fieldwork. There was a positive approach communicated by participants who wanted to:

“Road test what can be done and what can’t be done”. (Jim: Round 1 Interviews)

Similarly, several participants who had previously used DVAs were enthusiastic about revisiting the use of such devices with a different purpose, for example:

“it’ll be different because we won’t just be using it for the sake of it, we’ll need to use it”. (Joanne: Round 1 Interviews)

* 1. The responsibility to discover for others.

It emerged during this rapid analysis that many of the participants were enthused by the endeavour to discover new uses for DVAs and related technologies that would benefit themselves, but also serve as examples for others in similar circumstances experiencing similar limitations. The opportunity to uncover new ways in which the technology could serve people was reason to participate in the project:

“I’d love it if I learnt if it works for me because then I can make sure and tell others”. (Mary: Round 1 Interviews)

1. A community of researchers

An unanticipated theme that emerged from this initial analysis was a desire by participants to be part of a larger community of inquiry. Participants were motivated personally to be involved and although they were not aware of who the other participants were, they clearly identified with their fellow participants and communicated a sense of collective responsibility for the research.

a. Iterative sharing

Most participants expressed the desire to share their experiences with others and to learn through engaging with r fellow participants. This was communicated by some participants as a means of ensuring the effectiveness of the trials:

“It would be good for the whole project if we have the chance to let people know how we’re getting on” (Paul: Round 1 Interviews)

Participants felt that they could learn more effectively from each other given regular opportunities and mechanisms to communicate with each other.

“If we’re getting a chance to talk to each other, I’ll bring that home and try that out for myself” (Jack: Round 1 Interviews)

b. A collective experience

The sense of group identity was evident during these initial interviews. Emerging from these interviews was an expressed wish for the research team to provide a mechanism by which participants could work together to collate their experiences in using the technology in this study and identify some of the collective benefits and/or challenges encountered:

“If I come across something with the equipment it might just be something to do with me, I want to hear if others have had the same thing happening” (Sam: Round 1 Interviews)

1. Assistive Technology for People with Disabilities and Older People (2016) available at: <https://www.enableireland.ie/sites/default/files/publication/AT%20Paper%20final%20version.pdf> [↑](#footnote-ref-1)
2. Based on estimates recorded in Assistive Technology Usage and Unmet Need amongst People with Disabilities in Ireland Report (2005), available at <https://nda.ie/nda-files/assistive-technology-usage-and-unmet-need-amongst-people-with-disabilities-in-ireland1.pdf> [↑](#footnote-ref-2)
3. In the context of this report the work ‘connected’ refers to a device’s reliance on being connected to the internet for the functionality it affords its users. [↑](#footnote-ref-3)
4. Rayyan: <https://www.rayyan.ai/> [↑](#footnote-ref-4)
5. In social science research a ‘gatekeeper’ refers to a person positioned between the researcher (data collector) and the research subject (participant). The gatekeeper typically supports processes such as participant recruitment thus limiting bias during the part of the process, [Click on this line for further detail](https://uccireland-my.sharepoint.com/personal/bryan_boyle_ucc_ie/Documents/Documents/Random%20Files/NDA%20Versions/5th%20Round%20Revision/5andahalfth_Revision/(https:/methods.sagepub.com/reference/encyclopedia-of-survey-research-methods/n200.xml#:~:text=A%20gatekeeper%20is%20a%20person,and%20when%2C%20to%20the%20respondent.). [↑](#footnote-ref-5)
6. It was made explicit in the information materials distributed to potential participants that the gathered information would be used only for setting up and supporting any technology installed during this research. Potential participants were further advised that all information would be maintained anonymously for the duration of the project and then permanently deleted upon completion. [↑](#footnote-ref-6)
7. ‘Snowball sampling’ refers to a sampling technique common in qualitative research where existing participants will refer others to the research team as potential recruits for the research in question. It is a non-probability sampling technique and is said to secure a sample that share a commonality of characteristics or traits. [↑](#footnote-ref-7)
8. Where possible the ‘transcription’ feature on MS Teams was used in conjunction with MS Stream to streamline the process of converting audio to text. [↑](#footnote-ref-8)
9. This software was chosen as it provided a collaborative online platform that could be used by study participants and researchers to complete the various ranking exercises required of the methodology. Although the software proved useful in many instances, there were some challenges and accessibility issues reported during the process. For example, for those using screen-reading software the statements were parsed by the software as speech however there were instances where the sequencing of these was not correct, and support was required by the researchers online with the participant. For one other participant there were some issues with how the statement array presented – presumably due to the version of the web-browser being used. Again, this required resolving by one of the research team. Accessibility and usability issues were reported to the developer community at the time. [↑](#footnote-ref-9)
10. <https://hal.science/hal-01263483/document> (accessed February 2023). [↑](#footnote-ref-10)
11. <https://www.makeuseof.com/voice-recognition-improve/> (accessed February 2023). [↑](#footnote-ref-11)
12. Google Voice Search was a precursor to Google Now and more recently Google Assistant (released 2016) that provided limited, voice search capability for Android devices. [↑](#footnote-ref-12)
13. <https://medium.com/authority-magazine/the-future-is-now-how-5g-technology-will-impact-and-change-our-lives-with-ericssons-peter-507fed120f0f> [↑](#footnote-ref-13)
14. <https://www.insiderintelligence.com/content/there-s-still-lackluster-enthusiasm-shopping-buying-via-voice> - accessed 18th September 2022. [↑](#footnote-ref-14)
15. <https://www.aboutamazon.com/news/devices/amazon-alexa-matter-smart-home-standard-support> (accessed February 2023). [↑](#footnote-ref-15)
16. C[lick here to link to information about DVA’s and dyslexia](https://www.voicesummit.ai/blog-old/how-voice-assistants-are-helping-people-with-dyslexia).

    [Click here for further information](https://www.wired.com/story/end-of-dyslexia/) about DVA’s and dyslexia. [↑](#footnote-ref-16)
17. Examples such as the Intelligent Room Project, the ComHOME and the Aware Home projects demonstrate an interest in using natural language processing to control one’s home environment since the early 1990’s (Bentley et al., 2018). [↑](#footnote-ref-17)
18. https://www.iotworldtoday.com/2020/03/24/voice-activated-technology-redefines-the-internet-of-things/ [↑](#footnote-ref-18)
19. At the time this study was conducted the availability of large language model chatbots had not caught the public’s attention to any great degree. The release of ChatGPT by Open AI in early 2023 has brought to the fore a significant public debate about some of the practical and ethical questions that are associated with the emergence of consumer technologies that not only retrieves information but has a capacity to significantly manipulate such data as well. How such developments impact the lives of people with disabilities both positively and negatively will, no doubt be subject to intense debate over the forthcoming months and years. [↑](#footnote-ref-19)
20. Both participants indicated during initial discussions that they had used a DVA in the past and felt confident that they had the skills and the requisite support to install the technology in their own homes. [↑](#footnote-ref-20)
21. Where rural is defined as all areas outside of towns with populations of less than 10,000 people (OECD <https://www.oecd-ilibrary.org/sites/d25cef80-en/index.html?itemId=/content/publication/d25cef80-en>) [↑](#footnote-ref-21)
22. Dwelling Type determined as Apartment or House based on whether the dwelling was a constituent in a larger housing unit. [↑](#footnote-ref-22)
23. Maximum number of people living permanently or temporarily (in the case of Personal Assistants) function in the home daily. [↑](#footnote-ref-23)
24. Estimated Maximum Broadband Speed (in megabits per second) according to participant’s service provider. [↑](#footnote-ref-24)
25. Participant reported that they had purchased a DVA several years ago and used it over a period of several months. They discontinued using the device and are unsure as to its whereabouts now. [↑](#footnote-ref-25)
26. Participant indicated that they prefer not to disclose their gender. [↑](#footnote-ref-26)
27. The participant group comprised one co-habiting couple representing a single household as opposed to two separate dwellings. [↑](#footnote-ref-27)
28. Pseudonyms used throughout to associate quotations provided with anonymized participant. [↑](#footnote-ref-28)
29. Examples of Amazon Skills can be found on the dedicated website: <https://www.amazon.co.uk/b?ie=UTF8&node=10068517031>. [↑](#footnote-ref-29)
30. In the context of using the Amazon Echo range of devices with which the voice assistant is referred to as Alexa, ‘Skills’ refer to the equivalent of apps that can be downloaded to a device that will provide a new or additional function that the device can perform. An entire suite of such Skills apps are available and are continuously made available by a large, distributed, developer community further extending the functionality and use of the devices. [↑](#footnote-ref-30)
31. This software was chosen as it provided a collaborative online platform that could be used by study participants and researchers to complete the various ranking exercises required of the methodology. Although the software proved useful in many instances, there were some challenges and accessibility issues reported during the process. For example, for those using screen-reading software the statements were parsed by the software as speech however there were instances where the sequencing of these was not correct, and support was required by the researchers online with the participant. For one participant there were some issues with how the statement array presented – presumably due to the version of the web-browser being used. Again, this required resolving by one of the research team. Accessibility and usability issues were reported to the developer community at the time. [↑](#footnote-ref-31)
32. The Q-sortware was used to display the Q-sort to participants only so that data captured could be saved on secure UCC drives rather than on participants own home computers. [↑](#footnote-ref-32)
33. a As it had been agreed by the research team to conduct the data gathering in this way, the Q-sortware software was not subject to accessibility testing as such no conclusions can be drawn as to the efficacy of this platform for other studies with users with different accessibility needs. [↑](#footnote-ref-33)
34. <https://news.un.org/en/story/2022/05/1118212> [↑](#footnote-ref-34)
35. <https://www.vercida.com/uk/articles/assistive-technology-moving-towards-mainstream> [↑](#footnote-ref-35)