



**Enabling by Voice: An Exploratory Study on how  
Interactive Smart Agents (ISA) can Change the Design of  
Environmental Control (EC) Equipment and Service.**

by

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## Abstract

The use of well-designed assistive devices may improve the quality of life of individuals living with severe and permanent impairments and reduce the burden on their caregivers.

Interactive Smart Agents (ISA)s use the latest smart home technology to control devices around the house through voice interfaces. This study aims to investigate whether ISAs may be effective to support individuals who are affected by multiple sclerosis, stroke, spinal cord injury (SCI) or other neurological ailments. This study's approach is user-centred to ensure inclusion. This study includes two main parts: 1. the initial development of a technology adoption model informed by secondary research and exploratory primary data, 2. a second in-depth investigation of the initially identified constructs and relationships through a multi-points qualitative study. After data analysis the initial model was altered to reflect the insights generated by the primary research. By using this modified technology adoption model, designers and manufacturers can make changes in their future ISA devices so that they can be better suited to the needs of users with severe mobility impairments.

This research is in collaboration with the North Thames Regional Environmental Control Services (NTRECES), an NHS organisation that provides Environmental Control (EC) devices to manage the patients' electrical and computing appliances. Clinical staff have indicated an increasing patients' demand of ISAs instead of traditional EC devices and have suggested that their clients are keen to experiment with more intuitive interfaces.

The originality of this work consists of bringing together two established schools of thoughts, the Technology Adoption Model (TAM) and the Theory of Planned Behaviour (TPB) to arrive at a model that specifically considers adoption and usability factors relevant to a niche service user group (people with severe mobility impairments) and a specific technology, ISAs. This research has uncovered that, novelty, and ease of voice interaction as well as its entertainment value played a key role in the decision to adopt an ISA device. Users are willing to overlook the reliability, privacy and security issues if a back-up device is present and as most of the functions the users require are not security and privacy critical.

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## Chapter 1. Introduction

### 1.1 Environmental Control (EC) Devices

Electronic Assistive Technology (EAT) encompasses any item or piece of equipment used to maintain or increase the functional abilities of people with disabilities (disabled people). EC equipment forms a sub-component of EAT Paul et al. (2006). North Thames Environmental Control Equipment Service (NTRECES) provides environmental control (EC) equipment to severely disabled patients within the North Thames region. The first EC system, known as Possum (Patient Operated Selector Mechanism), was produced in the 1950s for survivors of the polio myelitis epidemic Wellings & Unsworth (1987). With the advancement in technology EC equipment has undergone various changes. The current systems include a control unit, which activates peripheral devices by means of infrared or radio signals Wellings & Unsworth (1987). These EC devices can operate through numerous methods for control and input. The most widely used method of input is a simple switch-based device. With one click of the switch the user can navigate through different options available for controlling their environment. Other forms of input can include eye tracking, 'suck and puff' and head movement.

Currently an excellent service is being provided by the NTRECES at Hillingdon Hospital, Uxbridge, London. Numerous types of equipment from multiple service providers are being prescribed to the patients.

#### 1.1.1 User Experience with Traditional EC Devices and Speech-Controlled EC Devices

The unintuitive and cumbersome part of the user experience when interacting with EC devices is the method used for input, especially for people with severe mobility impairments Craig et al. (2004). The most popular method of input is scanning-based; this means that the user has to sequentially scan all options available until the required one is highlighted and can finally be selected. Examples of this type of input device are the buddy button (Figure 1.) a single large clickable button, IntegraMouse® (Figure 2.) controlled with the lips, suck and puff whereby one breath counts as one click. In the EC device all the menu options available are displayed in the form of a sequential list. User can browse the menu one by



one and choose the options with a single click. Due to the sequential browsing and selection of the options available and when there are several peripherals (TV, lights, curtains etc.) controlled by the EC device, this can become a very lengthy process. Using scanning as an access method caused frustration with technology as it slowed down the speed of use Verdonck et al. (2011). Moreover, users with deteriorating mobility impairments have growing difficulty in operating the EC Craig et al. (2004).

Some other options that are available for operating the EC devices are eye gaze or head mouse. These methods require extensive eye focus and neck movement, which causes tiredness and fatigue, if used for longer periods of time. Automatic speech recognition is believed to be one of the most promising developments for users who are severely disabled Noyes et al. (1989). Research states that users' preferred way to control EC units was to directly interact with them through voice activated commands, rather than select from a menu through a switch-based input Craig et al. (2004). One of the major advantages of speed recognition over other methods of input is its speed efficiency Hawley (2002). Speech-driven systems enabled control for patients when other input methods are not possible. It offers a faster and aesthetically considerate option, giving the users a sense of independence and dignity Judge et al. (2009). The ease of use of speech recognition has led to its inclusion into many types of EC integrated systems Noyes et al. (1989), Jiang et al. (2000), Aguilera et al. (1992) one of them is SiCare® Pilot. However, studies highlight that speech-controlled EC devices have reliability issues, which result in patients opting for backup systems for functions such as call for help Judge et al. (2009).



Figure 1: Buddy Button



Figure 2: Integra Mouse

## 1.2 ISA Devices

ISA devices commonly known as smart speakers, have been on the market since November 2014 when Amazon launched Amazon Echo. They are an evolutionary form of chatBots, which were computer programs, simulating conversations with the user via voice or text Chung et al. (2017). After the release of Amazon Echo, Google has released Google Home, Apple their HomePod and Microsoft came up with Invoke as their versions of ISA devices. The cost of these devices ranges from 299\$ for a HomePod, 230\$ for an Amazon Echo Show to 29\$ for a Google Home Mini. The statistic shows that the market revenue of smart speakers with personal assistants worldwide in 2018 amounted to 11.8 billion U.S. dollars Laricchia (2019). According to Gartner, the ISA market will reach \$2.1 billion by 2020 Chung et al. (2017). Majority of these devices only have audio output, but Amazon Echo Show, Google Home Hub and Amazon Echo Spot, have a display output as well.

The main method of interaction with these devices is through speech. In addition, ISAs can control multiple (IoT) compatible devices for example, smart TV, smart light bulbs, smart doorbells, smart security cameras, automated blinds, smart door locks and openers.

These ISA devices continuously listen to their surroundings using their multiple microphones, on hearing the activation or 'wake-up word', the device starts recording the sound input. This sound clip is then transmitted via the internet to the cloud servers, where the processing takes place, and the ISA device responds to the "user request" accordingly. This request could be either ordering something online, weather information, internet search or controlling of a device connected to the ISA device through the home Wi-Fi.

This continuous listening has raised several security and privacy concerns; users are wondering if all of their conversations are being recorded, for what purpose these recorded sound clips will be used (e.g., targeted marketing etc.). ISA manufacturers have responded by providing several security features e.g., the mute button within the devices. They have assured the users that only the sound clip recorded after the 'wake-up word' will be transmitted to the cloud servers Lau et al. (2018).

Moreover, there have been some security concerns regarding the ISA devices. Reliance of these devices on home Wi-Fi and internet makes them vulnerable to malicious attacks. There has been reported incidents where smart devices linked to the internet have been

hacked and controlled by outside entities e.g., webcam, baby monitors etc. As smart agents can also be used to control smart locks for home entry, a potential risk is that they could enable unauthorized and malicious entity impersonating the user to obtain illegal access to the user’s residence Chung et al. (2017).

In addition to that, there are concerns about ISA devices spying on users for market research gains Chung et al. (2017). This effects the trust between the user and the device. However, research found that users mostly trusted the manufacturer companies to protect their privacy Lau et al. (2018).

Despite all the security and privacy issues surrounding the ISA devices, numerous studies report a mostly positive user experience. Users personified their ISA devices and treated it as a human because of its ability to hold a conversation. Users reported improvement in their quality of life, not only of the assistance provided by the ISA, but also because of its ability to provide companionship through voice communication interaction Gao et al. (2018).

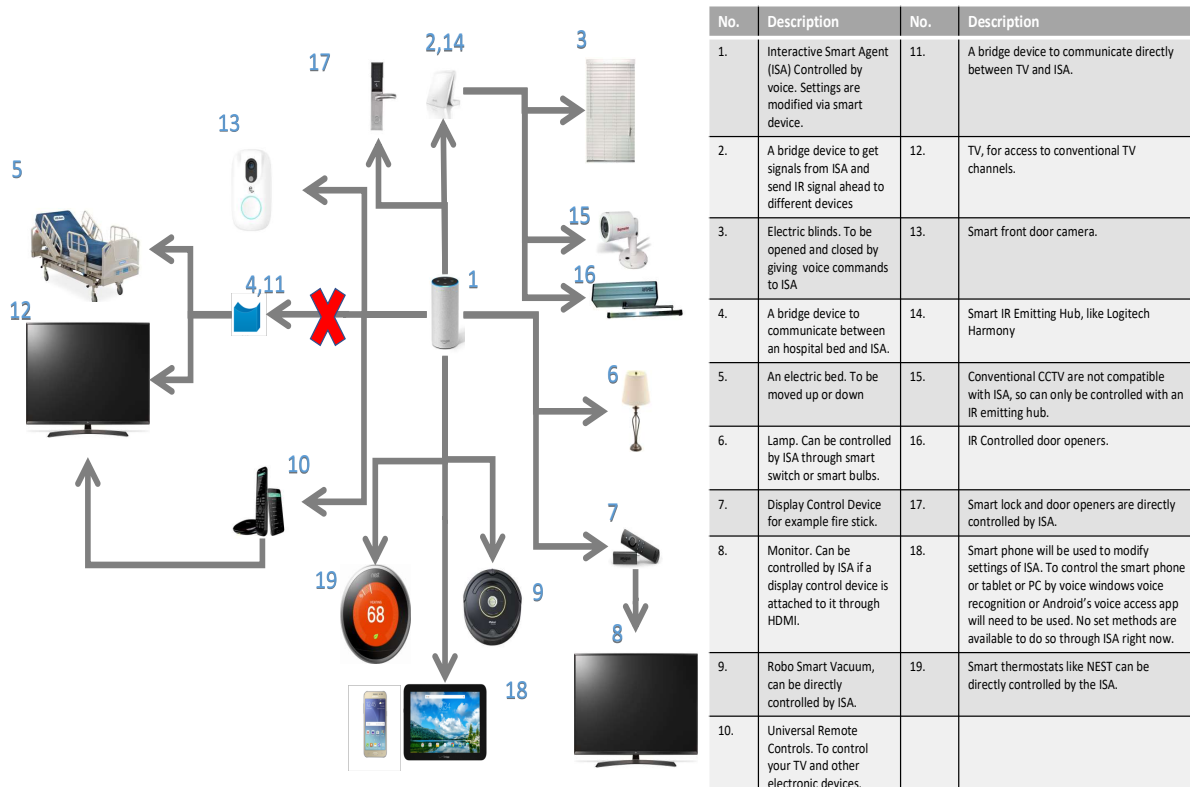


Figure 3: Map and List of the Functionalities that ISA Devices can and cannot Provide.

## 1.3 ISA As EC Devices

ISA devices can provide all the functionalities of an EC device, bar a few. This is summarized in Figure 3 above.

### 1.3.1 SWOT Analysis

There are pros and cons for people with severe mobility impairments to use ISA devices as EC device. To compare, different types of devices for example ISA or EC, a SWOT analysis was conducted. This analysis has been conducted taking into considerations the professional opinions of NTRECES staff and the researcher's experience of the devices under scrutiny.

#### EC Devices Controlled by Methods Other than Voice (For Example Switch)

Strengths	Weaknesses
<ol style="list-style-type: none"> <li>1. Reliability</li> <li>2. Tried and tested</li> <li>3. Familiarity</li> <li>4. Compatible with existing peripherals</li> <li>5. Troubleshooting and backup service available</li> </ol>	<ol style="list-style-type: none"> <li>1. Lengthy selection</li> <li>2. Un aesthetic designs</li> <li>3. Lack of input in design from users</li> <li>4. Gap between current technology available</li> <li>5. Lack of innovation</li> </ol>
Opportunities	Threats
<ol style="list-style-type: none"> <li>1. Adapt the speech recognition technology available</li> <li>2. Add an emotional human element to the design</li> <li>3. Introduction of more functionalities</li> </ol>	<ol style="list-style-type: none"> <li>1. New interactive smart agents are offering a more personal experience</li> <li>2. A software in a smart phone can replace the whole EC device</li> </ol>

The major advantage of using a conventional EC device will be its reliability. Whereas the biggest disadvantage will be the inefficient operation. These devices have been tested through the times but are being threatened by the immense functionalities available in the mainstream off the shelf products.

#### EC Devices Controlled by Voice (For Example Pilot)

Strengths	Weaknesses
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<ol style="list-style-type: none"> <li>1. Easier and more natural control of devices through use of speech</li> <li>2. No reliance on internet as all speech processing is done offline.</li> <li>3. Alternate control methods are in available in case of emergencies</li> <li>4. Tried and tested</li> <li>5. Familiarity</li> <li>6. Compatible with existing peripherals</li> <li>7. Troubleshooting and backup service available</li> </ol>	<ol style="list-style-type: none"> <li>1. A device can only learn a limited number of commands</li> <li>2. Some training time is required initially</li> <li>3. Less reliable if voice changes in time of distress</li> <li>4. Failure in case of background noise</li> </ol>
<b>Opportunities</b>	<b>Threats</b>
<ol style="list-style-type: none"> <li>1. Make use of the new technology for natural language processing.</li> <li>2. Introduction of some interaction abilities in the devices can add a human dimension to the design</li> </ol>	<ol style="list-style-type: none"> <li>1. New interactive smart agents can already understand and respond to commands spoken in natural language</li> <li>2. With access to the internet, the smart interactive agents are a source of infinite information and not just mere home control devices.</li> </ol>

One of the biggest plus points of the speech-controlled EC devices is a speedier operation and aesthetically pleasing solution. However, these devices are found lacking in reliability. There is a steep learning curve and only a set number of instructions can be recognized by these devices. The latest speech recognition technology, on the other hand is not bound by such constraints and is very close to holding a conversation in a natural way.

### Interactive Smart Agents (For Example Amazon Echo)

<b>Strengths</b>	<b>Weaknesses</b>
<ol style="list-style-type: none"> <li>1. Ability to respond to Natural Language</li> <li>2. Ability to hold a simple conversation</li> <li>3. Control other smart household devices</li> <li>4. Good sound quality</li> </ol>	<ol style="list-style-type: none"> <li>1. All speech processing is on the cloud so internet availability is a must</li> </ol>

<ul style="list-style-type: none"> <li>5. Can be controlled by a smart phone app</li> <li>6. Can interact with your smart phone or tablet</li> </ul>	<ul style="list-style-type: none"> <li>2. Less reliable in case of emergency. If the user can't call out or the internet is down</li> <li>3. Very new technology so early adoption can have its own hiccups</li> <li>4. No support is available from manufacturers</li> <li>5. Peripherals that would work with this new technology will be different from the existing ones and will need to be replaced.</li> <li>6. Will need to comply with standards, to qualify as a medical device.</li> </ul>
Opportunities	Threats
<ul style="list-style-type: none"> <li>1. The area of assistive technologies is wide open for these innovative products, with a little or may be no modification these products can be marketed as assistive devices</li> <li>2. Addition of monitoring functionalities to raise alarms in case of emergencies</li> <li>3. Provision of offline processing of speech</li> <li>4. Alternate call for help method</li> <li>5. Partnering with other manufacturers and assemble an EC package for user with debilitating physical disabilities.</li> </ul>	<ul style="list-style-type: none"> <li>1. Already established assistive devices companies can tap into the agents already available in smart phone and provide the functionality on their own</li> </ul>

The biggest plus point in favour of the ISA devices is its ability to hold conversations in a natural way and to be a source of information as well as entertainment. On the other hand, these ISA devices are marketed as mainstream devices and do not offer additional qualities that are very critical in Assistive Technology (AT) tools for example reliability.

### 1.3.2 More than an EC Device

People suffering from mobility impairments not only need help in conducting physical tasks, but they need emotional support as well. Often, people suffering from profound disability, end up being home bound. There is a high prevalence of depression and anxiety in people who have compromised mobility Craig et al. (2002). They can lose contact with friends and family and have a non-existent social life. These ISA devices in such cases can offer easier options for communication and keeping in touch with friends and family Marston H. R. & Samuels J. (2019). Moreover, ISA devices are improving with regards to speech recognition and responding in natural style of conversation as compared to voice-controlled EC devices. This ability of ISA to hold a conversation humanizes the devices in user's mind. Some existing users of Amazon echo feel that they share a bond with the smart agent and treat it as a member of the family Purington et al. (2017). In addition to that, due to the ability to connect to the internet, ISA devices can be a source of a wealth of information e.g., weather forecast, traffic reports, to do list, reminders, internet search results. These smart agents not only provide information and automate the home but also provide entertainment and companionship. ISA enable users with mobility or visual impairments to feel more independent, free, and safe Pradhan et al. (2018). Mobility impaired users were able to control smart home appliances like lights, thermostats, door locks, TV etc. independently. Whereas users with visual impairments were able to listen to music or books or news all on their own.

### 1.3.3 Risks of Using an ISA as an EC Device

As mentioned above, there are certain issues associated with the usage of ISA devices. One major cause of concern is the dependence of ISA devices on the internet. In addition to that, constant listening to users' conversations for the "wake-up word" is another worry. It gives rise to issues related to reliability, privacy, security, and trust. People with severe mobility impairments are very vulnerable and can be in situations where help is needed urgently. It is of utmost importance that the devices used by them would be always reliable in emergency situations. However, ISA devices fail to function in case of loss of internet or power. There is no in-built battery backup or an option to switch to 4G/3G internet. Hence, people in vulnerable situations should be provided with extra security and privacy options. This downfall also determines that the NHS in the UK does not recognize ISA based devices

as assistive technology that can be prescribed. In addition to that, as already mentioned, after the 'wake-up word' the ISA device records the user's commands and this recording is vulnerable to third party hacking programs, simulating conversations with the user via voice or text Chung et al. (2017). In April 2019, Amazon Echo announced their health skills, and the business giant made very clear that they comply to the U.S. Health Insurance Portability and Accountability Act of 1996 (HIPAA) Jiang (2019). Amazon is now providing HIPAA eligible environment for developing new health related skills to its business partners. This way it is made sure that all the health sensitive information is properly protected and cannot get into the hands of an unknown 3rd party.

### 1.3.4 User-Centred Investigation on the Design of Voice Controlled ISA based EC Devices

EC devices have been the subject of several evaluation studies, focusing on quality of life, user satisfaction, user experience, user perceptions, effectiveness, efficacy, benefits, and usability Brandt et al. (2011), Myburg et al. (2017), Rigby et al. (2011), Verdonck et al. (2011), Verdonck et al. (2014), Judge et al. (2009), Hawley (2002), Craig et al. (2002), Craig et al. (2004), Squires et al. (2013), Boman et al. (2007). Overall, users reported frustration with the technology Verdonck et al. (2018). On the other hand, user's satisfaction was linked to the emotional perception of the devices Jardón et al. (2011). It was also noted that, suitability of EC devices to the context and environment of use is one of the major factors in its better utilization. Moreover, the research highlights that clinical personnel prescribing the EC devices could consider the client opinion, efficient set-up and installation, and adequacy of follow-up for the successful ongoing usage of EC devices Myburg et al. (2017). Some of the challenges that the medical personnel feel whilst evaluating EC devices include a lack of understanding of the methods that can be employed to conduct evaluations, lack of resources, access to end users and the required expertise to apply evaluation techniques Woodcock et al. (2012). Following the same trend Regional EC services in England are looking into using standard methods like Therapy Outcome Measures (TOMs) to determine user satisfaction from installation. TOMs Enderby & John (2015) is a clinically validated measure that allows professionals to describe relative abilities of clients in four domains: Impairment, Activity, Participation and Wellbeing. In February 2018, a working group has been established to adapt TOMs specifically for EC services. Similarly, voice-controlled EC



devices were the subject of a qualitative study in 2002-2009 to determine the user perceptions and to inform the design of a new speech or voice driven EC system Judge et al. (2009). Amongst the voice operated EC devices, SiCare Light<sup>®</sup> is one of the few that are prescribed by the Regional Environmental Control Equipment Services (RECES) within England Geggie (2003). Voice operated EC devices are controlled via a set of pre-defined instructions, differently from ISA-based device that accept natural language instructions. Users go through a period of voice training after installation. This study concluded that there are obvious benefits of speech-driven systems, as it provides an option where other means of input are unavailable given the complex disability of the patients. In addition, voice control devices were found to be more efficient and aesthetically pleasing. Like conventional EC devices speech-driven systems enable a perception of increased independence. However, due to reliability issues the users always preferred a backup or alternative system for certain functions. Unfortunately, the results of this study were only used for academic purposes and were not used to modify the design of speech-driven EC devices.

Using a voice-controlled ISA based EC device is still in its idea phase Noda (2017). The EC services within England are currently exploring the adoption of mainstream devices (for example ISA) as EC devices. This has also been prompted by patients' direct requests for off-the-shelf ISA devices rather than expensive traditional EC. However, as not much time has passed since the introduction of ISAs on the market, there is not much research on their adoption and usage as Assistive Technologies (ATs) Pradhan et al. (2018). Some companies are experimenting with the use of ISA as EC or AT devices Limited Mobility Solutions Weis (2019). People with a variety of disabilities, have however taken an independent initiative to use ISA devices as AT tools. A customized ISA based EC device, designed through the process of user-centred design (UCD), is not yet available. In order to consider user's experience, needs and demands a UCD approach is critical. Similarly, there is no standardized evaluation criteria for such a device. There is a need to investigate the use of voice-controlled ISA based EC as well as its usability, efficiency, and psycho-social impacts. In addition, factors determining the impact of ISA based EC and the differentiating factors amongst conventional EC and ISA based EC require further inquiry and investigation.

## 1.4 Ethnographic Inspired Observations and Explorations

To explore the research area, to understand the context and to design the research, ethnographic inspired observations were carried out during patient home visits as well as in the hospital's rehabilitation ward. These observations were augmented with probing, open-ended questions. The goal of this exercise was to identify the needs, wants, hopes, aspirations as well as frustrations of the current users. Conventional EC equipment users, EC service providers and conventional EC developers were engaged in informal discussions and conversations. It was observed that, patients were inquisitive about new voice-controlled technology. They wondered if such devices will be issued to them through NTRECES. Some patients demonstrated how they use their voice to control their mobile phones and were curious to know if it was possible to do the same with the EC devices. Moreover, patients wanted to know more about the ISA devices. Keeping in view the increased interest of the patients in voice-controlled ISA devices, RECES services in England have established a working group to investigate the feasibility of using ISA devices as EC device and rules and regulations related to that.

## 1.5 Research Questions / Aim(s)

In light of the literature and of the primary research so far conducted, the following question has been identified as key to this research:

How can Interactive Smart Agents (ISA) be integrated through a person-centred design approach to improve Environmental Control (EC) design and services?

By using a user / patient centred design approach, **the aim is to understand the factors that may affect the adoption of ISAs among severely disabled users and, from this understanding, identifying the key functionalities and attributes of a voice-controlled ISA.**

### 1.5.1 Objectives

1. To identify and study the current user's experience when controlling the environment, including the use of current EC devices and services, applying a User Centred Design (UCD) methodology.
2. To create a data collection tool to reflect the factors identified in the model.

3. To identify the functionalities and requirements that Interactive Smart Agent (ISA) based device can deliver to support new user's experience.
4. To identify a set of research propositions integrated in a theoretical model that can explain the relationship between severely disabled users and voice-controlled ISAs.

### 1.5.2 Outcomes

1. Following are the planned outcomes of the study:
2. A conceptual model explaining the adoption of ISA devices by patients with mobility impairments.
3. A data collection tool, based on the conceptual model, to generate user requirements.
4. Evaluation criterion for conventional and ISA based EC devices.
5. Concerns of patients and carers and benefits of EC devices.

## 1.6 Structure of the Thesis

The first chapter introduces EC and ISA devices. It presents a SWOT analysis of EC and ISA, and the pros and cons of using different devices are highlighted. The SWOT analysis along with initial ethnographic observations helped shape the research question and objectives.

The focus of the second chapter is the literature review of technology adoption with an emphasis on assistive technology. The emergence of the theoretical model and description of its components is then discussed.

In the third chapter, methodology chosen by this research study is justified and explained. Followed by explanation of choice of methods for data collection and tools developed for it.

The fourth chapter is about the analysis of the data collected by the methods mentioned in chapter 3. It lists the profiles of the participants of the study followed by one-by-one analysis of the different themes that emerged during the process. It led to the modification of the proposed research model.

The fifth chapter then discusses the position of this research study within the academic literature. It also focuses on how this research study adds something to the existing knowledge base.

The last chapter then tries to analyse if at the end of the study, how the research objectives were met. It also states the difficulties and shortcoming of the work and if any future work can be done in extension to this study.

## Chapter 2. Literature Review

The first step in the redesign process is to determine the factors affecting the adoption of ISA devices. The identification of these factors that may lead the consumers towards using or discarding these devices can be significant in their future redevelopment and increased acceptance Kowalczyk (2018). To accomplish this a comprehensive literature review was carried out. This literature review addressed the objective four of this research “To identify a set of research propositions integrated in a theoretical model that can explain the relationship between severely disabled users and voice-controlled ISAs.”

### 2.1 Technology Adoption

According to previous research on average one third of all assistive technology devices get abandoned Goodman et al. (2002). Numerous factors are responsible for this for example, lack of user motivation, changes in users’ medical condition, difficulty in device configuration, device’s appearance, device’s performance, lack of training for the users Goodman et al. (2002), Carmien (2010). Despite costing more than the mainstream technical devices, assistive devices are far behind in terms of aesthetics Shinohara & Wobbrock (2011) and often also in terms of their functionalities. Low appeal and basic functionalities do not contribute to deflect the stigma associated with the assistive technology, rather they attract attention to the impairment Ringland et al. (2016).

The Matching Person and Technology (MPT) model Goodman et al. (2002), suggests that designers should focus on three important factors: i) psychosocial environment, like motivation and facilitation from peers and surroundings ii) personal traits, such as optimism, cooperation, coping skills, willingness for change, and iii) technology itself, its compatibility, usability, portability, and ease of use. Barriers and facilitators have been at the centre of other research Greenhalgh et al. (2013), and factors like age, gender, social status, financial situation, ethnic group have also been recognised as having significant impact on access to information, digital literacy and availability of resources Greenhalgh et al. (2013).

The Technology Acceptance Model (TAM) Davis (1989), the Unified Theory of Acceptance and Use of Technology (UTAUT) Venkatesh et al. (2003) are some examples of the well-

known theoretical contributions in the field. These theories along with the theories that predict human behaviour like the Theory of Reasoned Action (TRA) and the Theory of Planned Behaviour (TPB) Ajzen (1991) have also been used to understand the adoption of technology. With new technology emerging, scholars have modified existing theoretical models to cater for the unique features of emerging technologies Kowalczyk (2018), Yang et al. (2017).

The model proposed in this paper presents concepts and research propositions that bring together secondary research and exploratory primary research. The model is an attempt to modify existing technology adoption and consumer behaviour frameworks to consider the specifics details of the users in questions and the technology considered (ISA). This initial model, explained in detail in what follows, will be driving a future primary data collection to further specify the research propositions it contains.

Given the ability of TPB to be used across different settings Matheison (1991), Heath & Gifford (2002) TPB is the blueprint for the adoption model presented here. TPB states that an individual's behaviour is determined by the individual's intention to perform that behaviour. This behavioural intention is in turn affected by an individual's Attitude, Subjective Norms and Perceived Behavioural Controls (PBCs) Ajzen (1991), Heath & Gifford (2002). A straightforward application of TPB without additions or amendments may not be detailed enough to capture the factors playing a role in the adoption of ISA devices by the specific user group considered in this research.

### 2.1.1 Adoption of Voice User Interfaces

Based on previous research on the adoption of Voice User Interface (VUI), variables contributing towards the adoption of a technology are the context of use, the type of task to be conducted and the user characteristics Easwara Moorthy & Vu (2015). However, due to the innovative nature of the technology and the unique interface modality, ISA may be attributed certain characteristics of anthropomorphism, that may be leading to emotional attachment and recognition and/or assignment of agency Lopatovska & Williams (2018). Therefore, the factors that lead to intention and subsequently adoption of ISA devices, need further exploration.

## 2.1.2 Adoption of ISA Devices

Like any other new technology on the market, several studies have been carried out to understand the adoption and acceptance of ISA devices (also known as Smart Speakers). Academics as well as market researchers looked at different aspects of consumer behaviour around the usage of ISA devices. Given the novelty of ISA devices, such research work is scarce Huag et al. (2020).

One such study Park et al. (2018) investigated the effects of product (functionality, design, brand, price) and platform (service availability, network size, complementarity) characteristics and privacy on the adoption of ISA devices. This study however concluded that, platform related variables have a bigger impact on consumer behaviour as compared to the product related variables.

Similarly, Kowalczuk (2018) modified Technology Acceptance Model (TAM) and added some constructs like, the quality and diversity of a system, its enjoyment, consumer's technology optimism and risk (surveillance anxiety and security/privacy risk). According to the results of Kowalczuk (2018), perceived usefulness, enjoyment, and risk are the most important factors effective the behavioural intentions of a user.

Huag et al. (2020) studied the privacy and security concerns of users in relation to the adoption of smart speakers. According to this study, even though users have concerns about privacy, but it did not affect the adoption of the device. However, security risks seemed to have a bigger impact than the privacy risk.

In another study Ashfaq et al. (2021) investigated the effects perceived coolness of the smart speaker on functional, hedonic, social, and economic values. This in turn affects the user acceptance behaviour of smart speakers. It was revealed that only social values do not play a part in the user acceptance behaviour, which is only affected by hedonic, social, and economic values.

Lau et al. (2018) studied the behaviours concerning privacy around the smart speakers. It was discovered that non-users did not trust the manufacturing companies of smart speakers and did not see the utility of them. Whereas users of the smart speaker either did not understand the privacy risks completely or trusted the smart speaker manufacturing

companies. The users of smart speakers thought of it as a trade-off between convenience and privacy.

Using an adaptation of Technology Acceptance Model (TAM) Cha et al. (2021) studied the effects of Perceived Usefulness, Perceived Ease of Use, Perceived Enjoyment, and Perceived Privacy Risks on the intention to adopt a smart speaker. In addition to that several control variables were also considered such as Gender, Age, Education Level, IPA usage experience, Privacy Invasion Experience, Technology Readiness. The research revealed that perceived usefulness and enjoyment has a positive effect on the intention to adopt. Also, increased perceived usefulness counterbalances the impact of perceived risk on the intention to adopt.

A modified model based on Unified Theory of Acceptance and Use of Technology (UTAUT) was presented by Zaharia & Würfel (2021). In the modified model an additional construct of perceived risk was added. According to the results of this study, hedonic motivation and performance expectancy were the most significant factors effecting the user behaviour. On the other hand, perceived effort expectancy indirectly impacted behavioural intention. The intention to use had a negative relationship with perceived risk. The intention to use smart speakers was less influenced by prior experience with and perceived price value.

Another factor that was also considered significant in the adoption of smart speakers was Interpersonal attraction Han & Yang (2018). In this study, it was concluded that manufacturers should concentrate on creating "human-like" and "professional" assistants in order to increase the adoption of ISA devices. Also, to increase physical attraction to the device, manufacturers should focus on the design and user interface of the device.

Again, Technology Acceptance Model (TAM) was used a basis for a model to understand the adoption of ISA based smart home systems Pal et al. (2021). In this study three additional factors were added, compatibility, perceived complementarity, and privacy concerns. Perceived usefulness, perceived ease of use, compatibility and perceived complementarity had a positive effect on behavioural intention. Income and protection of privacy did not affect purchase intention but affected purchase timing option.



Hence, various studies were conducted that examined effects of different constructs on users' behaviour intention towards adoption of smart speakers (ISA devices). However, majority of these studies focus on mainstream users and not on users with disabilities.

### 2.1.3 Adoption of ISA Devices as Assistive Technology

Although not a lot of studies were conducted to investigate the use of smart speakers (ISA devices) in medical settings or as an assistive technology. However, there are some examples of such studies that can be found in the current literature.

Edwards et al. (2021) studied the use of ISA devices within a care home setting. They examined the effect on the well-being of the care home residents. This study recommended that, as ISA devices are not very expensive and relatively easier to install, so they should be used across the care homes to improve interaction with the residents.

In another study focusing on blind users, Abdolrahmani et al. (2018) examined how ISA devices made interaction with multiple interfaces easier for blind people. However, issues such as privacy and use of ISA devices in a public setting, seemed to effect users' behaviour towards the adoption of ISA devices.

ISA devices were trialled to determine the effect on the health of ageing users with comorbidities Balasubramanian et al. (2021). Ease of use and utility of the device had a positive impact on the adoption of the ISA devices. Age, technical skills, privacy, and health issues were some of the other factors that were explored in the study.

Similarly, there were some studies examined the technology adoption amongst people with disabilities (disabled people) like Kim (2021) specifically looked at technology adoption in older adults with visual disabilities.

### 2.1.4 Target User Characteristics

Initial inquiries from the NTRECES clinical staff revealed that the target user group for this research has the following characteristics:

- They have minimal exposure to technologies available on the market due to their mobility impairments. Most of their exposure to market and innovations is through, friends, family, caregivers and the media.

- Their adoption or acceptance decision about a technology differs from the norm as their assistive technology devices are funded by the NHS.

Technology adoption literature has little contribution to make towards the understanding of technology adoption behaviour by users with disabilities Djamasbi et al. (2006) and this is the intellectual gap that this research contributes to.

## 2.2 A Proposed Model of Adoption of ISAs Among Severely Disabled Patients

The underlying assumption of this research is that understanding the factors that influence users' behaviour may directly impact the design of the technologies in both their functional and non-functional requirements and may suggest improvements in the service provided by RECES in the UK. A model that is realistic enough to the phenomenon under study is presented in figure 4.

### 2.2.1 Model's Components

The model proposed here proposes:

- A set of factors, here named User Characteristics, that are determinants of attitude and of PBCs.
- An extended and modified list of items that constitute PBCs.
- An extended and modified set of items defining Subjective Norms.
- An additional set of items linked to the quality of the interaction with ISA devices, here called Voice Interaction Experience

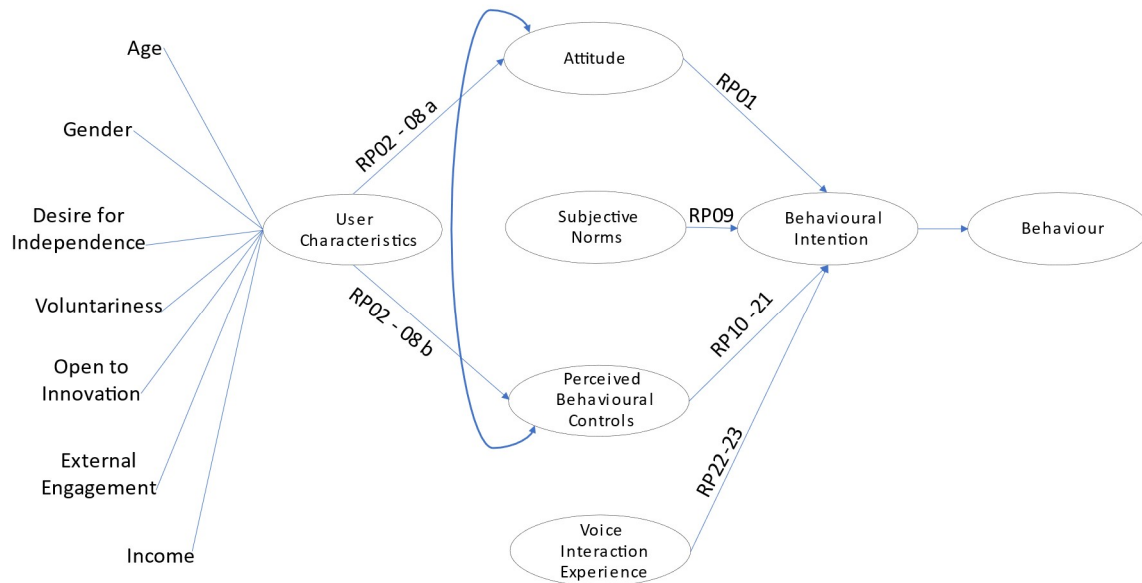


Figure 4: User Characteristics Variables, Components and top-level relationships of the proposed model

## Attitude

If a user has a positive attitude towards a certain behaviour or towards adoption of a certain technology, then the user develops a positive intention towards said behaviour Ajzen (1991), Davis (1989). Scholars demonstrated that a positive user attitude leads to the adoption of smart speakers Chu et al. (2019). Similarly, here it can be stated that:

**(RP) 01:** Positive attitude towards ISA devices is associated with the intention to adopt them.

## User Characteristics

As indicated by existing literature, users' personal characteristics play a significant part in the uptake or abandonment of technology Goodman et al. (2002), Samaradiwakara (2014). The user characteristics considered relevant are listed below. In the proposed model the user characteristics affect both Attitude and PBCs as depicted in Figure 5 and 6.

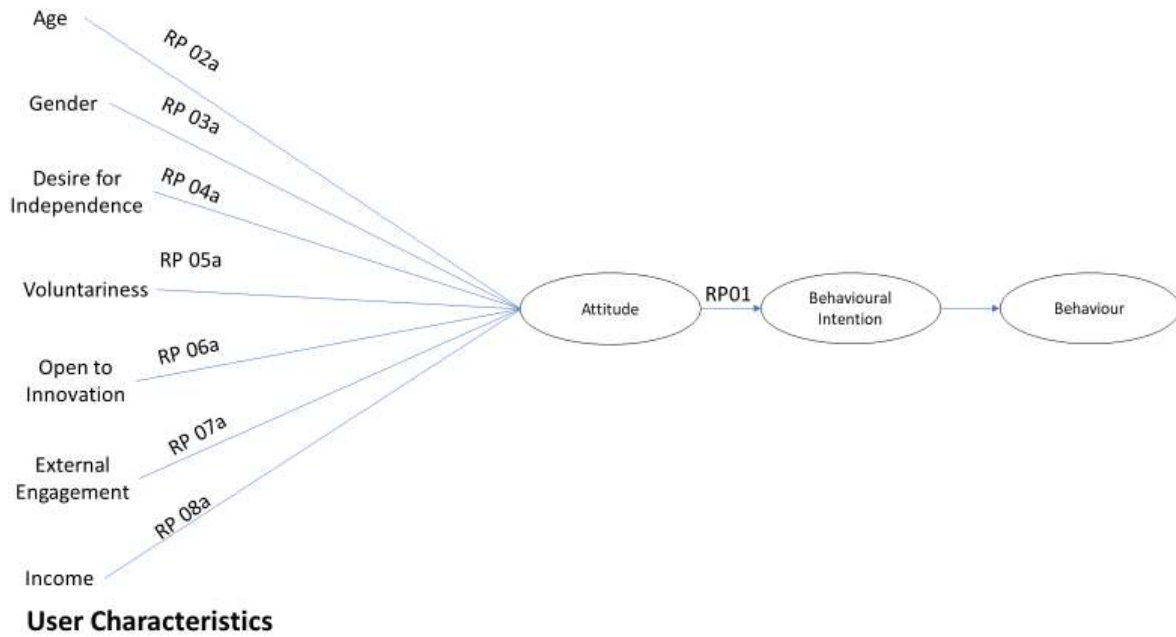


Figure 5: Research propositions 02a - 08a, user characteristics effect on attitude

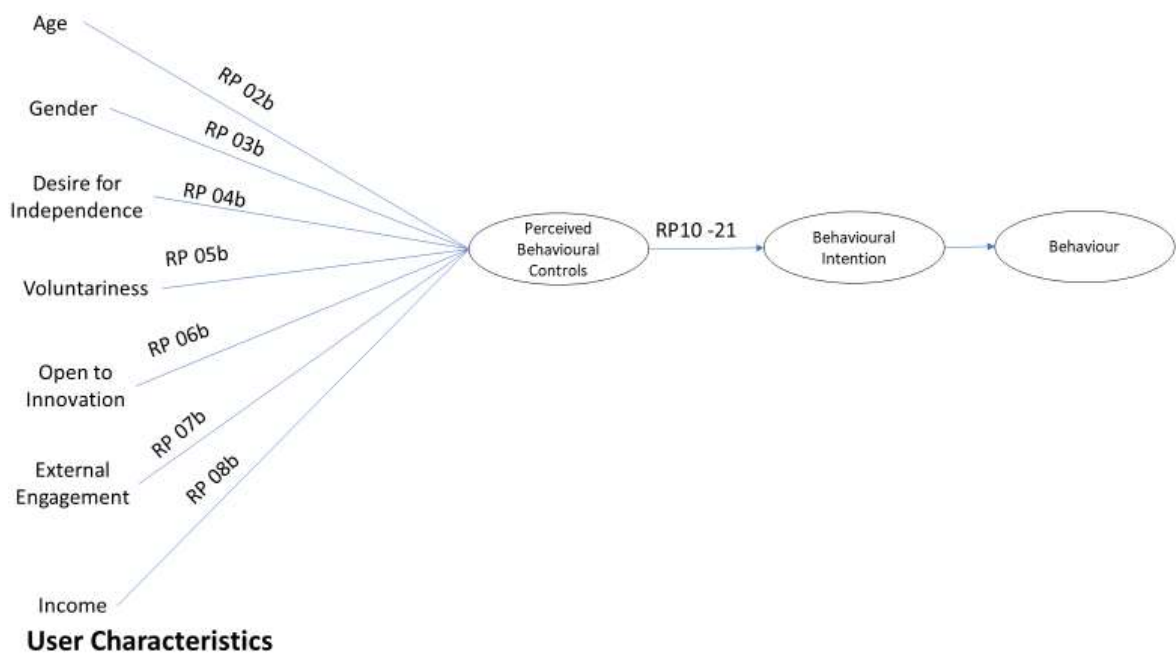


Figure 6: Research propositions 2b – 8b user characteristics effect on PBCs

## Age

Age has been a very important variable in studying technology adoption. Elderly population is generally considered as technology laggards, but this is not always the case Conci et al.

(2009). During the shadowing of NTRECES staff it was observed that age seemed to play a part in the enthusiasm users felt for new technologies. Elderly users perceived new technologies difficult to use, as with age the learning curve becomes steeper, due to sensory, motor and cognitive changes Conci et al. (2009). As this may still be valid with people with severe mobility impairments, it is proposed that:

RP02a: Old age has a negative effect on the attitude towards intention to adopt ISA device.

RP02b: Old age has a negative effect on PBC.

### Gender

It is a general perception in the literature that females are not early adopters of technology. According to previous studies, women are less likely to adopt a new technology than men Li et al. (2008). Similarly, women have less confidence in their abilities to use new technologies. This consequently affects their perception of ease or difficulty of adopting new technologies Li et al. (2008). However, this is not a universal finding, and this concept is changing with time Li et al. (2008). The proposed model accepts this hypothesis as valid also for ISA and states that:

RP03a: Females have a negative attitude towards intention to adopt ISA device.

RP03b: Females have a negative effect on PBC.

### Desire for Independence

According to previous studies Kintsch & Depaula (2002), one of the characteristics of successful adoption of assistive technology is that the user must have a desire for independence. User who want to change the activities they can currently perform to do more, to attain independence have a higher chance of adopting an assistive technology to help them achieve their goals. In this study, desire for independence will affect the users' attitude to adopt the ISA device positively. Similarly, a desire for independence will also influence the perceived ease or difficulty in adoption of ISA devices. Moreover, the desire to be independent can motivate the user, hence reducing anticipated difficulties.

RP04a: Desire for independence can positively influence attitude towards intention to adopt ISA device.

RP04b: Desire for independence can have a positive effect on PBC.

## Voluntariness

People who are willing to try a new technology tend to have a positive attitude towards it instead of the people the technology has being forced upon. According to Agarwal & Prasad (1997) voluntariness is a significant factor in users' adoption of technology. In the same way users' willingness to adopt a new technology reduces the perceived barriers towards adoption. It is proposed that:

RP05a: Voluntariness to try a new technology have a positive attitude intention to adopt ISA device.

RP05b: Voluntariness to try a new technology have a positive effect on PBC.

## Open to Innovation

Individuals who are more receptive to new solutions and ideas and want to try new things tend to have a more positive attitude towards technology. This is known as open to innovation. Users with a higher degree of innovativeness tend to be early adopter of technology Laukkanen & Pasanen (2008). Similarly, users who are more open to new ideas and technology will also perceive easier the adoption of new technology.

RP06a: Openness to innovation leads to a positive attitude towards intention to adopt ISA device.

RP06b: Openness to innovation has a positive effect on PBC.

## External Engagement

Whilst shadowing the NTRECES staff on their patient visits it was observed that, patients who have higher external engagement, for example, work, hobbies, support groups etc. have a positive attitude towards technology. They viewed technology as a means to support their various activities, to which their access is otherwise limited due to their mobility impairments. Users' external engagement also acts as a motivation for them to adopt new technology.

RP07a: Users with higher external engagement have positive attitude towards intention to adopt ISA device.

RP07b: a higher level of external engagement has positive effect on PBC.

## Income

Level of wealth has been identified as one of the factors, that can determine better access to technology and as a result positive attitude towards it Feder et al. (1985). Users who have higher disposable income and higher purchasing power find it easier to adopt a new technology as compared to users with lower purchasing power.

RP08a: Users with higher income have a positive attitude towards intention to adopt ISA device.

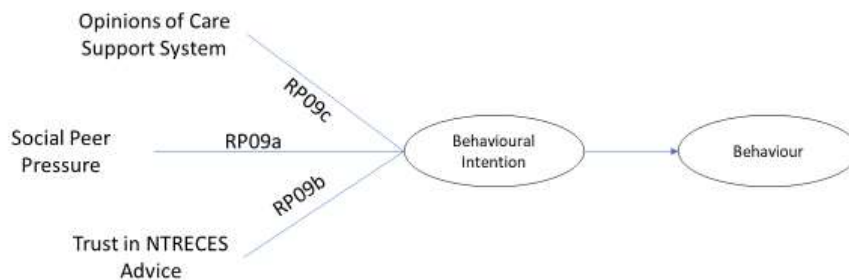
RP08b A higher income has a positive effect on PBC.

## Subjective Norms

According to the TPB, the opinion of the people who are important to the user, is vital in forming one's intention. Yang, Lee and Zo established in their study Yang et al. (2017) that if the users perceive that the people who are important to them think they should use smart home services then it will result in the intention to use smart home services. This model suggests that:

RP09: There is a positive relationship between Subjective Norms and the Intention to adopt ISA devices.

There are three items included in Social Norms, these are listed below. The variables that constitute Social Norms are presented in Figure 7.



### Subjective Norms

Figure 7: Research proposition 09a - 09c effect of subjective norms on behavioural intentions

#### Family and Peer Pressure

As stated above, SN is formed by the perceived opinion of people who are important to the users Ajzen (1991). In addition to the group of people providing care to the users, there are also other friends, family and associates (support group, clinical staff), whose opinion can be significant to the users in question. Therefore, this model proposes:

RP09a: Social peer pressure positively affects the intention to adopt ISA device.

In a study conducted by Luijkx et al. (2015) influence of family members in the selection of technical devices and their usage was determined. In the majority of cases, spouses, children, and grandchildren played a vital role in the selection and purchase of a device.

#### Trust in NTRECES Advice

One other factor that plays a significant part in SN is the clinical staff of NTRECES as they are the provider of all assistive technologies the patients are equipped with. During the first visit by NTRECES staff, patients are given a demo of the EC devices and how the technology can support them. The opinion of NTRECES and their advice affect the decision-making process of the potential users. If the users trust the advice of NTRECES staff, then it will act



as a positive subjective norm towards the adoption of ISA device. Therefore, this model proposes:

RP09b: Trust in NTRECES advice is positively associated with intention to adopt ISA device.

### Care Support System

The group of users in this study are suffering from a mobility impairment. They receive care and support for their daily living, either by their family, NHS or privately hired caregivers. The views and opinions of their caregivers can have a high influence on the forming their subjective norms. As stated in TPB subjective norm is the users' perception about, what do the people (who are most important to them) think Ajzen (1991).

RP09c: There is a positive relationship between the opinions of those who provide care and support and the intention to adopt ISA devices, specifically if caregivers are enthusiastic towards ISA devices, the users will form a positive intention to adopt.

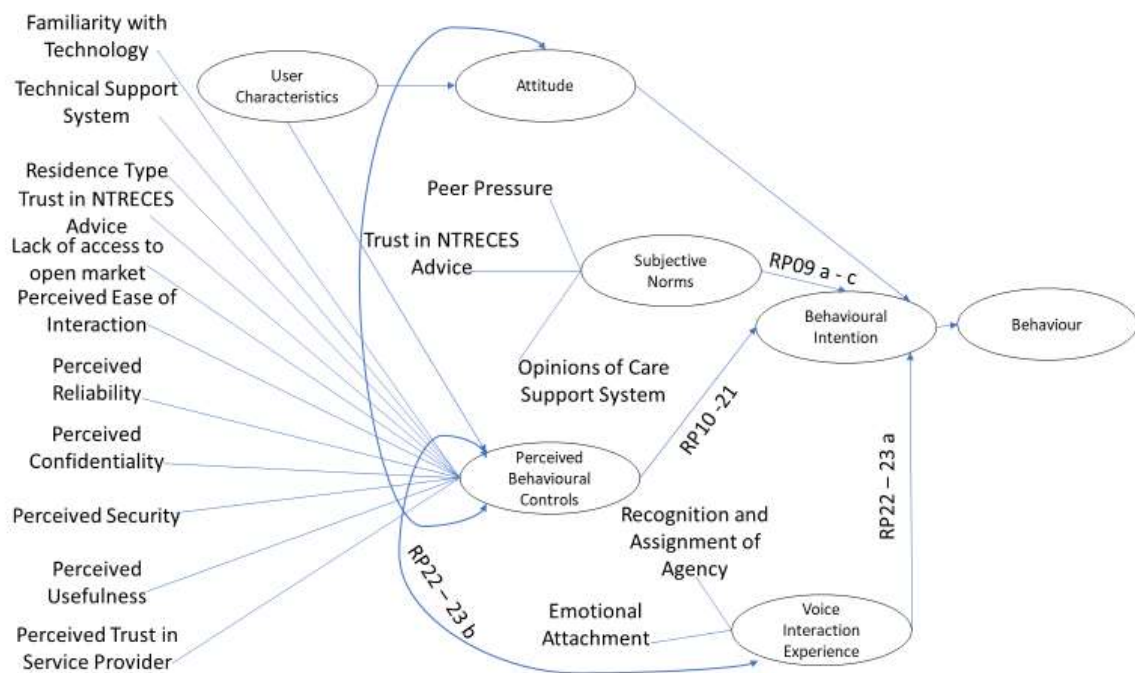


Figure 8: Subjective Norms, Perceived Behavioural Controls and Voice Interaction Experience Variables integrated in the proposed model.

### Perceived Behavioural Controls

PBCs are the users' perception of how difficult or easy it is to perform a certain behaviour, in this case to use ISA devices. This perception is based on previous experience and anticipated obstacles Ajzen (1991).

In exiting literature PBCs have been demonstrated to have a positive effect on behavioural intention Yang et al. (2017). In line with previous work, the model here proposes that:

RP10: PBC is positively associated with the intention to adopt ISA devices.

Extending and applying the definition of PBCs by Ajzen (1991) to the context of this study, several factors that constitute PBS has been identified. These are listed below. PBCs' factors are contextualized in Figure 8 and listed in Figure 9.

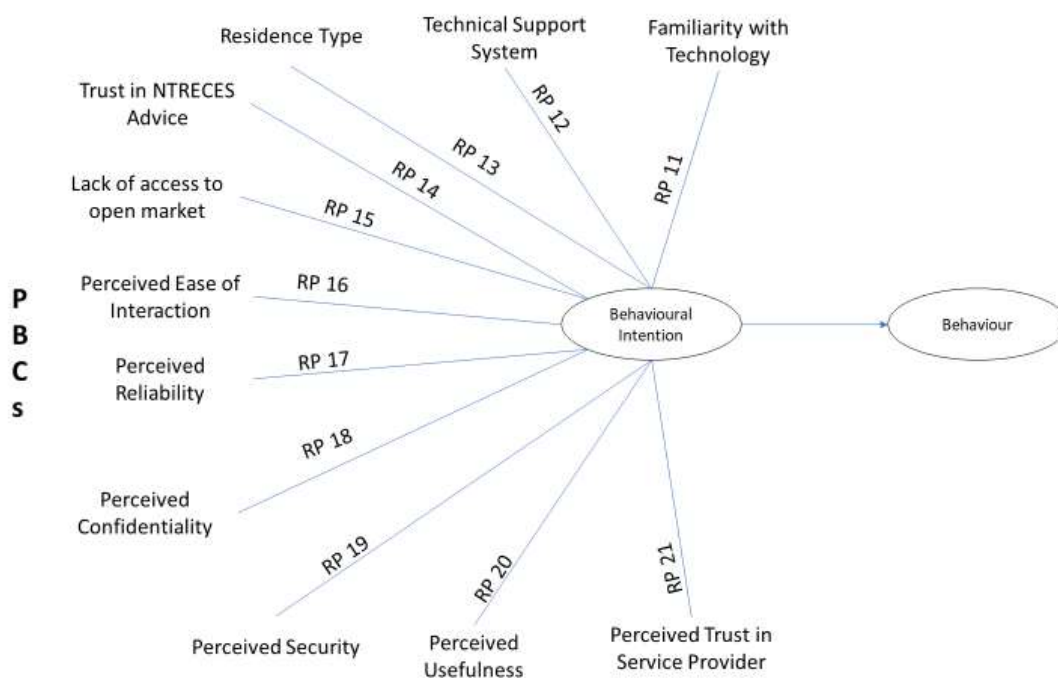


Figure 9: Research propositions 11 – 21 effects of PBCs on behavioural intention.

### Familiarity with Technology

During initial observations it was observed that patients with an existing familiarity with technology were more open towards newer device options and functionalities. They perceive the devices easier to use.

RP11: There is a positive relationship between familiarity with technology and intention to adopt ISA device.

### Technical Support Network

One of the reasons for high abandonment of assistive technology is its lack of customization and integration. Users found it very difficult to install and customize their assistive devices, on their own, hence leading to rejection and abandonment Goodman et al. (2002). This can

be mitigated by the presence of a technology support network around the users, hence reducing the obstacles in the way of adoption of technology.

RP12: Users with a good technical support network have a positive intention to adopt ISA device.

### Residence Type

One of the major factors constituting the surrounding of the user is their living space. Some of the users live in privately-owned residences and some are in government funded housing schemes. According to the staff at NTRECES, sometimes there are obstacles in installation of peripheral devices due to the residence being owned by a government department. This can be counted as a hurdle towards forming an intention to adopt technology.

RP13: Users' residence owned by a housing association negatively effects the attitude towards the intention to adopt ISA devices.

### Trust in NTRECES Advice

The participants in the study had been issued EC devices by the NTRECES. Before issuance of any device, the NTRECES staff demonstrate different options available to the patients. They also give advice on what sort of devices are more suitable for a particular patient. Trusting the advice and decision of NTRECES staff about the technology assigned to them can be a major factor in the adoption and usage of the EC devices.

This resolves in:

RP14: Trust in NTRECES advice leads to a positive attitude towards the intention to adopt ISA devices.

### Lack of Access to Open Market

Due to physical constraints imposed by the disabilities of the study participants it is often logistically difficult for them to directly explore the new technological devices available on the market. Although, they might get information about new devices through the internet, print media and TV, the only way they can physically interact with the device is when friends and family or the clinical staff of NTRECES bring the device(s) to them. The user's exposure is limited both in range, as they cannot explore the full variety of the devices on sale, and in

depth, as their physical interaction is limited because it is controlled and mediated by a third party.

RP15: The lack of access to the open market has a negative effect on the intention to adopt ISA devices.

### Perceived Ease of Interaction

One of the discerning points of ISA devices is the interaction through voice. Existing EC devices use a 'one click switch' scanning method to interact with the devices. The switch scan method is lengthy and cumbersome, whereas interaction through voice can be considered easy and natural. As mentioned in TAM Davis (1989), Perceived Ease of Use (PEoU) directly drives the attitude towards intention to adopt technology adoption.

Similarly, the Perceived Ease of Interaction (PEoI) affects the attitude positively towards the adoption of ISA device. Moreover, according to TPB perceived ease of a certain behaviour positively effects the PBC towards that behaviour. Hence, PEoI positively effects the PBC towards the adoption of ISA device.

RP16: PEoI leads to positive attitude towards intention to adopt ISA device.

### Perceived Reliability

In the case of assistive technologies, they need to be reliable in emergency situations Goodman et al. (2002). These devices and technologies are used by people who are vulnerable. It is not affordable that, if in a situation of emergency these assistive devices fail to perform.

RP17: Higher perceived reliability leads to positive intention to adopt ISA device.

### Perceived Confidentiality

ISA devices are continuously listening to the users so that they can respond swiftly to the wakeup word. Users of ISA devices then need to trust the manufacturers that their private conversations, as well as their commands to ISA devices are kept confidential and are not used for any other purpose Yang et al. (2017). In this study, the potential users have significant mobility impairments. If the users perceive the devices to be trustworthy then, it will be easier for them to form an intention to adopt it.

RP18: Higher perceived confidentiality results in a positive intention to adopt ISA device.

### Perceived Security

All smart home devices installed in the residential settings of NTRECES patients as well as the ISA devices are connected to each other using the home Wi-Fi network. However, there is always a possibility that these devices can be hacked. By this it is meant that malicious entities can have access to confidential information. Given the vulnerability of the users in this study, it is of utmost importance that they perceive the technology to be secure in line with what has been identified by Jutai & Day (2002). Kowalczyk (2018) has established that Users of ISA devices fear that malicious entities can access their data and this poses as a risk to their security.

RP19: Higher perceived security has a positive impact on intention to adopt.

### Perceived Usefulness

According to TAM Perceived usefulness directly influences users' intention towards adoption of technology Davis (1989). One of the major aims of assistive technology is to enable its users to accomplish more Kintsch & Depaula (2002). Higher perceived usefulness will also affect the users' intention to adopt the technology.

RP20: Higher perceived usefulness leads to a positive intention towards adoption of ISA device.

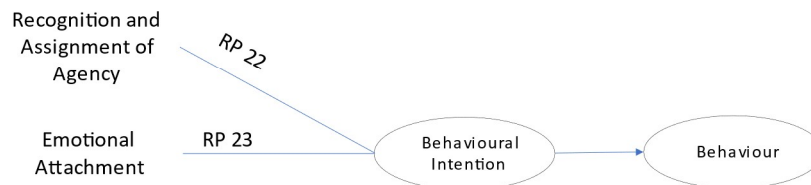
### Perceived Trust in Service Provider

The internet is a vital component for the ISA device to function properly. In some cases, users fear that by using internet they are exposed to malicious entities and their information is not secure anymore Chung et al. (2017). In this study the users are vulnerable and need to trust the internet service providers, that their information remains secure and confidential.

RP21: Perceived trust in service provider leads to a positive intention towards adoption of ISA device.

### Voice Interaction Experience

Recognizing the value of intuitive interaction facilitated by natural language, this study proposes a construct, Voice Interaction Experience, that acknowledges the unique characteristics that VUI enable Lopatovska & Williams (2018). These are included in the presented model (Figure 10) and are described below.



### Voice Interaction Experience

Figure 10: Research proposition 22a - 23a and 22b - 23b effect of voice interaction experience on behavioural intention and PBCs.

#### Recognition and Assignment of Agency

It is natural for people to treat things that talk back to them as humans Klein (2016). Perception of anthropomorphism in a technology will result in the increase in credibility, reliability and perceived usefulness hence leading to a positive behavioural intention Wagner et al. (2019).

RP22 Identification and assignment of agency to ISA devices will positively affect the intention to adopt the ISA device.

#### Emotional Attachment

The functional aspects of the device users' experience also encompasses the hedonic aspects of the interaction with the device, like pleasure and emotion, in addition to satisfaction and usefulness experience Knijnenburg et al. (2012). Given that the interaction with ISA are based on natural language, this work postulates that there will be the formation of an emotional attachment to the devices. Therefore:

RP23 The Greater the emotional attachment to the ISA devices, the stronger the intention to adopt the ISA device.

## Chapter 3. Research Methodology

### 3.1 Introduction

Person-centred design of technology revolves around the consumer of the technology Mallin & Carvalho (2015). In this approach, users are not simply asked about their needs, but it is the duty of the designer to enable the users to express themselves in a way, which can lead to innovation and generation of new ideas Felipe & Luna (2017). As mentioned in the previous chapter design of assistive technology lacks involvement of users during the design phase Williamson et al. (2015). Involving users during the design phase can lead to decrease in abandonment of assistive technology and greater user satisfaction Martin et al. (2011).

The literature review conducted in the previous chapter highlighted the factors that are important in the adoption of an ISA based device especially by users with mobility impairments. This chapter will focus on the methodology of how this research will be conducted. The factors identified in the research model will be investigated with the help of tools identified in previous studies available in the literature. This addresses objective two of this research “To create a data collection tool to reflect the factors identified in the model.”

The first topic of discussion in the chapter is the design of the research especially the choice of qualitative methods to conduct this study. The second topic of discussion in this chapter is, as mentioned above, the design of the data collection tool with respect to the proposed research model. The use of semi-structured interviews in this study, followed by data analysis, to support or modify the proposed research model will be further explained in this chapter.

### 3.2 Research Methodology

Out of the three types of research design qualitative, quantitative, and mixed, this research study follows the qualitative research paradigm. In order to make sense of phenomena or interpret them in terms of the meanings that people assign to them, qualitative researchers investigate things in their natural environments Jones (1995). Qualitative research approach focuses on understanding peoples’ perceptions and experiences mostly accessed via observations, interviews, and narratives Blandford (2013). This study focuses on identifying

the factors that can be significant in the adoption of an ISA based EC device through an exploratory approach. Data is collected and analysed via a mix of deductive and inductive reasoning process. Following the deductive reasoning, the research hypothesis proposed in the research model were then analysed against the data collected via semi-structured interviews. The research model was then modified through inductive reasoning according to the findings of data analysis.

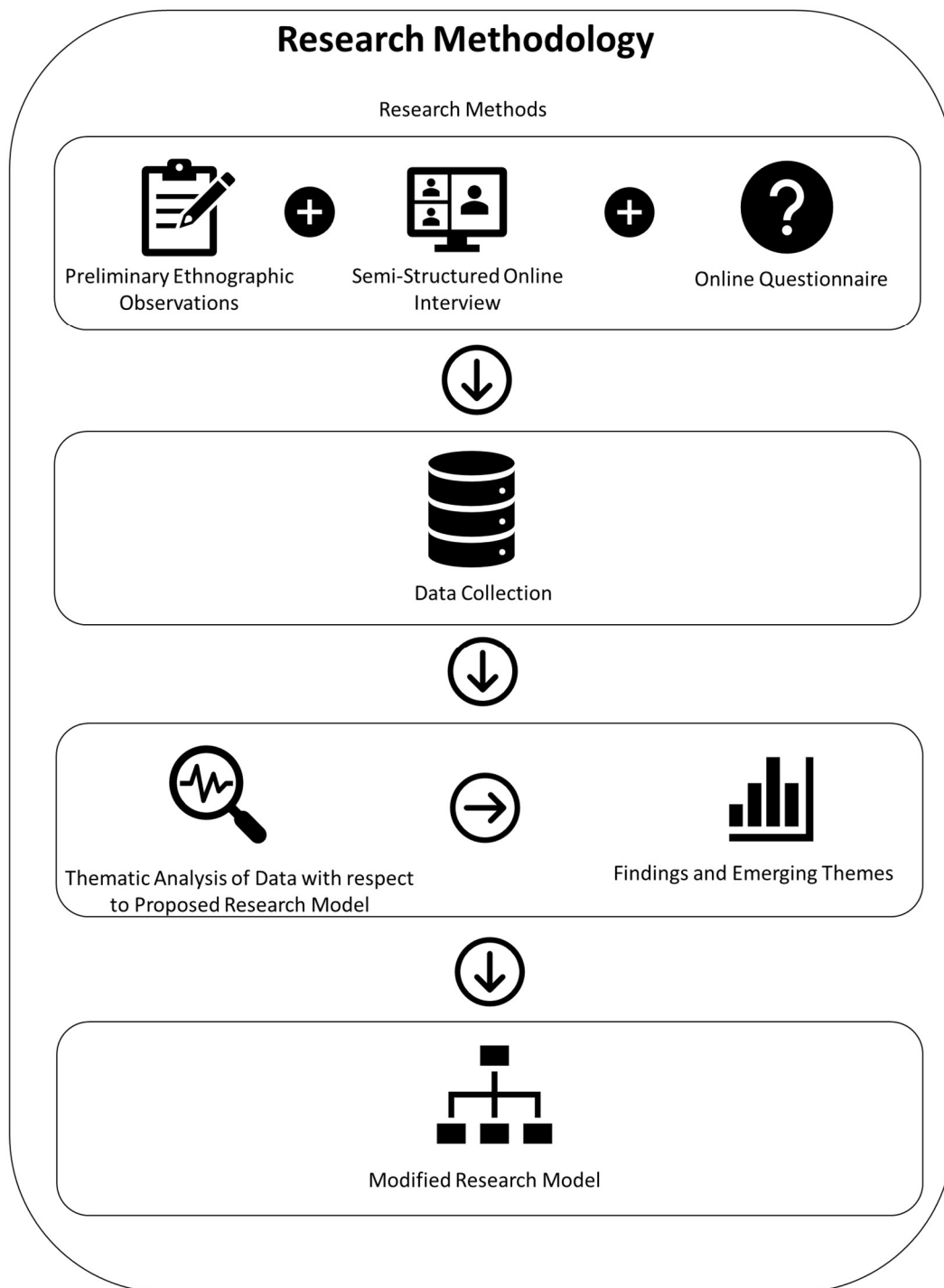




Figure 5: Research Design

### 3.3 Research Methods for Data Collection

The choice of method to collect data is dependent largely on researcher's choice due to limitations of the study settings and nature of the problem Berg & Lune (2017). One of the limitations of this study is the highly selective eligibility criteria. Due to which the sample size was limited to no more than 15 participants. Moreover, the limited mobility of the perspective participants excluded certain data collection methods like focus groups and diary entries. In order to collect context rich data, it was imperative that observations and investigations to be carried out at the participants' place of residence. Hence initially it was proposed, to enlist 15 shortlisted NTRECES patients. The initial protocol included three visits to each participant at their place of residence. The repeated visits over a course of 6 months were designed to enable the collection of deep insights in the characteristics, socio-technical environment and requirements and aspirations of the users. The final outcomes of this study would have consisted of a refined model for the adoption of ISA devices among patients with severe mobility impairments and a set of design and service improvements that would enable the adoption of ISA technologies as assistive devices.

However, due to the covid-19 pandemic, the data collection method had to be revised. Due to the vulnerability of the participants, the residential visits were replaced by online semi-structured interviews and questionnaires.

#### 3.3.1 Data Collection Tool

In order to investigate the research hypothesis proposed in the research model, an interview guide was developed. The main themes in the interview guide reflected the variables within the proposed research model. In order to investigate the themes guidance was sought from existing literature and preliminary ethnographic observations. In chapter 2 justification for the inclusion of each variable in the research model was given. In this chapter how each variable of the research model is investigated will be stated.

#### User Characteristics

The user characteristics proposed in the research model are listed below.

## Age

For age specifically no extra questions will be asked as it will be provided by the NTRECES team.

## Gender

Similarly for gender, specifically no extra questions will be asked, it will be provided as part of initial information provided by the NTRECES staff.

## Desire for Independence

To investigate the desire for independence the focus will be on the following points:

1. What independence means to the participant?
2. How independent do they feel?
3. Do they have a desire to be more independent?
4. How can the new device (ISA based EC) can help them in achieving it?

The UN Disability Rights Convention defines independent living for people with a disability. According to the convention, people with a disability should have the same choice, control, and freedom as every other person. It does not mean that they should be able to do all tasks without help or assistance, but it means that any assistance or help required should be their personal choice and not be imposed on them Parker & Clements (2008). Hence, the idea of independence will differ from person to person. So, the first question to be asked should be:

1. What does independence mean to you?

The next question should be related to how independent they actually feel. This would enable, the researcher to determine if the participant is currently satisfied with the level of independence or not?

2. Can you list the activities that you are able to do and for you represent independence?

The reply to this question will then be linked to how much independent a participant feels and what do they actually feel independent in doing.

It will be followed by a question about their inability to do a certain task and whether it makes them feel less independent and do they ask help from caregivers.

3. Can you list activities that you are unable to do?

4. Does it make you feel less independent?
5. Do you ask help from your caregivers in those tasks?

The above list of questions can produce a list of tasks that are important for the independence of the participant. By asking the participant to rate these tasks in order of importance and his/her ability to undertake them, participant's desire for independence can be figured out.

6. In the list below can you order the tasks that you consider more important for your independence and tick the box if you are able to undertake them:

Task	Importance for independence (1to 5)	Able to do	Unable to do
Walking			
Bed / Chair Transfers			
Eating			
Personal Hygiene			
Shopping			
Make and receive calls			
Community Travel			
Medication Management			
Financial Management			
Switch lights on and off			
Use of PC			
Bed Controls			

It is possible that a participant that feels very independent but is unable to do the most important task.

7. With 1 being the least and 5 the most, how independent do you feel? (Then this value will be correlated to answers of further questions, that will further explain representation of independence for the participant.)
8. What are the tasks that you are currently unable to perform and that would enhance your sense of independence?

## Voluntariness

In order to determine people's voluntariness, participants can be asked about how they ended up using the EC system, did someone for example, their doctor, a family member, physio therapist etc convinced them into requesting one.

1. How did you learn about EC service (NTRECES)? Was it recommended by someone? Can you tell me how the EC service was prescribed for you?
2. On a scale of 1 to 5 how free do you feel in the decision of using the EC device?
3. How did you feel about the EC device before it was installed in your home?
4. How do you feel about it now?
5. How did you go about learning to use it? (if they discovered and learnt by themselves there was more voluntariness).

## Open to Innovation

The questions regarding open to innovation will be targeted towards determining how the participants feel towards trying new things and technology.

1. How do you feel about trying new technology?
2. On a scale of 1 to 5 (where 1 is never and 5 is always) how comfortable are you with change (in routine or life in general)?
3. On a scale from 1 to 5 (where 1 is never and 5 is always) how often do you try new things?

On a scale from 1 to 5 (where 1 is never and 5 is always) how often do you try new technology before your friends and family?

## External Engagement

Questions regarding participants' career status as well as hobbies and social activities can give an indication of their external engagement.

1. Are you in paid employment at the moment?

If yes

- a. What is your occupation?
- b. How long you have been working in this occupation.
- c. How many hours
- d. Do you always work from home?

If no

- e. How long has it been since you have undertaken paid work?
  - f. Can I ask you the reason you were unable to continue working?
2. Can you name a few of the activities for which you have to leave your house?
  3. On a scale of 1 to 5 (where 1 is never and 5 is every day) how often do you connect with people from outside of your household (friends, peers) through phone, email, video call for (catchup, hobbies, support group, leisure/sports activities)?
  4. On a scale of 1 to 5 (where 1 is low and 5 is high) how connected do you feel to the outside world?
  5. In your opinion, how have the EC devices helped you in your work tasks and your social life?
  6. Is there anything you would change in the setup to make it easier for you or improve your connectivity?

### Income

Specific questions can be asked to get an estimate about the participants' income. Questions related to other variables will give clues about the participants' attitude which can be used to verify the relationship between income and attitude listed in the research proposition. People with higher and lower incomes and their attitude towards technology adoption can then be compared.

- Are you in paid employment at the moment?  
If yes,
  - a. what is your occupation?
  - b. how long you have been working in this occupation.
  - c. How many hours
  - d. Do you always work from home?
- If no,
  - e. How long has it been since you have undertaken paid work?
  - f. Can I ask you the reason you were unable to continue working?

### Subjective Norms

There are three items included in Social Norms, these are listed below.

### Family and Peer Pressure

In a study conducted by Luijkx et al. (2015) influence of family members in the selection of technical devices and their usage was determined. In the majority of cases, spouses, children, and grandchildren played a vital role in the selection and purchase of a device.

Participants will be asked to choose 1 device from around the house that is the most important to them. This should be followed by the questions regarding their purchase process and how much do they use it and for what purpose.

1. Do your family and friends/carers suggest what technology to buy?
2. Do you welcome their suggestion?
3. Do you ask for help? If so why. If not why?
4. Can you give me an example of a device that you bought because it was suggested to you?

So, two important devices can be identified, and it can be determined if there was peer or family pressure involved in its choice, purchase, or usage. The influencing factors in the purchase and usage of technology can be identified. Then it can be determined if those influencing people also have these new ISA devices. If so, then it might be a positive step towards acquiring these devices into the future.

### Trust in NTRECES Advice

By determining how much the participants trust the NTRECES staff and then trying to determine if that trust is a factor in the way they use their current devices. If they had conflict from the beginning but if they trusted the staff and accepted the device given to them or they didn't accept it and are not using it as much as they have disagreement with staff and they don't trust them.

### Care Support System

To determine the importance of opinion of care support system to the participants, following questions can give some idea.

1. On a scale of 1 to 5 how much the opinion of your caregivers matter to you? Why?
2. Can you please give an example of a decision or action that was influenced by the opinion of your caregivers?

So, if the opinion of the caregivers matters a lot to the participants then, they can be asked what the caregivers think about the ISA devices and then maybe they can influence them into accepting the ISA based EC device.

### Perceived Behavioural Controls

Extending and applying the definition of PBCs by Ajzen (1991) to the context of this study, several factors that constitute PBS has been identified. These are listed below.

### Familiarity with Technology

In order to determine the relationship between familiarity with technology and adoption of technology, the participants will be asked two types of questions. One targeted at finding out how familiar the participant is with different technological devices. The second one targeted at the adoption and use of their EC devices. If the participants use only EC and not much of other technologies, perhaps they will be less ready and flexible with other technology.

In order to determine a participant's familiarity with technology or technology competence targeted questions will be asked, about all types of technology present around them. This can be technology related to household activities like washing machine, for entertainment like DVD player, for Personal care, for DIY, data, and communication etc. Rosenberg et al. (2009).

1. On a scale of 1 to 5 (where 1 is low familiarity 4(inc) medium familiarity and 5 is high familiarity) can you rate the following devices.

Technology	Familiarity
1. TV	
2. Mobile Phone	
3. Laptop / Desktop	
4. Tablet	
5. Smart Speaker	
6. CCTV	
7. DvD Player	
8. Smart Watch	
9. Games Console	
10. Satellite / Digital Radio	

2. Can you tell me about any issues you had with any of these devices?

3. If the PC or Laptop or any other computer devices have not been mentioned already then ask the following questions separately:
4. Do you have internet availability at your home?
5. Do you have a PC or a Laptop at home that you use?
  - a. How often do you use it? Once twice thrice a week daily
  - b. What do you use it for? Email browsing entertainment (music / video) shopping account banking social media work skype hobbies others
  - c. Do you have any difficulties in operating your PC? Can you tell me the most important one?
  - d. Do you have specialised hardware for using your PC? For example, eye tracking mouse or mouth operated IntegraMouse.
    - i. If answer is yes, what, and why?

The second type of questions will be related to the use of EC devices:

6. What EC device was given to you initially?
7. Are you still using the same device, or has it been replaced or updated? Why?
8. How long you have had this equipment for?
9. How often do you use it?
10. What do you use it mainly for?

#### Technical Support Network

To determine the kind of technical support and its effect on technology usage and adoption the following questions can be asked from the participants.

1. What was the most recent device you have purchased?
  - a. Did you make the decision alone or sought someone's help and assistance?
  - b. Did you require some training before starting to use the device? If yes, who provided the training?



- c. Have you ever abandoned a device on the basis of technical issues, for example, unable to customize font size, cursor speed, change input method from conventional keyboard and mouse to eye gaze or voice?
2. In case of a technical difficulty either with your EC device or any of your other equipment, who do you contact?

### Residence Type

Information about residence type will be provided as part of initial information by the NTRECES staff.

### Trust in NTRECES Advice

1. On a scale of 1 to 5 (where 1 is very little to 5 is a lot), how much do you trust the advice of NTRECES staff.
  - a. Can you give a reason for your trust or lack thereof?
2. During the demonstration visit (first visit of NTRECES staff) did you and the NTRECES staff agree about the devices most suitable for you?
3. Do you think that trusting the advice of NTRECES has been a factor in your adoption and use of your EC device?

By determining how much the participants trust the NTRECES staff and then trying to determine if that trust is a factor in the way they use their current devices. If the participants trust the NTRECES staff, they might have accepted the device assigned to them, even if they disagree with the assessment of NTRECES staff. But if the participants distrust the NTRECES staff and also disagree with the NTRECES staff's assessment, then they might not have accepted the device assigned to them and end up not using it as much.

### Lack of Access to Open Market

The access of participants to open market before and after the pandemic can be determined with the help of the following questions.

1. If you want to purchase something what is your preferred way of purchase?
2. Can you please walk me through a recent process of purchase, preferably a technology or an appliance?

3. How would you describe this process? What is effective and what is frustrating?
4. Do you feel that you would have made a different purchase decision if you were able to browse all the variety of products available, and physically interact with it?
5. Do you feel that if you can browse through the items of your interest, you are more inclined to purchase?

The focus here is that the participants are limited in their access to technology in retail, they don't have the choice to interact with it in reality before deciding to buy it. Or they can't browse the whole variety and make up their mind by viewing things in the real world. From previous questions in the interview information is obtained about different types of technologies in their use and issues related to their access to market. So, a comparison can be drawn between their control of market experience and inclination to purchase or use technology.

#### Perceived Ease of Interaction

Targeted questions will be asked from the participants regarding their perception about ease of interaction with ISA devices and compared with the ease of interaction with EC devices. Also, the enjoyment factor of using ISA devices as compared to the EC devices, will be investigated.

1. Can you tell me of a technology that you use, and you find easy to use?
2. Have you ever replaced it?
3. If so, how much on the scale of 1 to 5 (where 1 is very little to 5 is a lot), ease of use counted in your decision to replace it?
4. Can you describe in your own words what it means for a technological device to be easy to use?
5. On a scale of 1 to 5 (where 1 is very little to 5 is a lot) how much easier (do you think) is voice interaction as compared to conventional input methods?
6. Given the choice what method of interaction you would choose for what? voice or conventional?

It is going to be analyzed that Perceived Ease of Use (PEoU) for general technology leads to positive attitude in general. If this relationship works for a digital radio (it is perceived as easy to use and they would buy it) they would do the same, normally, for other technology.

## Perceived Reliability

A device would be considered reliable if it functions correctly according to its technical capability, without interruption, has systems in place to recover from shutdown, has reliable privacy protection and information security Kim et al. (2015).

According to a previous study by Judge et al. (2009) reliability of the devices were not an issue for functions such as changing TV channels but was an issue for critical functions such as call for help. So, participants often had switch operated backup systems for their voice-controlled EC systems.

So, the focus of the questions will be how reliable the participants think their technological devices are and how will it affect their decision to use them.

1. If you are asked to rate different devices in your house on the basis of reliability, on a scale of 1 to 5, which device would you rate the highest?
2. Can I ask why? Which features of the device makes it most reliable?
  - i. It performs seamlessly without interruptions.
  - ii. It does not shut down abruptly.
  - iii. It has backup in case of emergency.
  - iv. Alerts you that it is down.
3. What rating between 1 to 5 (where 1 is low and 5 is high) would you give to your EC device for reliability and why? Which feature makes it unreliable or reliable (from i to iv)
4. Has there been an instance when your EC device failed to perform? If Yes can you, please tell me about the incident.
5. How would you rate the reliability of ISA Device (Alexa) between 1 to 5? Which features make it reliable or unreliable?

Device	Reliability Rating	Reliable Features	Un Reliable Features
Generic Technological Device			
Existing EC Device			
ISA Device			

On the other hand, it must also be investigated how much the participants rely on their EC devices in their daily life. This way it can be determined what will be the requirements of an ISA based EC device. For that, questions about their daily routine and what role EC devices play in it can be used from Familiarity with Technology section, questions 2.1.5 to 2.1.9.

This will enable gathering information about what participants think about the reliability of different technology, their EC device, and of ISA device.

### Perceived Confidentiality

Most of the non-users of ISA devices don't trust the big technical companies with their data and feel that these companies keep on changing the terms of service Lau et al. (2018).

1. When using different technologies for example your smart phone or internet how concerned are you on a scale of 1 to 5 (where 1 is low and 5 is high), about breach in confidentiality?
2. If the user was ever concerned then ask, can you give me an example?
3. If the user was not concerned then ask, why?
4. If the user is worried about confidentiality then we can ask, what precautions do they take against the breach in confidentiality?
5. On a scale of 1 to 5 how comfortable will you feel having a conversation in a room with a smart speaker installed? And why?
  - a. If very uncomfortable, then is there anything that can be added to the device to make it more trustworthy? For example, a microphone mute button.
6. If you have to install a smart speaker in your house, which room would you choose for its installation and why?
7. On a scale of 1 to 5 how much do you trust the technical giants like Google, Amazon, Facebook etc. with your information? Why?

These questions will help in figuring out how much trust the participants have in other devices and in ISA devices. Does this trust or mistrust go up till the manufacturers or just the device? If there is trust in manufacturers then there will be usage of the device. These questions will also inform the researcher of any design changes that can be done to make the device more trustworthy.

## Perceived Security

A majority of the population would conduct online transactions only if the security of their private information is guaranteed. Users judge the security of the service or device through the following means mechanisms of encryption, protection, verification, and authentication Chellappa & Pavlou (2002).

In this study, the potential users have significant mobility impairments. They are prone to physical harm through hacking, misuse or malfunction of smart home devices Yang et al. (2017). If the users perceive the devices to be secure then, it will be easier for them to form an intention to adopt it.

1. Please rate on a scale of 1 to 5 (where 1 is low and 5 is high) how secure you feel about using the different technologies listed below (if they use them)?

Name of Technology	perceived Security Rating (1 to 5)	When and How do you feel at risk?
1. Online Banking		
2. Email		
3. Texting Apps like Whatsapp		
4. Search Engines like Google		
5. EC Device		
6. ISA Device		

2. What concerns you most about ISA device?

By asking these questions it can be determined how secure a user feels whilst using different services or devices through the internet. Also, that feature of a service or a device can be identified, that would deem it safer. Similarly, it can also be figured out why the participant will be ok sharing information through one medium whilst feeling unsafe through another medium. So, if those features can be introduced to the other medium then may be technology adoption can be improved.

## Perceived Usefulness

A previous study Mao et al. (2015) stated that the factors that contribute to perceived usability of an Assistive Technology (AT) for dementia patients are: ease of use, intuitive interface, familiarity, affords autonomy and let the caregivers know about any difficulty the patients are facing related to their condition. However, there are other factors related to AT devices which make them perceived as less useful such as, infringement of privacy and autonomy. However, these factors are specific to AT devices for dementia patients and context and activity specific.

Hence, using these factors in our context for specific activities of our participants can help us investigate the perceived usefulness.

What the dementia study did was to divide issues according to rooms for example living room issue could be dialing the telephone. Then they listed different AT solutions against that problem or issue. For example, number cueing telephones, single button telephones etc. voice dialing by name, photo buttons. And then they asked which solution was the most useful in solving the problem rate from 1 to 10. So, we can list activities w.r.t rooms, drawing from our observations during our initial inquiries.

<b>Living Room</b>	Are you able to do this activity? If Yes, How? On your own/ Caregiver/ EC Device/ ISA Device	Rate from 1 to 5 how easy it is with the help of EC Device	Rate from 1 to 5 how easy it is with the help of ISA Device
1. Make or receive call on the phone. 2. Turn TV on/off. Change channels. 3. Listen to music / radio. 4. Let someone in the house.			

5. Check emails.			
6. Browse internet/social media.			
<b>Bedroom</b>			
1. Adjust bed			
2. Turn light on/ off			
3. Open/ Close blinds			
4. Set the room temperature			
5. Call the caregiver			
6. Read a book			
<b>Bathroom</b>			
1. Call for help in case of fall or emergency			
2. Listen to music			
<b>Kitchen</b>			
1. Turn the stove off in case something is burning			
2. Turn the kettle on			
3. Look for a recipe			
4. Order takeaway			

An actual comparison between the usefulness of an EC device and an ISA based EC device will not be possible in visit 1. However, it can be done after creation of a prototype in visit 2 and 3.

#### Perceived Trust in Service Provider

Consumer behaviour can be significantly influenced by their trust in service providers, especially in uncertain environments like, internet-based services Chellappa & Pavlou (2002).

According to a previous study by Ray et al. (2011), trust in online service providers is determined by perceived security. In turn perceived security is dependent upon users' predispositions and providers assurances.

In this study the users are vulnerable and need to trust the internet service providers, that their information remains secure and confidential.

1. Do you have a home internet connection? If no, why?
2. How did you choose your internet service provider? (This will allow us to understand whose advice they trust).
3. What were the qualities you looked for when deciding about the internet service provider?
4. On a scale of 1 to 5 how trustworthy do you think your Internet Service Provider (ISP) is? Why?

To measure the perceived trust in service provider it will be determined that what features of the service increased the user's trust and how more of such features can be added or improved.

### Voice Interaction Experience

Recognizing the value of intuitive interaction facilitated by natural language, this study proposes a construct, Voice Interaction Experience, that acknowledges the unique characteristics that VUI enable Lopatovska & Williams (2018).

### Recognition and Assignment of Agency

Characteristics	Rate (EC) 1 to 5	Rate (ISA) 1 to 5	Reason, Why
Looks / sounds like humans			
Presence of consciousness			
Presence of emotionality			
Behaves like humans			
Extraversion e.g., talkative, enthusiastic			
Agreeableness e.g., polite, helpful			



Conscientiousness e.g., reliable, organized			
Neuroticism e.g., moody, tense			

In the first interview if the participants own the ISA device or have used it then the questions about identification and assignment of agency can be asked. According to previous studies Bartneck et al. (2009), Kiesler & Goetz (2002) questions should focus on factors such as naturalness, likeness to humans or machines (in appearance and behaviour), presence of consciousness, lifelike, presence of intention and emotionality. In addition to that agency can also be recognised if several other personality traits are assigned to the device under study, these traits had been used in personality, mental health and social psychology research Kiesler & Goetz (2002), Moussawi & Koufaris (2019).

However, if they have not used an ISA device / smart agent or do not own one then an experience needs to be created so that perception of agency can be investigated. To create that experience Alexa can be brought into the online interview and participants can be asked to interact with it or a small video demonstrating what Alexa can do can be shown to the participants. After that, some questions can be asked from the participants analysing the personality of the smart agent.

If they do not have an ISA:

1. On the basis of these qualities that you have discovered in the interaction (done online with us) how likely is it that you would use this device from 1 to 5?

If they have and use an ISA.

2. How much from 1 to 5 did the qualities we have just reviewed influence towards your purchase and use of the device?

## Emotional Attachment

In a previous study Pradhan et al. (2019) discovered that older users who were living alone, tend to treat the smart speakers more as social partners rather than a device. Factors such as personal touch of using their name, ability to use multiple voices, the always listening mode, made the users think of smart speakers as an amiable companion.

In the first interview if the participants have used the ISA device, then the questions about emotional attachment can be asked. However, as stated above, if they have not used an ISA device / smart agent or do not own one then an experience needs to be created so that perception of agency can be investigated. To create that experience Alexa can be brought into the online interview and participants can be asked to interact with it or a small video demonstrating what Alexa can do can be shown to the participants. After that, some questions can be asked from the participants analysing the perspective emotional attachment with the smart agent. These questions should focus on desire to personify, to talk to the devices as companions, to investigate if they would feel that someone is always there and listening.

1. On a scale of 1 to 5 how would you rate the ISA device as a conversational partner?  
Why?
2. When addressing the ISA device would you rather use the pronoun it, her, or him? Why?
3. Would you prefer a male or a female voice for the ISA device? Why?
4. If I ask you to describe this technology how would you describe it?
5. Do you think you would like to personalise this device if it was yours?
6. How? (If they do not come forward with suggestions you can suggest a nick name, or something else)
7. Why? (By asking why they may say for a stronger link).
8. Do you think you would develop a strong link with this technology if you used it?

Once the presence or absence of emotional attachment has been established, the next step is to determine the effect of that on the adoption behaviour of the ISA device.

9. If given a choice would you like your device to have customized personal touches just for you? For example, in case of ISA device addressing the user by their name.

10. In your opinion, addition of this emotional aspect of your user experience is a plus in an assistive device, agree or disagree. Why?

### 3.3.2 Study Setting

Initially all the research data would have been collected on patient's place of residence. As mentioned before, following were the reasons for conducting patient home visits:

1. The patients suffer from severe mobility impairments, it will be very inconvenient for them to travel.
2. It is of critical importance that the participants are observed in their natural surroundings. It will enable the researcher to observe what is not usually communicated through words.

All the participants are the clients of NTRECES (Alderbourne Rehabilitation Centre, Hillingdon Hospital). Hence, it was a single centre study.

The staff NTRECES (Alderbourne Rehabilitation Centre, Hillingdon Hospital) helped in identifying and contacting the patients, according to the inclusion and exclusion criteria mentioned in the next section.

However, due to the change in circumstances due to covid-19 pandemic the meetings with the shortlisted participant took place online via video conferencing tools.

### 3.3.3 Sample Recruitment

#### Eligibility Criteria

Patients who are registered with NTRECES were eligible to participate in the study.

#### Inclusion criteria

Several attributes of potential participants were preferred for inclusion in the study:

1. Willingness and motivation to participate. Only patients who were motivated to contribute to the research were recruited.
2. Good and non-deteriorating voice quality, as the research was looking at voice - controlled equipment. In case of absence of good voice and communication skills, it would have been impossible to use voice-controlled equipment.
3. Good cognition. It was vital for the research that the potential participants were able to understand the questions put forward to them and reply with a well thought out answer.

## Exclusion criteria

If the perspective participants were suffering from communication and cognition disability or deterioration in their communication, they were not shortlisted to participate in the study, unfortunately.

## Size of sample

The sample size in qualitative studies is rather small generally as compared to quantitative studies. It is due to the time-consuming nature of the data collection methods. In turn the results of the study cannot be generalised.

The sample size target for this study was 15 patients. 28 participants were contacted in total but due to precarious health conditions of short-listed participants, only 11 interviews were conducted.

## Sampling technique

Random sampling technique was used within this study. As long as the patient met the inclusion criteria there were no other conditions. However, it was preferred if there was equal representation across age, gender, multiple diagnosis, and EC equipment being used.

## Sample identification

The staff at NTRECES helped the researcher in identification of potential study participants. Eligible participants were informed by their direct care team about the ongoing study, by calling them up. Perspective participants were asked if a member of the research team can contact them through email or phone. On receiving confirmation from the perspective participant, the researcher contacted them via phone, after confirmation the invitation email was sent. The perspective participant was informed further about the study via email and was asked to sign the consent forms if they were willing to participate in the study.

## Consent

Participants went through the process of informed consent before the start of the research process.

1. Participants who were interested to take part in the research, will be provided with a participant information sheet. After that, participants were given some time to think about their decision to participate and ask for more information from the research

team. Interested participants could contact the research team to discuss any queries they had. For further details please see Participant Information Sheet, in the appendix.

2. All the patients who agreed to take part in the study should have signed the consent forms and send them back by post. This form could have been signed by the patient or their carer/friend/relative on their behalf (due to mobility impairments patients might not be able to write). Researchers also asked verbally to make sure that the interested patients:
  - a. Are participating in the study by their own free will.
  - b. Have gone through the participant information sheet (PIS) provided.
  - c. Understand the contents of the PIS.

### 3.3.4 Patient Interviews

#### Online Interviews and Questionnaire

After the consent was received from the participant a date and time was set with the participant for the video call via phone call or email beforehand, to conduct an online interview with the help of secure video consultation link for example, “Attend Anywhere” or MS Teams. Due to COVID19 restrictions and social distancing measures, instead of the original face to face interview, an online interview was conducted. The participant also filled in a questionnaire (included with the invitation email). The link for the video call was sent to the participant via email. The participant was advised to trial the link once before the actual time of the video call to see if all the hardware was working. The researcher was in contact with the participant through email in case of any technical difficulties. At the start of the online interview, the researcher introduced the project, to establish a rapport with the participant, to make sure they have understood the information in the participant information document and had gone through and signed the consent forms (with the help of caregiver). The consent from the participants is for participation in the study as well as for the use of data, audio and video recordings. Participants were assured of their anonymity. Unique codes were assigned to each participant for identification purposes. All the data collected was stored under the unique codes assigned. During the study only the researcher had access to this data.

Participants had to the opportunity to be chaperoned by their carers or friends or relatives if they wished. In the event of participants becoming distressed during the course of the interview, the researcher would have stopped the interview and contacted the participant's carer, making sure that they are feeling calm and safe. The researcher would have asked the patient if they wanted to continue with the interview. In case of a negative reply, the researcher would have ended the call. After a few days the researcher would contact the participant to see if they were coping well and if they wanted to continue with the study or not.

According to the original plan, before the pandemic, the first visit included the introduction of the researcher and the study, followed by observations and interview. These observations were participant led. The researcher would follow the participants as they go about their usual day. An informal explanatory interview concluded these observations. In case of participants getting over tired, the end of the day interview could be postponed or replaced by a questionnaire to be emailed later. Although the interview was much more preferable to email questionnaire, decision could have been taken according to participant's wishes. These questionnaires was to be formulated after the conclusion of the visit, depending upon the points of interest discovered and questions raised during the observations. However, all the questions in the questionnaires and in the interview will only cover the topics mentioned in the Interview Topic List provided in the Appendix.

The original face to face interview was to address the issues that surfaced in the observation. For example, the lack of use of certain functionality in the Environmental Control (EC) device, preference of human help over device assistance etc. Participants were to be asked focused questions regarding the behaviour observed during the observation session. In addition to that, participant could have been asked to perform certain tasks using their EC devices. Moreover, participants were to be presented with a network diagram, depicting their EC control and peripherals attached to it. Participants were to be asked to comment about each node. This exercise would have enabled the researcher to analyse the participants' emotional or functional attachment to the device.

However, due to the covid-19 pandemic the original design of how to carry out the research did not work out and alternative method had to be developed.

## Analysis

After the interview, all the audio, video, data collected was reviewed and analysed. The researcher listened to all the audio recordings and watched all the captured videos and read through all the interview responses and notes. All the audio and video recordings was transcribed by the researcher. The data generated by the interviews was analysed with the help of the proposed research model. This data analysis informed the validity of proposed research hypotheses about the adoption of ISA devices.

## Modification of Proposed Research Model

Based on this analysis the research hypothesis of the proposed model were proved or disproved. In addition to that, certain new emerging themes were identified as well. As a result of which, following the bottom-up approach, the proposed research model is modified on the basis of the data collected from the interviews.

## 3.4 Ethical and Regulatory Considerations

The aim of the study is to understand the adoption of an ISA device, as well as to determine the consequences of such a device on the design of conventional EC devices and service.

The research study revolves around a user centred design approach; hence the role of the patients is central as well as vital in conducting and designing of the research. This required access to participants already using EC devices. As these participants were clients of NTRECES which is an NHS organisation it was necessary that all the ethical and regulatory conditions set by NHS were met by this research project.

Given the nature of the observations, the researcher gave the participant privacy during matters of personal care and hygiene (if need arose during the interview). The participant had a choice to have their carer, friend, or relative present throughout the study. They had a choice to not answer a question or to stop at any time if they didn't want to continue. If they felt distressed or tired, they could ask the researcher to stop and take a break. The researcher would have been more than happy to stop and maybe continue at a later time. The researcher would contact their carer, friend or relative for them before leaving the house. The wellbeing of the participants took priority over everything.

### 3.4.1 Assessment and management of risk

The decision to participate or not to participate will not in any way effect participants' current or future medical care. However, participating in the study will take up some of the participants' time and can be inconvenient. Given the nature of the observation, the participant can feel that privacy is being invaded and they could feel vulnerable. If they felt that they were not comfortable, they could discontinue their participation in the study without any consequences.

Participants could experience extra fatigue and tiredness due to a busy day. The risks were not greater than what they anticipate in daily life. Participants could become distressed or slightly stressed when asked to perform a task under observation. If they found any part of the research study distressing or stressful, they could let the researcher know, and the session will be stopped to be continued later depending on their wishes. The researcher would also contact their carer, friend or relative for them, if they so wish.

If during the research proceeding the researcher obtained information that indicate any potential risk/harm to the participant or to others, the researcher would be obliged to inform the participants direct care team, as soon as possible. This will ensure that proper help will be provided through proper channels.

### 3.4.2 Research Ethics Committee (REC) and Other Regulatory Review & Reports

This research was presented for approval before Brunel University London College of Engineering, Design and Physical Sciences (CEDPS) REC and by Health Research Authority (HRA) through the Integrated Research Application System (IRAS). All the supporting documents including, Research Protocol, Participant Information Sheet, Consent Form and Interview Topic List were provided for approval.

### 3.4.3 Resubmission of REC and BREO Applications

Due to the COVID19 pandemic face to face interviews were no longer allowed by The Brunel University London. Similarly, studies involving patients were also put on hold by the NHS. In order to shift the interviews from face to face to online sessions, ethics approval



applications were resubmitted to the REC and BREO. After getting approval from them data collection was allowed to proceed.

## Chapter 4. Findings and Analysis

In this chapter the findings and analysis of the data is presented. The data was collected by interviewing 11 participants via online interviews. In the first iteration of data analysis, a structured top-down approach was used for coding the data. Using the proposed research model as a guide, data excerpts were assigned to codes, each referring to a separate variable. There are 23 codes in the original conceptual models one for each of the variable identified. The 23 variables contribute to define 4 main constructs (C. f. chapter 2). In the second iteration, an inductive approach was used for coding the data. This resulted in the identification of themes not specified by the initially proposed model.

### 4.1 Introduction

First in this chapter the profiles of the 11 study participants are presented, this will provide the context in which the study was carried out. It will give an idea about the demographics to which the study findings will be applied to. The central part of the chapter (sections 1 to 4) focuses on the analysis of the data based on the 23 variables of the initial model. The final part of the chapter discusses themes that emerged from the data and that the initial model did not include.

### 4.2 Participant Profiles

#### Participant 1

Participant 1 is 77-year-old male. He suffers from a neuro degenerative disease, which is affecting his mobility as well as his lungs. He is unable to walk and uses a wheelchair to get from one room to another. His dexterity is better in his left hand, whilst his right hand does not close properly anymore. There is tremor in his hands and progressively he is losing his grip. He occasionally uses a Continuous Positive Airway Pressure (CPAP) machine, to help in his breathing. He is slowly losing his voice and his voice quality varies over time. He always needs to be within a travelling distance to a hospital. He lives in his own home with his wife. His wife is his main caregiver. A carer also visits during the day. He is retired now but volunteers for different organisations. Due to the covid-19 pandemic, he is mostly home, before however he used to go out to the shops sometimes, visit his children and visit the organisations he volunteers for. He used to also leave the house for his appointments. He

was issued an Environment Control (EC) device 10 to 15 years ago. He uses the EC device to control the bed, TVs, some plug sockets, telephone, and door intercom. He knows how to use a computer. He is aware of the emerging technologies like smartphones, smart speakers, keyless cars. He does not own a smart speaker.

## Participant 2

Participant 2 is 71-year-old male. He has a Spinal Cord Injury (SCI), because of which he is unable to walk and uses a wheelchair. He still has little mobility left in his hands and can operate a keyboard and mouse for his desktop. He lives at his home with his wife. A carer comes a few times a day to help his wife with his daily care. He used to work in interior decoration and after his accident he stopped working. He does not go out much, just to his medical appointments or maybe to a garden centre sometimes or to the pub for a meal, but not very often. His outings depend on the availability of the carer, for him to be able to go out. They especially hire a carer when he needs to go out. He spends most of his time in front of his computer, watching different movies and dramas that he has downloaded to watch. He has a smart speaker, but it is just used for setting reminders for his medicine. He has not purchased any additional devices to be connected to the smart speakers. He doesn't use the smart speaker to listen to music or news or the radio. He was issued a scanning-based EC device about 25 years ago. It has been upgraded recently to a tablet-based device. He uses it for TV control, bed positioning and door entry system.

## Participant 3

Participant 3 is 59-year-old female. She has been recently diagnosed with MS. This has affected her ability to walk. She uses a wheelchair. She has her house adapted for a wheelchair and this enables her to move around the house. MS is also affecting her dexterity in her hands gradually. She can use the computer keyboard, but it takes her a long time to type. She is a widow and lives at her house with her 3 sons. She has carers that come in twice a day to help her with her daily tasks and cooking. She works as a free-lance corporate researcher for different companies. She works virtually from home; however, she needs to access certain surveys and other public domain information, that she can only view at the British Library. This requires that she visits the library sometimes. She has been issued dragon dictate™ from the NTRECES and uses it to operate her computer for her work. She

has an intercom connected to her land line phone from the front door. She does not use a smartphone, she has one, but she only uses it to watch movies and dramas in bed. She had been given a smart speaker by her sister, but she promptly gave it away to her son as she could think of no use for it, as she already is managing everything with remote controls.

## Participant 4

Participant 4 is 58 years old female. She lives in the house with her partner and her caregiver. She always has someone in the house with her at all times. She has MS and her mobility is getting worse with passage of time. Before covid she was able to sit her wheelchair and spent her time downstairs, but nowadays she is mostly bed bound. Her carer used to sit her up in front of the desktop downstairs and she used to use it, but now she mostly stays in her bed and uses her iPad. Her iPad is set at a certain angle so that she can be able to see it and operate it. She is not working anymore but used to work as a financial consultant before. Before covid she loved to go out for shopping, to socialise with friends and family and she used to be able to take the bus. But after covid all of this had stopped. She has purchased multiple smart speakers and use them for different purposes. She uses her iPad to control the EC device that has been issued to her. The buddy button™ is connected to the iPad, and she uses her head to click on the button. She uses cross hair method to browse things on her iPad. She uses land line phone which is controlled by the EC device.

## Participant 5

Participant 5 is 68-year-old male. He has MS which has progressed over the years. Now he has no mobility from the neck down. Carers move him to his electric wheelchair in the morning and this enable him to get around the house. There is some slurring of speech, but he is able to communicate what he intended. He lives in his house with his wife. His wife is his main caregiver. NHS caregivers also visit multiple times a day to help with the dressing and feeding. He used to work in insurance but is retired now and does not work. He goes out to meet his daughter who lives in another town Before covid he used to go out now and then but after covid it has not been possible. He has been issued an EC device for 15/20 years. He has one of the earliest models of Possum an EC device. He uses the EC device to operate the land line phone, his bed, and lights too. He thinks that because of this EC device

he can be left on his own for a few hours and without it would not have been possible. He uses the buddy button to control the EC device and he operates the button with his head. He uses Microsoft voice control and dragon dictate on his PC. He uses his EC device to control his TV.

## Participant 6

Participant 6 is 65-year-old male. He suffered a spinal cord injury, during an event organised by his work. He has lost all mobility from the neck down. He has just a little bit movement left in his left bicep. He lives in the house with his carers, whereas his wife lives in the house next door. He used to work in the marketing department of Ford company. He is bed bound, but he has vehicles for him to be transported to different places. For example, he likes to visit his daughter in Portsmouth. He has been bed bound for quite a long time so that is why he suffers from bed sores, due to which he is not able to sit in wheelchair to go out for some time. He owns several smart speakers and use them often. He uses it to project the CCTV camera on the monitor positioned over his bed. He uses iPhone voice assistant Siri to call people. He has been using his EC device for almost 30 years now. He uses it to control his phone, TV, Bed, Front door release and intercom, fan, heaters, air conditioning, fly killer, curtain control and pager.

## Participant 7

Participant 7 is a male in his early 60s.. He had a recent diagnosis of Multiple Sclerosis (MS), and the disease has progressed quickly. He is unable to use his hands and is having difficulty in breathing nowadays. He is unable to walk anymore and uses a wheelchair. However, there is still some movement left in his feet, so he can use his feet to click a buddy button (normally used to control EC devices). He lives at his home with his wife, who is his primary caregiver. His job was of technical nature, but he is retired now and no longer working. His diagnosis and covid-19 pandemic almost happened in parallel, so he is mostly home bound and does not get to go out much except for his medical appointments. He has been referred to NTRECES but due to covid-19 no one was able to visit personally. First dragon dictate was installed on his computer which he uses and finds useful. He was also given eye gaze, but due to covid-19 no engineer can come visit him to help him with the installation and learning process. So, he just looked online to figure out the device. However, it is not easy

for him to use as he has to sit in a certain position for a long while. This is very tiring for him. Another device was sent to him, but he needs to upgrade his phone before he can start using the new EC device. He is currently using an Alexa to control some lights and his TV.

## Participant 8

Participant 8 is 49-year-old female. She suffers from scoliosis, which is a result of osteogenesis, due to which she has limited mobility in her arms and hands and uses a wheelchair to get around. She also has difficulty in breathing. She has limited arm reach and her hand grip is affected too. She has a live-in carer. She works as a director in an organisation Save the People. She used to go to office before covid but now works from home. She uses her EC device to control some lights, TV and she has a door opener too.

## Participant 9

Participant 9 is 33-year-old female. She suffered a SCI 5 months ago and is unable to use her lower or upper limbs. She still has some movement left in one of her little fingers. She moves around the house using wheelchair. After her discharge from the hospital, she has moved into her current flat. She has a live in carer. She used to work as a trading content manager for a company, but she was furloughed. Due to covid-19 she rarely gets to leave her flat, she has been out only once and that was for her hospital appointment. Sometimes her friends do come over though. She uses her iPhone via Siri, she also has been issued a housemate EC device by NTRECES. She has purchased a smart speaker to control her TV. She manages to control the devices with the combination of EC device, smart speaker, eye gaze and Siri on iPhone.

## Participant 10

Participant 10 is a 50-year-old male. He is suffering from cerebral palsy due to which he has limited mobility. The movement and control of his hands is also affected. His speech also got affected and sometimes the words are bit hard to understand. He lives in his own home with a live-in carer. He has a university degree and is now working towards his master's degree. He volunteers for different organisations including the county council. He is not undertaking paid work at the moment. He likes to go and watch theatre plays. Since everything has opened up again he has been to the theatre five times. He has several smart speakers in his house, one place in his carers room too, so if he needs to call him during the

night he will be able to do so. He has purchased some smart bulbs and plugs around the house to be controlled by the numerous smart speakers he has purchased.

## Participant 11

Participant 11 is a 28-year-old male. He had a SCI due to which he lost his ability to walk. His hand control and arm movement is also affected. He uses a wheelchair to get around the house. He has a 24-hour live-in carer that is funded through the social services. He lives in the annex of his parents' house, which has been modified for his use. He is a university student, and he works part-time as well. His organisation works for providing sports opportunities for people with disabilities (disabled people). Since covid-19 he has been working from home and doing online learning. Before covid though he would go out every day to university or to work. His carer would help him with the car transfers and driving. He has purchased a smart speaker for himself and mostly use it for music. He does not have it connected to different smart devices around the house yet. He was prescribed the EC device about 10 years ago on the recommendation of his Occupational Therapist. The EC device was used mainly for opening doors, TV and for the intercom at the main door. But due to an issue with the application of EC device on the iPad and connectivity to Wi-Fi, he is not using the EC device a lot. As most of the time he has someone with him, so he does not need to use the EC device to open doors.

## 4.3 Validation or Rejection of Research Propositions

### User Characteristics

One of the four constructs in the proposed research model is user characteristics, which includes seven variables. User characteristics affects user's attitude towards the adoption or purchase of a new technology and Perceived Behavioural Controls (PBCs). PBCs refers to users' perception of how easy or difficult it would be to use a technology.

### Age

According to previous studies, elderly users found it difficult to use new technologies either due to steeper learning curves Goodman et al. (2002) or due to diminished faculties with age Conci et al. (2009). In this study it is proposed that age has a negative effect on the attitude to adopt an ISA device (RP02a) and on PBCs (RP02b). Age, in this study, was

collected as part of the initial demographics of the participants. 56 was the average age of all the participants that were interviewed, with 3 participants being younger than 50 years old.

All of the participants used various technological devices and software packages daily for their work, entertainment or to help them with their daily tasks, irrespective of their age. All of the participants were issued EC devices and voice to text software for their computer by the NTRECES. The participants were questioned about the learning process to use a new technological device and the ease of interaction with the new technology. Some of the participants enlisted the help of clinical staff, friends, and family, some used online resources to learn about new devices. However, all of them, whether young or old, learned to use new technological devices and software to help them in their daily lives. All of the participants, except one, also used their EC devices daily, for various activities. Only participant 11 had stopped using his EC device. Participant 11 was 28 years old, and he used a PC, smart phones, video game controllers and ISA device almost daily for his studies, work and for help in his daily tasks. The only reason he stopped using his EC device was because of some unresolved technical issues with his EC device. Whenever, he would use the EC device controlling application on his phone or iPad he couldn't connect the phone or the iPad to the home Wi-Fi. Participant 11 had a live in caregiver, who is with him 24/7. He found it easier to ask for help from the caregiver instead.

All the participants except one, were positive about using an ISA device. Participant 3 (59 years old), who did not want to use an ISA device, felt that it would require technical know-how and considerable financial commitment to properly install an ISA device with all its peripherals. She felt that she was not in a position technically as well as financially to proceed with such a decision. According to her "I know you can use it [AN: Alexa] to control your central heating and all these sorts of things. But if you want to do that you gotta change all the wiring, so I wasn't I wasn't up for that". The fact that participant 3 is above 50, did not play a part in her decision to not purchase and use an ISA device.

Considering that all 11 participants regardless of their chronological age used a variety of technological devices and demonstrated their willingness to learn about new technologies including ISA devices, RP02a that age has a negative effect on the attitude to adopt an ISA



device is not supported by the data. Older participants in this study were equally using technology as younger participants of the study.

Majority of the participants were apprehensive about using different technological devices due to their current and increasing mobility impairments. Participant 4 for instance said “I have thought about getting those emergency buttons or pendants bracelets? But then how? I had them but then I couldn’t press the button”. Participant 1 was worried about his voice quality being different at different times, which can result in non-recognition by the devices “I’m a bit worried about my voice. When I give the voice to a machine? Is it gonna say not recognizable, wrong thing”? Due to the limitation of the participants’ mobility, it also effected the choice of technological devices. It made it difficult for them to carry out complex setup and installations. Hiring professionals resulted in an additional expenditure which was not possible for everyone. According to participant 6 “The problem is more...Who is going to fit it up? Who's going to put it up? I mean, I'd much rather have had a proper CCTV system. But it would be expensive.” Some participants were not very keen on using new technological devices as they had security concerns. For example, participant 5 had this to say about using ISA devices “I've not used one. I am getting a bit worried from the security point of view. Is it listening to everything outside? No, it's not. Just wondered if it is possible for them to monitor when someone is not actually using them? It's connected to the Internet, and It's got a microphone. Can you be sure that it's not listening to private conversation...?”. All of the participants perceived difficulties in using technological devices because of their mobility impairments, financial constraints, or security concerns. However, it is apparent that the age of the participants did not affect the perceived difficulties in controlling different devices. Hence, RP02b that age has a negative effect on PBCs is not supported by the data.

## Gender

Females are presented as late adopters of technology in the literature, due to lack of confidence in their abilities Li et al. (2008). It was proposed in this study that being female has a negative attitude towards intention to adopt an ISA device (RP03a) and has a negative effect on PBCs (RP03b). The gender of the participants was recorded with the initial demographics.

Out of the 11 participants 7 were male and 4 were female. All of the female participants used technology in their daily lives for different purposes. Female participant, participant 3, had been diagnosed with MS and was unable to use the conventional keyboard for longer durations of time. Hence she used the Dragon Dictate software that had been issued by the NTRECES. Participant 4, another female participant, had her bed surrounded with many technological devices that she was running out of space. According to her “I got an echo show [AN: Amazon Alexa Echo Show]. The reason I haven't used it is because I haven't got any electricity points left”. Similarly, another female participant 8, used various software and technological devices for work and for her personal use. Participant 9, also female, used various technological devices including her EC device, smart phone, eye tracking mouse for her computer etc. several times a day. Out of the 4 female participants, only participant 3, did not reply positively about using an ISA device in the future. Similarly, to what mentioned earlier, this disinterest in ISA technologies was due to the financial investment and technical know-how required for the installation and purchase of smart home devices, that participant 3 did not want to use an ISA device.

The Majority of female participants were positive about adopting an ISA device. Hence, RP03a, that females have a negative attitude towards intention to adopt an ISA device is not supported by this research data.

Perceived Behavioural Control (PBC), the difficulties perceived by the participants in using different technologies, was influenced by their financial constraints, security concerns and inability to use them due to mobility impairments. Regardless of their gender, male and female participants alike reported perceived difficulties in using different technological devices. For example, participant 9 (female), was apprehensive about using new devices as she has almost no mobility left in her hands. According to her “So one of the reasons I used Home Sense [AN: EC device] is to call my carers during the night. But I need to do that from my phone [AN: phone acts as EC controller]. I'm unable to reach, so I have to have my phone popped up in front of me”. Similarly participant 10 (male), had similar issues, whilst talking about controllers, according to him “I've got limited hand function, so I need certain adaptations”.

Most of the perceived difficulties in using different technological devices is due to the current and increasing mobility impairments of the participants, regardless of gender. On this ground, RP03b, that being female has negative effect on PBCs cannot be accepted.

### Desire for Independence

When the users have a desire to do more in their daily lives and to be more independent it is a positive indicator for adoption of assistive technology Kintsch & Depaula (2002). It is proposed in this study that (RP04a) desire for independence will positively influence attitude towards intention to adopt the ISA device and have a positive effect on the PBCs (RP04b).

To investigate the participants' desire for independence, three aspects of independence were explored in the interview: 1) what does independence mean to them, 2) how independent do they feel, and 3) how independent they want to be. Several questions targeting desire for independence were asked during the interview, as well as in the questionnaire sent with the invite email. For example, what activities would make them feel more independent and how can technology help them in being more independent.

In this study, the majority of the participants said that independence is about control, the ability to make decisions on their own, the availability of choices and not to ask for help as participant 9 clearly stated "to me (independence) means being able to do things completely on your own without any help from others".

Participants also expressed how lack of choice can make them feel less independent whilst devices with easier mode of interaction can make them feel more independent. Participant 8 for example, stated that she feels that people in Government and people in the medical profession take choices away from her. Whilst proposing new regulations and prescribing aid devices, people with disabilities (disabled people) are not consulted about their choices, thus making them feel less independent. Other participants expressed that if the control of devices around them is through voice it will add more to their independence as some of them have lost the use of their hands. According to participant 4 "It [AN: ISA device] gives me some semblance of independence back, in addition to the EC devices because I am in control. Independence is being in control. If I want to read a book, I read a book. If I want to listen to music, I listen to music. If I want to sing a song I'll sing a song"

Participants with seemingly similar circumstances and mobility impairments felt differently about their independence. Two of the participants had no mobility left in their body below their neck. Both could execute similar tasks with the help of their EC devices and used numerous ISA devices around the house. Both participants had live-in carers as well. It was interesting to note that one of them felt very independent (participant 6) and one not independent at all (participant 4). EC devices have helped participant 4 in gaining some independence, but she was still unable to do the tasks that she deemed more important for her independence, like walking. Participant 4 said: "I would probably say to you I don't really have any [AN: independence]. About things that I can't have that I'd like, yeah I'd like my body back and I can't have that, so I'm not going to be able to be independent." For participant 6, independence meant financial ability to hire his own caregivers and the ability to make decisions for himself.

Despite both participants had different meanings associated to independence and they felt different degrees of independence, both accepted the issued EC devices, because they desired to improve their degree of independence.

All participants used technology and EC devices in their daily life. For example, participant 5 did not want to be dependent on his wife all the time, according to him: "Without it [AN: EC device] I can't do very much at all. And my biggest problem is that, if I don't have anyone around, then I'll get very anxious, if I don't have my possum [AN: EC device prescribed and issued by NTRECES], coz that is the only connection I've got with the outside world. So, she [AN: wife] can go out for a couple of hours, and I can watch telly, or even, if I want to, switch lights on...". Some participants were using EC devices to help control their computer, as they wanted to continue working. For example, participant 3 used voice to text software to operate her computer, to help her in her office work, as she is finding it increasingly difficult to type, due to her progressing ailment.

Hence, all of the participants had demonstrated a desire for independence, which led to their acceptance and usage of EC devices. Similarly, all of the participants except one were positive about using an ISA device. Given the observations listed above, RP04a that desire for independence has a positive influence on attitude towards intention to adopt ISA devices cannot be accepted.

All of the participants demonstrated a desire for independence, however, all participants also perceived difficulties in using different technological devices. As discussed in the previous sections, the majority of the perceived difficulties were due to the current and increasing participants' mobility impairments. Participants voiced their difficulties in using technologies, irrespective of the fact that they also demonstrated a desire for independence. Hence, RP04b, that desire for independence have a positive effect on PBCs cannot be accepted.

## Voluntariness

One more variable part of the User characteristics construct in this study is Voluntariness. This meant to explore the circumstances around the prescription of EC devices and whether their decision to use them is mandated or self-initiated by participants. The desire of service user to try new technological or EC devices, can be a positive attitude towards intention to adopt and use them Agarwal & Prasad (1997). In this study, it is proposed that voluntariness of the participant to try a new technology will positively influence their attitude towards intention to adopt an ISA device (RP05a) and will positively affect their PBCs (RP05b).

To determine voluntariness among the participants, they were questioned about their referral process, about their usage of EC devices and how free they felt in the decision about choosing an EC device.

All of the participants in this study, were referred to the EC services via hospital, physio therapists or social services. Participant 3 remembered that she was very motivated herself to find out about NTRECES and understand about the services they provide: "It was somebody at the neurological hospital in Queens Square and he said, oh, these people exist in Hillingdon. So, I then went looking for them, found them. They are sort of hidden secret, very few people know they exist."

When questioned about the use of EC devices, none of the participants felt that they were being forced to use EC devices. The Majority of them have been using ECs since they have been issued to them, although the frequency and use might have changed over time. Participant 4 has been using her EC device for quite some time, but due to progression of her disease she is now bed bound and not using many functions anymore. According to her "With the possum I use it for TV and phone. When I was sitting downstairs I used to get up

more. Until lockdown. I used to eat downstairs, and I had lights attached to it. I had my virgin box. My box is all connected, my TV is smart. I could use the TV on it.”

Some of the participants have been offered upgrades and the majority have accepted the upgrades. Whereas some participants have decided to stay with their older devices. NTRECES have respected their decisions and have offered technical support even when the manufacturers have withdrawn support for older models. Hence, NTRECES did not force its customers to switch to a certain newer device and it is up to the customers which device they choose.

It was observed that, all participants had been using their EC devices on their own volition. Which led to most participants using their EC devices on a daily basis, except participant 11 who finds it easier to ask for help from his caregiver. Similarly, some participants (7 out of 11) had already purchased an ISA device, on their own initiative. Currently ISA devices are not prescribed by the NTRECES. 7 out of the 11 participants had already purchased ISA devices on their own and were using it for different purposes. Participant 7 was diagnosed during the covid-19 pandemic, so there was a slight delay in getting the EC device prescribed to him. In the meanwhile, however participant 7 purchased an ISA device on the recommendation of a friend and was using it to call people, control his TV and some smart lights etc. Even the participants who had not purchased an ISA device yet, were positive towards using it in the future, except participant 3. Hence, (RP05a), that is voluntariness have a positive influence on attitude towards intention to adopt ISA device is supported by the findings listed above.

As stated above participant 7 showed voluntariness in purchasing an ISA device privately, before an EC device was prescribed to him by the NTRECES. Although participant 7 showed voluntariness, he perceived difficulties in using different types of technologies. According to participant 7 “Because of my illness, I can't always stay in the same position. Because every time I use it [AN: eye gaze, mouse controlled by eye movement], you have to re calibrate.” Just as all participants demonstrated voluntariness, all of them also demonstrated perceived difficulties in using different technologies. However, majority of the perceived difficulties were due to the current and advancing illness of the participants. Hence, (RP05b), that voluntariness has a positive effect on the PBCs does not hold true in the light of the current findings.

## Openness to Innovation

Individuals who are more receptive to new solutions and ideas, find innovative solutions to problems and want to try new things, tend to have a more positive attitude towards technology. This is known as open to innovation Laukkanen & Pasanen (2008). This study proposes that Openness to innovation leads to a positive attitude towards intention to adopt ISA device (RP06a) and has a positive effect on PBCs (RP06b).

To determine the participants' openness to innovation, they were questioned about how often they purchase and try new technological devices, how comfortable they are with change in their daily lives and how often they found themselves being early adopters of new technology. These questions were then linked with their actual use of EC, ISA, and other technical devices to determine their attitude towards adoption of existing technologies.

When the participants were asked about how often they try a new technology, all of the participants, except one, stated that they try new technologies at least once a year. Only participant 3 stated that she could not try new technology due to financial reasons and her feeling that she does not feel the need for it. She is happy with her radio and landline telephone and hardwired intercom and would not want to change as it would require technical know-how and financial investment which she cannot afford. Some participants experiment with the new devices they purchased and explored all the functionalities. For example, they purchased smart speakers and, to utilise all the available functionalities, they purchased other smart devices like security cameras, smart lights, smart plugs etc. However, some participants who did try new devices at least once a year, used just the basic functions and did not explore further. Participant 2, for example, got Alexa as a gift from his nephew, was just using it as a reminder for his medication. Participant 2 relied on his nephew for technical support and advice, so despite wanting to, he was unable to setup and control other devices via Alexa himself. According to his spouse: "[..] But if something can do that (AN controlling peripherals) for my husband like light on, that would be really good, by just saying (AN voice-control)". Some participants also stated that they do try a new technology at least once a year and they could be amongst the early adopters to try a new technology, but due to their circumstances (mobility or financial) they are not. According to participant 6: "If I had the hands and the money. I would probably be the sort of person who wants to play with it (AN new device) and buy it and then try it,

but...". However, for some participants this was not an issue, and they were amongst the first ones amongst their friends and family to try new technological devices like cameras, phones, robo-vaccums etc.

Given the different variations in behaviour of the participants it can be observed that there are some participants who are open to innovation, some who accept new technology because it has been given to them and setup for them, and some who are complacent with whatever technology they have. Most of the participants were open to innovation with respect to purchase and use of new technological devices. In addition to that some participants also displayed interest in finding innovative solutions to their problems through the use of technology. For example, some participants, who also try out new technologies frequently, were in the process of installing video cameras to record the timings of the carers, as they found discrepancies in the timings that were logged and the actual time for which they were at their place of residence. Moreover, some participants also took self-initiative to troubleshoot their devices. An example of this behaviour is participant 5 who re-programmed his EC device by himself to include new phone contacts.

On the other hand, only one participant, participant 3, stated that she does not buy new technologies very frequently. She is set in her ways and would not switch to a newer technology if she sees no need for it. For example, she only uses her land line phone and finds no use for a smart phone. She has a hard-wired door intercom with her telephone landline and does not want to switch to new video doorbells, as she feels there is no need for it. "I haven't needed one (AN: video doorbell). Where's the camera going to go? Where am I going to see it? I don't use a smartphone. That's one thing I haven't needed". However, she does use technology that helps her in her daily life and that helps her with her work. For example, with the progression of her disease, she finds it difficult to use conventional keyboard and mouse. NTRECES has installed dragon dictate software for her on her PC, which she uses regularly. Participant 3 was unwilling to buy or use new technological devices just for the sake of exploration. In her opinion these devices require substantial financial investment and technical expertise for installation.

In this study all participants demonstrated openness to innovation to varying degree from very open to not open at all. It appears that the degree of openness to innovation is mediated by a participants' financial circumstances, technical know-how and security



concerns. According to participant 5: "It's (AN: ISA device) connected to the Internet, and it's got a microphone. Can you be sure that it's not listening to private conversation, so it's always worried me" However, some of these participants had already purchased an ISA device and were using it for various purposes. The other participants were also positive towards the idea of using a smart speaker in the future and liked the idea of voice-control. So, we can say that the majority of the participants had varying degrees of openness to innovation and were positive in their attitude towards adoption of an ISA device.

On the other hand, participant 3, refused to use an ISA device gifted to her by her sister as she found no need for it, and she realised that she does not have the finances and technical expertise to fully exploit an ISA device to control various smart devices around the house.

Hence, in light of the findings it can be stated that, (RP06a) openness to innovation has positive effect on the attitude towards the intention to adopt an ISA device holds true.

All the participants perceived difficulty in using different types of technologies. Participant 3 who was not very much open to innovation perceived the use of ISA device to be difficult due to the financial investment and technical know-how required for its installation.

According to her "I know you can use it (AN: ISA device) to control your central heating and all these sorts of things. But if you want to do that you got to change all the wiring, So I wasn't up for that.". On the other hand, participant 6 who voluntarily purchased and installed several ISA devices in his house, perceived similar difficulties in using different technologies due to financial investment required for installation. As mentioned above in section 4.3, under the heading of Age, according to participant 6, "The problem is more...Who is going to fit it up? Who's going to put it up? I mean, I'd much rather have had a proper CCTV system. But it would be expensive."

Despite participants displaying various degrees of openness to innovation they perceived difficulties in using different technologies due to reasons such as financial investment.

Hence, (RP06b) that openness to innovation has a positive effect on the PBCs does not hold true in the light of the findings.

## External Engagement

During the primary research phase, the NTRECES staff was shadowed during the patient visits. It was observed that patients with higher motivation to use technology had more

external engagement in terms of work, socialising, hobbies, and participation in support groups. These service users considered technology as a support to accomplish their various activities, which they couldn't accomplish otherwise, due to their mobility impairments. It was proposed that participants with higher external engagement have positive attitude towards intention to adopt ISA device (RP07a) and a positive effect on the PBCs (RP07b).

In this study, participants were asked questions about their employment status and their activities for which they have to leave the house. They were also questioned about how connected they feel to the outside world.

All participants interacted with people outside of their household daily, either virtually or in real life (face to face). They went out for appointments and for work purposes occasionally. Some participants were still working either in paid employment or volunteering. They were mostly involved with charities and organisation that work for the betterment of the life quality of the people with disabilities (disabled people). Before covid-19 lockdown some of the employed participants worked from an office, but they had to transition working from home because of the pandemic.

Out of the participants not in paid employment at the time of the study, some participants went out to meet family or for shopping and some only for hospital appointments.

Participant 2 mostly spent time on his computer, watching movies. If he must go out then a private carer needs to be hired for the day, for driving and wheelchair transfers is needed. According to the wife of participant 2: "Yeah, we have a carer that we would probably hire. When he needs to go out than carer can take him out". Participant 7 on the other hand, has had a very recent diagnosis, which was followed closely by covid-19 lockdown. Due to his progressing ailment, he stopped working too. So, now he doesn't leave his house unless it's for medical appointments.

All the participants of this study had external engagements either virtually or face to face. However, they felt disconnected from the outside world. In some cases, this disconnect was either due to covid-19 lockdown or in some cases due to the progression of their disease. Although, when the participants were asked about using an ISA device in the future, the majority of them replied positively. Participant 3 was not positive about using ISA device. This was not due to lack of external engagement, rather she felt that all her needs are

already met by existing technology around her, and the ISA device would not add any extra functionality. According to her “I want things if they are useful to me, then I'll be interested in it. But it's not as if I've got to try and find a purpose for it.” Hence, the proposition (RP07a) that participants with higher external engagement have positive attitude towards intention to adopt ISA device can be reasonably accepted.

During the interviews, all the participants talked about various difficulties they perceived in using different technological devices. The fact that the participants were engaged externally did not appear to influence the perception of these difficulties. For example, when talking about her external engagement before the covid-19 lockdown, participant 4 said “I used to go to physiotherapy, I used to go to a gymnasium. I go shopping all the time. I go on the busses. After lunch meeting my family, meeting friends...”. However, due to her progressing illness she had lost the use of her hands and there is no mobility left in her body from the neck down. Participant 4 found it very difficult now to use conventional PC controls, remote controls, or anything with buttons to be pressed. According to her “I have thought about getting those emergency buttons or pendants bracelets, but then how? If I had them but then I couldn't press the button”. Participant 06 was also engaged externally, he had specially adapted vehicles and wheelchairs for going shopping and going to visit family. However due to SCI, there is no mobility left in his body from neck down. Participant 6 felt that he is very dependent on his caregivers for use of his computer due to his mobility impairments. According to him “My carer is sitting in the chair beside my bed, and they work the computer for me”. In light of the above findings (RP07b) that, participants with higher external engagement have a positive effect on the PBCs does not hold true.

## Income

In existing literature, personal income is identified as a positive indicator for access to technology and willingness to purchase and use it Feder et al. (1985). In this study it was proposed that participants with higher income will have a positive attitude towards intention to adopt an ISA device (RP08a) and will have a positive effect on the PBCs (RP08b)

To estimate the level of income of participants in this study, they were asked about their status of employment. An estimate of their income was then cross referenced with their living arrangements, to get a general idea of their income and purchasing power.

Most of the participants were either retired or not in paid employment at the time of the study. Only 4 participants were in paid employment. The remaining participants were receiving pension and benefits from the government. Some participants had other sources of income as well. For example, participant 6 had received compensation money from the company he worked for as he suffered from a Spinal Cord Injury (SCI) due to an accident that happened during a company event.

During the data analysis it became evident that the income coming into a household was not important. In fact, it was the disposable income that dictated the participants' spending behaviour regarding purchase of new devices. Taking the example of four participants participant 6, 10, 4 and 3. Participant 6 is retired but had an additional source of income due to compensation money from his company. He had numerous Alexa around his house, Blink cameras, monitors perched on the ceilings connected to the CCTV cameras and his PC. He even purchased Alexa for his mother's home. He purchased another EC device privately to be used when he is travelling. Participant 10 does volunteer work and receives state benefits. However, he has no dependents, so he has some disposable income. He too purchased numerous Alexa for his house, some smart plugs, smart bulbs and wanted to buy a smart TV. According to him "I have personally invested in other smart devices. I have 4 Alexa, numerous smart plugs, smart lights. But gradually I wish I had a smart television.". Similarly, Participant 4 purchased numerous new devices like Alexa, Google Home, Alexa Show and CCTV camera. Participant 4 was not in paid employment at the time of the study and was retired. She had no children dependent on her and her husband was living with her. On the other hand, participant 3, worked as a free-lance researcher. Participant 3 had 3 sons who were still students, and her husband had deceased. Participant 3's limited disposable income was evident in her spending behaviour, including new technological devices: she had not purchased a single technological device privately to explore or to help her in her daily tasks.

From the findings listed above, it can be concluded that people with higher disposable income developed a positive attitude to the adoption of new technology. In conclusion RP08a, that participants with higher income will have a positive attitude towards intention to adopt an ISA device needs to be altered to state that participants with higher disposable income will have a positive attitude towards intention to adopt an ISA device.

Whilst investigating the PBCs, the participants shared that they perceived numerous difficulties whilst considering use of new technological devices. Most of these difficulties were due to the current and increasing mobility impairments of the participants. Some participants also felt that due to their disability they are unable to carry out some complex installations and unable to hire professionals due to financial constraints. According to participant 6 “The problem is more...Who is going to fit it up? Who's going to put it up? I mean, I'd much rather have had a proper CCTV system. But it would be expensive. You probably end up having to use a professional company, which would have been thousands of pounds. Whereas for a couple £100 I got blink cameras. And they were easy to put up because I don't have to source power to them.” Another example is of participant 3, she felt that she did not have the financial resources to get an ISA device installed along with other smart devices that the ISA device can control. So, despite the fact that the perceived difficulty is due to a participant’s disability, but if the participant had higher disposable income then the issue could have been resolved by delegating the PBC to professionals. It would have been easier for the participant to hire professionals if he had higher disposable income. Hence, RP08b that participants with higher income (disposable income) will have positive effect on the PBCs as participants can delegate the complex task of technology set up to the professionals.

Table 1: Findings for User Characteristics Research Propositions

<b>RP No</b>	<b>RP</b>	<b>Accepted Or Rejected</b>	<b>Altered</b>
RP02a	Age has a negative effect on the attitude to adopt an ISA device.	Rejected	
RP02b	Age has a negative effect on PBCs.	Rejected	
RP03a	Being female has a negative attitude towards intention to adopt an ISA device.	Rejected	

RP03b	Being female has a negative effect on PBCs.	Rejected	
RP04a	Desire for independence will positively influence attitude towards intention to adopt the ISA device.	Rejected	
RP04b	Desire for independence will have a positive effect on the PBCs.	Rejected	
RP05a	Voluntariness of the participant to try a new technology will positively influence their attitude towards intention to adopt an ISA device.	Accepted	
RP05b	Voluntariness of the participant to try a new technology will positively affect their PBCs.	Rejected	
RP06a	Openness to innovation leads to a positive attitude towards intention to adopt ISA device.	Accepted	

RP06b	Openness to innovation has a positive effect on PBCs.	Rejected	
RP07a	Participants with higher external engagement have positive attitude towards intention to adopt ISA device.	Accepted	
RP07b	Participants with higher external engagement have a positive effect on the PBCs.	Rejected	
RP08a	Participants with higher income will have a positive attitude towards intention to adopt an ISA device.	Altered	Participants with higher disposable income will have a positive attitude towards intention to adopt an ISA device
RP08b	Participants with higher income will have a positive effect on the PBCs.	Altered	Participants with higher income (disposable income) will have positive effect on the PBCs as participants can delegate the complex task of technology set up to the professionals.

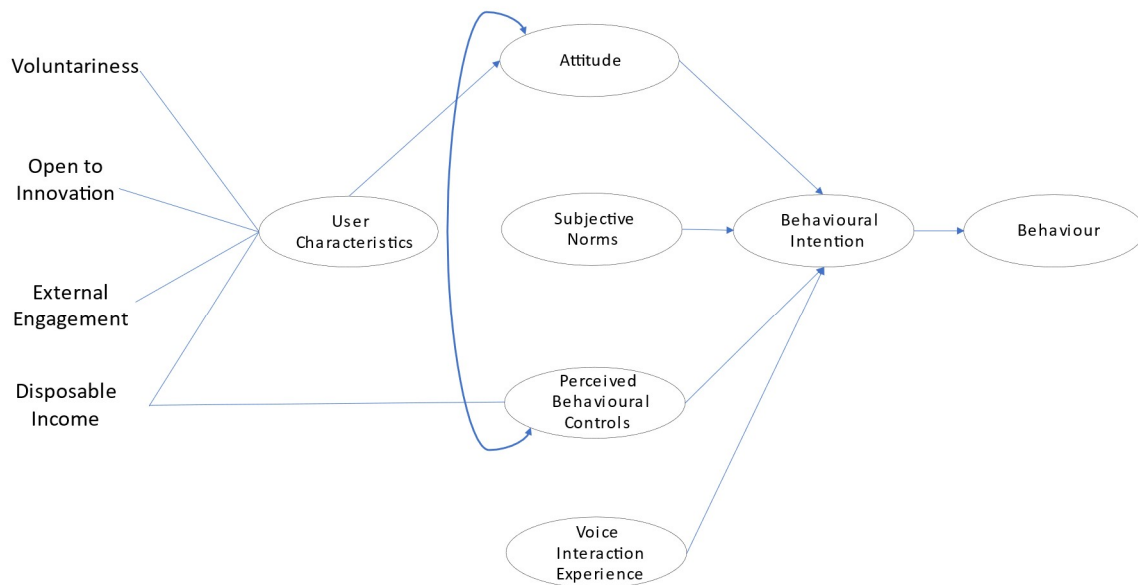


Figure 6: Modified User Characteristics Research Propositions

## Subjective Norms

Subjective Norms (SN) is the second construct considered in the model proposed in this work. SN are one's perceived opinions of people who are important to them (Ajzen, 1991).

## Family and Peer Pressure

According to previous studies, family members played a significant role in the selection of technical devices and their purchase Luijkx et al. (2015). It is proposed in this study that family and peer pressure positively affect the intention to adopt an ISA device (RP09a).

In this study however the word pressure is not used in the context of coercion but social pressure, for example, insistent invitation to purchase something because it would benefit the participants in their daily lives. Participants were asked questions about the most recent purchasing of a technological device with the intent to highlight the role of friends, family, caregivers or medical professionals in the selection and purchase of a device. It emerged that some of the participants asked for advice and suggestions from their friends and family. Out of these participants, some participants buy devices on the insistence of their friends or family, whilst some just listen to their suggestions and then make their own decision. For example, participant 6 purchased devices on the insistence of his friend, who is somewhat of an expert in this field: "I have friends who worked in the computer business. I would seek



advice and to be honest, most of my technological movement forwards either blink, Amazon devices, using Smart TVs etc. is very much based on what A(friend) told me, he's pushed me towards it basically". On the other hand, participant 11 just asks for friends' views: "I might speak to friends or family if I know someone's got a particular product to get their opinion, but generally look online [AN: for advice and reviews]".

In one case, the non-technical advice of family members negatively influenced a participant's decision in purchasing new technical devices. Participant 1 was reluctant to purchase smart switches and bulbs as they don't match with the existing bulbs and switches at his house and his wife did not approve of that. According to him "That sort of stuff that might not go down very well with my wife. I've been looking this up on Google and Amazon. There are no sort of lights like I have got in the main room, they're small candle ones". So, family and peer pressure can affect the technological adoption negatively too.

Some of the participants faced varying degrees of family or peer pressure (6/11) in the form of insistence to purchase certain devices to help them in their daily lives. The participants sought out advice of their friends and family if their friends already own a device they are thinking of buying and if they themselves do not have technical expertise. While some other participants did not ask the advice of their family or peers as they said that they were the technical people in the family, and they are the ones who offer the advice to the family instead of the other way round (5/11). Only one participant refrained from purchasing a technological device once because of the opinion of their family. Hence, we can say that for the participants, who lacked technical expertise, family, and peer pressure (advice) did play a positive part in the intention to adopt an ISA device (RP09a).

### Trust in NTRECES Advice

According to NTRECES protocol, the staff at NTRECES visit the residence of the referred patients first, to give a demo of the available EC devices. The staff of NTRECES is the only source of professional information and advice about EC devices for the patients. Trust in the advice provided by NTRECES can affect the patients' decision-making process to use these devices. In this study, it is proposed that (RP09b) trust in the advice of the NTRECES staff is positively affect the intention to adopt ISA device.

In this study participants were asked about their first demo visit by the NTRECES staff after their referral. What expectations did they have, whether the EC devices met their expectations, and whether the NTRECES service instilled trust in them

When participants were questioned about their trust in NTRECES staff, some participants (6/11) said that they trusted the advice of NTRECES. Whereas some participants (3/11) stated that they neither trust nor mistrust the advice of NTRECES staff. Out of the 11 participants 2 have recently been referred to NTRECES and due to covid-19 pandemic, have not met any NTRECES staff face to face, hence had no opinion to offer.

Some of the participants trusted the advice of NTRECES staff (6/11). Such opinion was formed because the participants believed that out of all the available devices at NTRECES, they were issued the best suited device. Out of the 11 participants, only participant 11 was no longer using the EC device issued to him. This is because there were some recurring technical issues with the EC device that made the usage of EC device difficult. The user found it easier to rely on his caregiver to do things like opening doors for him. However, he trusted the advice of NTRECES staff and agreed with the selection of EC device issued to him.

As the participants felt that they were not being forced to use the EC devices, so, the abandonment of EC devices amongst the participants was almost non-existent. They had continued using the devices since they have been issued to them, whilst they also accepted upgrades whenever they were offered to them. However, some participants have decided to stay with their older devices. NTRECES have respected their decisions and have offered technical support even when the manufacturers have withdrawn support for older models. Hence, NTRECES did not force its customers to switch to a certain newer device and it is up to the customers if they choose to use a certain device or not. This resulted in a relationship built on trust between the NTRECES staff and the service users. It is clear to the participants that the NTRECES will not force a device on them which will not benefit them or which the customers are not comfortable with. Hence, if the ISA devices will be recommended by the NTRECES staff, the participants due to their trust in NTRECES staff, will be positively influenced in their intention to adopt the ISA device (RP09b).

## Care Support System

Participants get support for their daily tasks by their care support system which consists of informal or professional caregivers (provided by Social Services or privately hired). These caregivers can be live-in i.e., available 24/7 or visit multiple times a day. As these caregivers play such vital part in the lives of the participants, their views and opinions can have a significant influence on the decisions of the participants. According to RP09c there is a positive relationship between the opinions of those who provide care and support and the intention to adopt ISA devices.

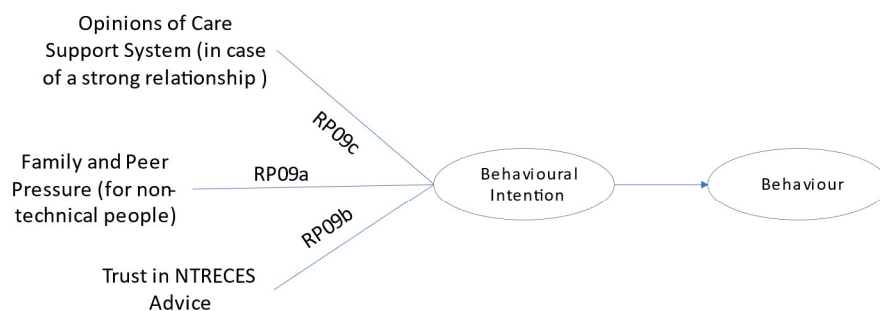
In this study, the participants were asked about how much the opinion of the caregivers' matter to them and if they can think of an example, where they took the opinion of the caregiver onboard, before making a decision.

4 out of 11 participants would give weightage to the opinion of their carers. The participants asked the opinion of their carers in those cases where the users thought that their decisions would also affect their carers. According to participant 11 "I think I probably do take into consideration, how they're going to feel about something and what they say". Some of the participants think of their caregivers as their friends as they live with them too and would consult them and ask them for help even in technical matters. According to participant 10 "My carers have become friends. We might have a discussion and I may ask them for their opinion". However, 3 out of 11 participants would give no importance to the opinion of their carers. These participants were, unhappy about the commitment of the caregivers assigned by Social Service.

It is apparent from the observations listed above that the caregivers who were with the participants for a longer time duration and have an established relationship with them, can influence the participants' attitude. For most participants, caregivers assigned by the social services visited three times a day. Each visit is an hour long, with an extra 45 minutes added to the evening shift 3 times a week. It was observed that temporary caregivers provided by the social services were unable to form a significant relationship with the participants. So, we can say that depending on the strength of the relationship of the participant with the caregiver, opinion of the care support system will positively affect the adoption of an ISA device (RP09c).

Table 2: Findings for Subjective Norms Research Propositions

RP No	RP	Accepted Or Rejected	Altered
RP09a	Family and peer pressure positively affect the intention to adopt an ISA device	Altered	For the participants, who lacked technical expertise, family, and peer pressure (advice) did play a positive part in the intention to adopt an ISA device
RP09b	Trust in the advice of the NTRECES staff is positively affect the intention to adopt ISA device.	Accepted	
RP09c	There is a positive relationship between the opinions of those who provide care and support and the intention to adopt ISA devices.	Altered	Depending on the strength of the relationship of the participant with the caregiver, opinion of the care support system will positively affect the adoption of an ISA device.



## Subjective Norms

Figure 7: Modified Subjective Norms Research Propositions

### Perceived Behaviour Controls (PBCs)

PBCs consists of the users' perception of how difficult or easy it is to perform a certain behaviour, in this case to use ISA devices. This perception is based on previous experience of the same or similar products and anticipated obstacles Ajzen (1991).

In existing literature PBC has been demonstrated to have a positive effect on behavioural intention Yang et al. (2017). In this study the PBC constructs includes 11 variables.

### Familiarity with Technology

In the early stages of the project, whilst shadowing the NTRECES staff, it was observed that patients who were more familiar with technology, either due to their own interest or due to previous professional experience, were more interested in newer device options and functionalities. They had a preconceived notion about the ease of use of devices. Hence people with good technological competence have a positive and significant relationship towards the intention to accept technology Baturay et al. (2017). Hence it is proposed in this study that (RP 11) there is a positive relationship between familiarity with technology and intention to adopt ISA device.

Participants were asked about their familiarity with different technological devices around the house as well as their usage of current EC devices. This approach can help in establishing

the relationship between familiarity with technology and usage of EC devices. To investigate familiarity with technology participants were asked about different technological devices around their house, which ones they use most frequently and the issues they faced regarding these devices. They were also asked about their computer literacy skills.

All participants used technological devices or software on a daily basis. The use of technology was either for their work, help in daily tasks or just for entertainment purposes. The most used technological device was computer or tablet (5 out of 11) participants use the computer for work purposes also, whereas (6 out of 11) were just using the computer or tablet for email, online shopping, online banking, social media, and entertainment. In some cases, the participants use additional software or hardware to access their computer, such as a head switch or voice to text software).

All the participants were familiar with technology and used it for different purposes. Participant 4 worked in finance all her life and used computer for work. According to her "I've used computers for many many years. So, I knew what the functions do". Similarly, participant 7 said "My background is in technology. I used computer all the time. Most of the technology was reasonably easy for me to use". Participant 8 also shared her experience of using different technologies at work "I use a lot of the other technologies at work. I use speech to text. I usually read through page 'cause sometimes I lie down at work". All participants but one use the EC devices that has been issued to them. All participants except one were positive about using ISA device in the future. For example, participant 11 uses his EC device as well as other devices he has purchased by himself. According to him "My front door speaker was controlled by Possum qwayo [AN: name of EC device]. And I've got two tablets, one stays in my bedroom. The other one stays in the living room. I have personally invested in other smart devices. I have 4 Alexa, numerous smart plugs, smart lights". Similarly, participant 6 also accounted for his use of technology, "Everyday I'm pretty much every minute of the day when I'm not eating. Apart from that, basically the computer is there, and I tend to use it, I use dragon for dictation, I can make notes". So, it can be safely concluded with the help of these findings, that there is a positive relationship between familiarity with technology and intention to adopt ISA device (RP11).

## Technical Support System

According to existing literature assistive technology lacks customization and integration with mainstream technology, this requires technical support around the user to avoid rejection and abandonment of technology Goodman et al. (2002). This means that if a user has good technical support network around them, they will help in the customization and integration of assistive technology. Hence, this study proposes that users with a good technical support network will have a positive effect on the attitude towards intention to adopt ISA device (RP12).

To determine the technical support available to the participants they were questioned about their recent technological purchase. The participants were asked whether they had asked someone's advice before purchase, what was the installation and learning curve like and who provided the technical support in case of a difficulty. The participants were also asked about what they would do in case they encountered difficulties when learning or using the device.

In this study all participants had a technical support system in place. Either it consisted of a friend, a member of the family, a professional technical support service or they themselves were tech savvy enough to fix technical issues. In the case of participant 3, she had to call in a professional for technical troubleshooting. As she had to pay for this service, and she encountered financial difficulties, she was reluctant to try and install new technologies, as it can cost her to install new devices and learn how to use them, as she is herself not able to do that. According to her "Sometimes my sons can help. My sons know how to build computers and things. But they know about the hardware side of it, but the whole software side of it they don't. I'll looking online for help or else if it really comes to, I have to call a man called AV".

In case of trouble with the issued EC devices the participants would call the NTRECES. In case of other devices privately purchased, they would call the manufacturers to solve the issue. When, asked about if they had ever abandoned a device due to technical issues, only one participant (participant 11) had done so. He stopped using his EC device as he was unable to keep both his smart phone and EC device on the same Wi-Fi network and despite multiple visits from the NTRECES team the issue was not resolved. So now he just asks his

caregiver to do the tasks for him rather than using the EC device. According to him “One of the barriers for the phone or the iPad was that you couldn't be connected to Wi-Fi if it was connected to use the app [AN: EC device controlling app]. So, I'd have to be going back and forth between the two. And I got buttons on the wall to open the doors, which I can manage rather than using the app so it's more practical. Also, I've had someone with me as well at other times”.

When the participants were asked whether they found it difficult to learn to use their EC device or any technical device, or they had to ask for assistance to learn how to use a device. All participants were able to learn how to use devices on their own. In some cases, they used resources online like YouTube videos to fully understand the functioning of the devices. According to participant 7 “We were not given any information about how to use it [AN: eye gaze, mouse controlled by eye movement]. So, we spent time looking at YouTube and tried to install it and started using it”.

All the participants in the study had a technical support system in place, albeit of different kinds. For some participants technical support is more accessible if they themselves are tech savvy or their family or friends can provide the technical support. Whereas for some participants it could cost them calling the technical support, so they did not reach out to them as often and as easily. Despite, the difference in access to technical support, 10 out of 11 participants showed positive intention towards adoption of ISA device, when enquired about it. These findings suggest that users with a good technical support network have a positive intention to adopt ISA device (RP12).

## Residence Type

NTRECES service users live in different type of residential settings, both privately-owned and rented government funded. During the installation of EC devices and their peripherals, sometimes there are obstacles due to the type of ownership of the property, especially if there are structural changes or electrical installation required and the service users must ask permission to the property owner to make the required changes. Funding for the installation of peripherals like curtain tracks, light fixtures, door openers, CCTV cameras etc. can also be a hindrance if the service user is not the legal owner of the property. Hence, it is



proposed in this study that (RP13) users' residence owned by a housing association negatively effects the attitude towards the intention to adopt ISA devices.

In this study information about the participants residence is collected as part of initial demographics. All the participants live in independent residences (6 participants live in a house, 1 in a bungalow, 3 in a flat and 1 in an annex). None of the participants lived in a government owned property. All the participants were able to install devices in their houses, without permission from any government body. Similarly, when asked about adoption of an ISA devices, only one of the participants felt that there will be issues related to installation of peripheral ISA devices.

Although participant 6 owned his residence, he was facing an issue with his internet speed and reliability. He wanted an internet with higher speed, but the road he lives on is a private road and is not under the council, so his house did not get connected to the fibre optic. This means that a lower speed broadband was the only available option for quiet sometime. Which creates issues for him, as he has a lot of devices connected to the Wi-Fi, including various ISA devices. So sometimes even if the residence is privately owned, there can be issues external to the residence which are not in the control of the owner and can affect the performance of technical devices.

So, within the constraints of this study not having participants residing in social accommodation, it is feasible to rephrase RP13 to state that residing in private residences positively effects the users' attitude towards intention to adopt an ISA device.

### Trust in NTRECES Advice

It has been discussed above under subjective norms

### Lack of Access to Open Market

The participants in this study suffer from severe mobility impairments and it is often difficult for them to visit the shops and explore and experience new technological devices available on the market. Although they can do their product research online, this does not provide a physical experience with the product. For example, participant 11 said "I will not buy a telephone unless I can actually see it and make sure it has all the accessibility". Sometimes, it is possible to physically interact with the new devices, if they are owned by their friends,

family, caregivers or clinical staff. For example, participant 11 shared that “We were at a friend’s, and he had one of them, Alexa. We kind of saw how that works for them. We decided to get it [AN: Alexa] and use that”. It is proposed in this study that (RP 15) the lack of access to the open market has a negative effect on attitude toward intention to adopt ISA devices.

The participants were asked about their recent experience of purchasing a new technological device. Whether they preferred online shopping or retail, were there any issues faced during the process, does physical interaction with a device make a difference etc.

All the participants did their shopping online. Some participants can access shops but were not doing retail shopping due to covid-19 pandemic. Due to improved online retailing experience, participants stated that they were comfortable in purchasing online and eventually returning the goods, if necessary. According to participant 5 “I always get from Amazon because they’re very good. 30 days to make your mind up. If you don’t like it, you can just send it back”. So, they don’t feel the need for going out to try the device physically at the shops. Participant 9 used a hybrid approach in her shopping and whilst she welcomes a physical interaction with the product, she completes her purchase online as she trusts the product reviews available online. According to her “Even if I went into the shop, I would probably then just take a look at different devices and then come home research it [AN: for reviews] online anyway”.

The importance of the physical interaction with the product seems still important when the purchase requires a high financial disbursement; participant 10 stated “I will not buy a telephone unless I can actually see it and make sure it has got all the accessibility, but I have been waiting for 3 months (AN: due to covid-19 pandemic)”. One participant was searching for specialist technology, specifically adapted for different mobility impairments. Such products were unfortunately only available online. According to participant 11 “If there was a shop that kind of had all these adaptations available and they knew everything, and you go in and someone could show you around. Yeah absolutely. It would be much easier.” Hence it can be inferred from this finding that people with mobility impairments would like to try specialized devices in shops before purchasing them, but it is not possible as the specialized devices are mostly available online.

As mentioned above most of the shopping was done online among the participants. Due to their mobility impairments and more recently due to covid-19 pandemic it was difficult for the participants of the study to visit the shops. According to participant 6 “I've been very restricted but mostly not because of COVID, but because I've had a sore issue between my legs and if you have a sore down there you can't sit in a wheelchair”. Due to improved delivery systems from online retailers, the participants can now afford to physically try out a product and return it for free if it does not suit them. According to participant 7 “I didn't do that [AN: go to the shop to try iPods] because I don't think anyone let you test out iPods like that, but I just went online and bought it and if they didn't work, I'll send them back”. Online reviews were also considered a benefit of the online shopping experience. Some specialized products were not even available in the retail sector and were available online only. All the participants have purchased technological devices online in the past year at least once. Hence in the light of current findings from the data it appears, that online shopping is the preferred method of purchase of the participants in this study. Given the mobility impairments, improved online retail experience and online availability of specialized devices, participants preferred online shopping experience to retail shopping experience. Hence, it can be stated that, lack of access to open market did not negatively affect the attitude towards intention to adopt an ISA device (RP15).

### Perceived Ease of Interaction

According to Technology Acceptance Model (TAM) Davis (1989), Perceived Ease of Use (PEoU) directly drives the attitude towards intention to adopt technology. One of the unique features of ISA device is the voice interaction interface. Conventional EC devices are generally controlled via a scanning method, which is lengthy and cumbersome. As compared to conventional methods voice control methods of ISA device is relatively easy and natural. Hence, it is proposed in this study that (RP 16) perceived ease of interaction leads to positive attitude towards intention to adopt ISA device.

To determine the participants perceived ease of interaction about different technological devices, including EC and ISA devices, the participants were questioned about which technology and methods of interaction they find easier to use. The participants were also questioned about the factors they consider whilst replacing a technological device. The participants who did not own an ISA device were shown a short demonstration video.

When the participants were questioned about which method of interaction with the technological devices, they find easier to use, 7 out of 11 believed they found voice interaction relatively easy. For example, participant 2, preferred voice interaction because according to him, “anything for which I don’t need to press a button is easier”. However, some participants were experiencing loss of voice which made them apprehensive about ISA device’s ability to support them. Some participants were apprehensive about the lack of variety of devices that can be controlled with voice and the amount of financial investment required to get all the peripherals controlled by voice. Participant 04 thought that “if iPad can be operated with voice it would be so much easier for me”. Another participant found it awkward that all the communication with an ISA device is broadcasted on a speaker and would prefer an earphone or headphone options for some functionalities for example, online banking. Depending upon the nature of the task, some participants become concerned about their confidentiality. According to participant 6 “Now if I had more reliable voice control systems and more reliable ability to liaise with my computer or my iPhone. I'm gonna of course use telephone banking but because it has to be done over a speaker, it's not exactly confidential”.

One of the major difficulties that the participants faced whilst using conventional, e.g., mechanical, interaction methods with technology was tiredness. EC devices are generally controlled with a single click switch button. Due to severe mobility impairments, most of the EC device users are unable to use the touch screen and can only click the switch with the help of little movement left in any of their limbs or their head. The controlling switch button for EC devices need to be placed in a certain position to be used by the participants. For example, participant 4, had no movement left below her neck. She needed her caregiver to place the switch button in a certain position underneath her chin, so that she could click it to operate her iPad. However, this was tiring for an extended period. According to her “It [AN: voice control] would be a lot better. I do get a lot of stiff neck because I have only a tiny bit of movement in my head for hitting the button. It moves out of the range as well sometimes. So, somebody has to bring it back up to my chin”. Participant 2 was just about able to use one finger to type on a conventional keyboard, which he found increasingly hard. He would have preferred just to dictate with his voice now, which is much less strenuous. According to his wife “He manages to slowly, with one finger, typing”. Participant

11 used finger splints so that he could operate a conventional mouse and keyboard.

Participant 7 tried using the eye gaze method to control the computer cursor but then he had to sit in a fixed position for a long duration otherwise the device had to be recalibrated, which was very tiring for him. Participant 9 usually operates her iPhone with voice, however she needs to wake the phone up manually, before she can start using her voice to control it. For that purpose, she needs to always have the phone in a certain position so that she will be able to reach it, which she thinks can be tricky, especially at nighttime in case of emergency. Some participants had placed an ISA device in their bedroom as well as their caregivers, just for the purpose of contacting them at night in case of an emergency.

When the participants were questioned about the device they felt easiest to use, most of them mentioned their phones. They said it was obvious how to use it, they did not have to look up a manual to learn how to operate it. Some participants also think that iPhones offered the best accessibility options, and it is very easy to link all apple devices like iPad, iPhone, Mac Book etc. Participant 10 however found his vacuum cleaner the easiest device he ever had to use. He thinks that it is easiest as it just has one button to turn it off and on.

Although the participants were finding the conventional method of interaction harder and tiring, they are still using it as there is no alternative available to them yet. They are using voice interaction in some places where they can, however, there are limitations to voice interaction like lack of variety of devices that can be operated, financial investment for installation and purchase of peripherals, loss of voice, lack of privacy due to interaction on a speaker. Despite these limitations most of the participants would like to switch to voice interaction as conventional interaction methods were becoming too difficult for them due to progression of their disease. In summary we can say that the perceived ease of interaction of ISA devices that are based on voice control, will have a positive effect on the attitude towards intention to adopt it (RP16).

### Perceived Reliability

EC devices are assistive technology, prescribed to people with severe mobility impairments and in case of emergencies it is necessary that these devices are reliable Goodman et al. (2002). A device would be considered reliable if it functions correctly according to its technical capability, without interruption, has systems in place to recover from shutdown,

has reliable privacy protection and information security Kim et al. (2015). Although EC devices provide multiple functionalities, according to a previous study Judge et al. (2009) the only function for which reliability is critical is call for help. In this study it is proposed that (RP17) higher perceived reliability of a device leads to positive attitude towards intention to adopt ISA device.

Participants in this study were questioned about the technological devices they use daily and how reliable they think they are. They were also questioned about why they think a certain device is reliable and were asked about any experiences where a certain device failed to perform.

All the participants were of the view that ISA devices, due to their reliance on internet, are not very reliable. According to the participants, the EC devices, were reliable most of the time. It was very seldom that they fail to perform a given task. EC devices were not dependent on Wi-Fi or internet; hence, internet issues did not affect their performance. Most of the EC devices worked on batteries so power failure was also not an issue. There were certain issues like short battery life which made their EC devices a bit unreliable sometimes.

According to some participants the most reliable devices in their use are their EC devices. Whereas some participants named other devices like laptop, radio, vacuum cleaner, and wheelchair. The participants explained that these devices had almost never failed to do the job they were meant to do, and they last for quite some time as well and don't need replacing as often. Some participants also pointed out that in some cases the devices don't fail but due to something in their surroundings they fail to perform their function. For example, participant 8 pointed out that when the door frames get warped due to temperature or humidity, the door opener is unable to open the door, despite no fault of its own. In some cases, reliability of a device is not only dependent on its internal functionality but also due to external factors. For example, ISA device would fail in a noisy place as it would not be able to hear the wakeup word.

In this study all the participants perceived that ISA devices would be unreliable to use due to their dependence on the Wi-Fi internet. However, all the participants except one replied positively about using ISA device in the future. It is interesting to note that the decision to

choose a device which is relatively unreliable is not black and white. Other factors such as lack of choice (due to advancing illness) and the assumption of a backup device for emergencies, also play a part. So, although participants were willing to adopt the relatively unreliable ISA devices, it does not mean that reliability is no longer a factor in their attitude towards intention to adopt an ISA device. Given the importance participants gave to reliability of the EC devices it can be said that perceived reliability does affect the attitude towards intention to adopt ISA device, but other factors such as lack of choice and availability of backup device should also be considered (RP17).

### Perceived Confidentiality

Interaction with the ISA devices is via voice and each interaction starts with the wakeup word. The ISA devices are continuously listening to the users so that they can respond swiftly to the wakeup word. Users of ISA devices need to trust the manufacturers that their private conversations, as well as their commands to ISA devices are kept confidential and are not used for any other purpose Yang et al. (2017). Most of those skeptical of ISA devices don't trust the big technical companies with their data and feel that these companies keep on changing the terms of service Lau et al. (2018) To explore the effect of perceived confidentiality, it is proposed in this study that (RP18) higher perceived confidentiality results in a positive attitude towards intention to adopt ISA device.

The participants were asked about their concern regarding the breach in confidentiality when using different services on the internet like shopping and online banking. They were also asked about their trust in Tech giants like Google and Amazon. Some questions were also asked about the ISA device like in which room of the house it will be placed and addition of extra security features.

All participants did not trust the tech giants with their information. To safeguard their information, when talking about passwords or pin codes, the participants would mute their microphones on the PC or unplug the ISA device. Some participants did not use online banking services as they felt it is not safe to do so. Others felt that by installing an anti-virus software, refusing to accept cookies and password protecting their documents were all the security measures they could take to safeguard their information online.

When the participants were asked whether they think their information is safe with the ISA devices listening in all the time, The participants said that first, they don't have any significant information in which a tech giant would be interested, so they are not bothered about whether their information is secure or not. Secondly, if the ISA device can control all the devices around their house, then they would not care even if their information was not safe with the tech giants. Compared to the benefit of house automation they were not concerned about the security of their information. Participants who already own an ISA device had placed it in their bedrooms, so they can contact someone at night in case of an emergency, disregarding the fact that confidentiality could be breached. Some participants trusted ISA devices more than chatting apps (like WhatsApp) and search engines. So, despite lack of perceived confidentiality all participants except one were eager to use ISA devices. It indicates that, additional factors such as significance of information, as well as benefits of the ISA device versus breach of confidentiality should be considered when analyzing perceived confidentiality. Hence, RP18 is now modified as, perceived confidentiality does not affect intention to adopt an ISA device negatively, unless other factors are considered.

### Perceived Security

Given the dependence of ISA devices on the internet and Wi-Fi network, it is a possibility that these devices can be attacked by malicious entities to access information and gain control of sensitive peripheral devices like smart door locks on the smart home network. As this study focuses on a vulnerable group of people, it is vital that they perceive that the technology is compliant to security standards Jutai & Day (2002). Users of ISA devices fear that malicious entities can access their data and this poses as a risk to their security Kowalczyk (2018). If the users perceive the devices to be secure then, it will be easier for them to form an intention to adopt it. So, it is proposed in this study that (RP19) higher perceived security has a positive impact on the attitude to adopt.

Participants in this study were questioned about how secure different online technologies and services (online banking, search engines etc.) are, according to them. The participants were also questioned about their view regarding the perceived security of an ISA device and what security issues it might have.



Out of all the functions and services that the participants were questioned about, they felt the most concern for the security of online banking and doing online transactions. A few of the participants had been victim of scams in the past, so they adopted some precautionary measures. For example, some participants only did online transactions via PayPal. Others had dedicated a credit card for online transactions. One of the participants, sometimes did a test transfer with small amounts before actually transferring the actual amount. In order to safeguard their online banking details, the participants would mute the microphones on their PC, unplug the ISA devices or ask their caregivers not to repeat the information aloud.

Some of the participants also pointed out that the level of security expected from an ISA device would also depend on the type of the peripherals controlled by it. For example, security would be of utmost importance if the ISA device is controlling the main door locks or controlling a car.

The participants in the study were aware of the security issues surrounding their information whilst using technological devices and online services. Most of the participants rated ISA devices to be more secure than text messaging services and online banking in the questionnaire. However, they were aware of how certain functionalities provided by the ISA devices can be more security critical than the others. For example, participant 1 did not like the idea of using Alexa to control the car. According to him "If you've got some idiot outside trying to get your car [AN: car with built in Alexa], they managed to get to the Alexa, they could access it by that [AN: Alexa] anyway". Despite these reservations, all the participants were positive about using ISA device in the future. However, the decision to adopt the ISA device despite their reservations about security is not black and white. Although the participants felt that ISA devices were not secure, they also realized that there is no alternative. Similarly, the participants realized that it is possible to use only those features of ISA devices which are not security critical. For example, smart locks or car controls. So, in the light of the current findings, RP19 can be altered that, the perceived security will negatively affect the attitude towards intention to adopt an ISA device, if the user does not have a secure alternative device or if the device is being used for security critical functions.

## Perceived Usefulness

According to the Technology Acceptance Model (TAM) perceived usefulness is the degree to which a person believes that using a particular system will improve their task performance and it directly influences users' intention towards adoption of technology Davis (1989). In this study it is proposed that (RP20): higher perceived usefulness leads to a positive attitude towards intention to adopt an ISA device.

The participants were questioned about how their life has improved after the prescription of EC devices. Questions also include What do they use their EC devices for and what more they think these devices can be used for. The participants were also asked about how useful they think the ISA device can be in their lives.

For most participants EC devices had been helping them in opening doors, switching lights on, adjusting their beds, using their land line phones, and operating their TV. These participants found the EC devices very useful in their daily lives, as it helped them to gain some independence. The participants agreed with the fact that the ISA device can provide all the functions that are being provided by the EC device. But the ISA device might need to be backed up by the EC device because the latter is more reliable since it is linked to the landline rather than an internet connection. Some participants also expressed their concerns about the cost of installation and the need for buying new peripheral devices to be controlled by the ISA device. According to some participants, if the installation and the devices are free or the ISA device works with the existing peripherals like ordinary bulbs, then it can be a plus point toward the ISA device. Some of the participants are already using ISA devices in addition to their EC devices. According to them ISA device can prove to be useful in providing some additional functionalities for example, playing music, setting reminders and alarms, searching the internet, reading books, displaying security camera footage on the monitor etc. Some participants also thought that ISA devices are more accessible and portable. For example, participant 11 said "... next to my bed at the minute I have a light switch, but if I haven't got a light switch next to me and if I could have an Alexa which is connected to a smart light bulb or something and then that kind of gives me independence 'cause when I'm in bed. I won't be able to get up and turn the light off...".

The participants in this study recognized the usefulness of the ISA device, whether they were already using it or not. As all the participants except one were positive about using the ISA device in the future, it can be concluded that perceived usefulness had a positive effect on the attitude towards intention to adopt the ISA device.

### Perceived Trust in Service Provider

The ISA device is an internet-based service, which makes it less reliable and less secure according to the users' opinion Chung et al. (2017). Consumer behaviour can be significantly influenced by their trust in the service providers, especially in uncertain environments like internet-based services Chellappa & Pavlou (2002). In this study it is proposed that (RP21) perceived trust in service provider leads to a positive attitude towards intention to adopt ISA device.

The participants were asked about how they chose their Internet service provider, what were the features they wanted in their internet and what were the problems if any they faced with their internet service provider.

Some of the things that the participants looked for when choosing the internet service provider is speed, cost, and reliability. None of the participants mistrusted their service provider and were of the viewpoint that the service provided is secure. The participants did not inquire about the safety features when selecting the internet service provider, despite free anti-virus software being available from the service providers as part of the subscription. Other participants had installed other freeware anti-virus software and that was the extent of steps they took for security purposes. There had been some instances, as expected, where internet went down, but overall, the service was satisfactory for the participants.

Irrespective of the quality of the service (unreliable connectivity and variable speed) provided by the internet service provider, most of the participants continued their contract with the internet service provider. Provision of extra security features was not a concern for them when selecting an internet service provider. Most of the participants have been with one service provider for a very long time and participants only switched service providers if they got a better deal. Some participants did not even choose their own internet service provider. Their family chose the internet service provider when they set up the participants'

accommodation. Given these observations, trust in the internet service provider did not appear to play a significant part in the choice of a service provider. So, it can be concluded that trust in internet service provider does not affect the attitude towards intention to adopt an ISA device (RP21).

Table 3: Findings for Perceived Behavioural Control Research Propositions

<b>RP No</b>	<b>RP</b>	<b>Accepted Or Rejected</b>	<b>Altered</b>
RP11	There is a positive relationship between familiarity with technology and intention to adopt ISA device.	Accepted	
RP12	Users with a good technical support network will have a positive effect on the attitude towards intention to adopt ISA device.	Accepted	
RP13	Users' residence owned by a housing association negatively effects the attitude towards the intention to adopt ISA devices.	Altered	Residing in private residences positively effects the users' attitude towards intention to adopt an ISA device.
RP14	Trust in the advice of the NTRECES staff is positively affect	Accepted	

	the intention to adopt ISA device.		
RP15	The lack of access to the open market has a negative effect on attitude toward intention to adopt ISA devices.	Rejected	
RP16	Perceived ease of interaction leads to positive attitude towards intention to adopt ISA device.	Accepted	
RP17	Higher perceived reliability of a device leads to positive attitude towards intention to adopt ISA device.	Altered	Perceived reliability does affect the attitude towards intention to adopt ISA device, but other factors such as lack of choice and availability of backup device should also be considered.
RP18	Higher perceived confidentiality results in a positive attitude towards intention to adopt ISA device.	Altered	Perceived confidentiality does not affect intention to adopt an ISA device negatively unless other factors are considered.

RP19	Higher perceived security has a positive impact on the attitude to adopt.	Altered	Perceived security will negatively affect the attitude towards intention to adopt an ISA device, if the user does not have a secure alternative device or if the device is being used for security critical functions.
RP20	Higher perceived usefulness leads to a positive attitude towards intention to adopt an ISA device.	Accepted	
RP21	Perceived trust in service provider leads to a positive attitude towards intention to adopt ISA device.	Rejected	

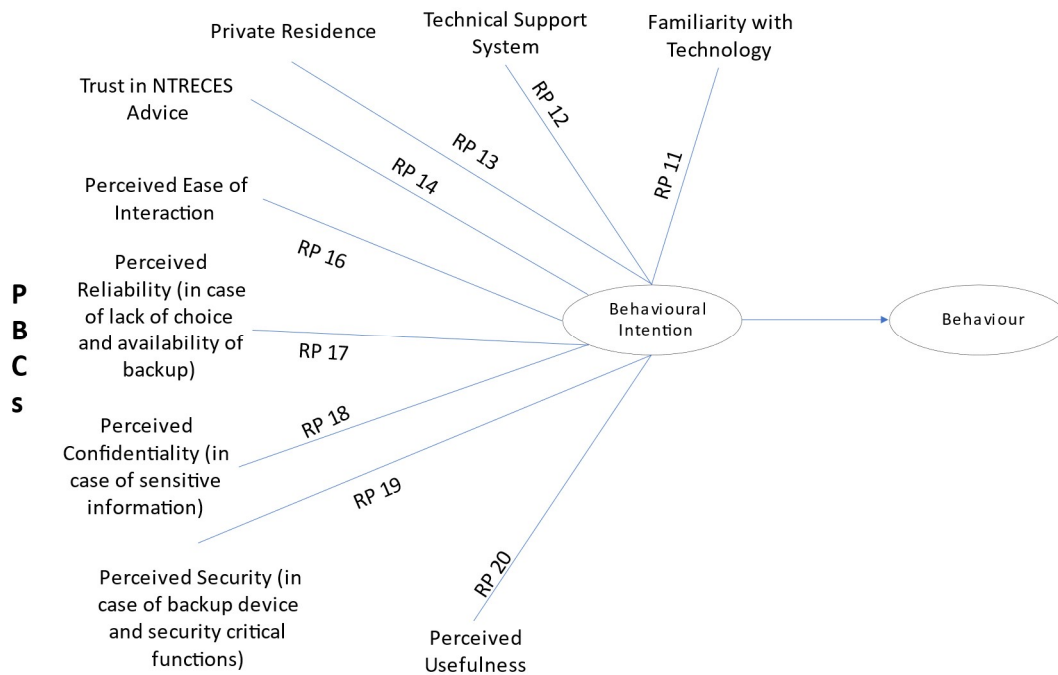


Figure 8: Modified Perceived Behavioural Controls Research Propositions

## Voice Interaction Experience

Voice interaction in natural conversational style with ISA devices is a relatively new technology. This unique feature of ISA device can lead to attribution of characteristics of anthropomorphism, which can lead to emotional attachment and recognition and/or assignment of agency Lopatovska & Williams (2018).

## Recognition and Assignment of Agency

People assume that anything that is talking back to them is human Klein (2016). Perception of anthropomorphism in a technology will result in the increase in credibility, reliability and perceived usefulness hence leading to a positive behavioural intention Wagner et al. (2019). Hence it is proposed in this study that (RP22) Identification and assignment of agency to ISA devices will positively affect the attitude towards intention to adopt the ISA device.

The participants were divided into two groups, ones who already own or have used an ISA device and ones who have not yet used an ISA device. For the non-users' group, they were shown a demonstration video about the various functionalities of ISA device, so as to give them an idea of the working of the ISA device. They were then questioned about if they detected or attributed a presence of consciousness or emotions in the ISA device. They were

also asked about if they think the ISA device acts like humans by displaying moods, by being polite or talkative etc.

Most of the participants think that the ISA device does sound like humans but does not look like one. Some of the participants were of the view that the ISA device does behave similarly to humans sometimes, as it understands what is being said to them (mostly) and answer to the user as mostly humans do, without sounding emotional. According to participant 6 “It answers you a lot like humans would answer you. It doesn't always connect the emotion though. It doesn't always, you know, understand you correctly. It doesn't really get upset or angry. So, it's still a machine”. The ISA devices sometimes also comes up with witty and smart replies but that is the extent of their emotional display. For example, participant 4 said “I think Google is more human than Alexa. It just seems more human. He's more polite. Alexa is more robotic”.

All the participants understood that there is no presence of consciousness, and the ISA device is just an Artificial Intelligence (AI) software, that needs electricity and internet to work. However, due to the voice, tone, and accent of the ISA device some participants associated some human characteristics with these devices and developed preference towards one kind of devices versus the others. Participant 4 assigned personality traits to two kinds of ISA devices that she owned “Alexa” and “Google Home” based on their voice, tone, accent, and replies. According to her Google sounded more human and Alexa sounded more American. She thought that Google was wittier, smarter, and more polite in its replies. However, she did realise that it is done on purpose in the software to make the device appear more human.

Some participants used the pronoun “her” for the ISA device and one participant would always use the name of the device “Alexa”. Whereas most participants addressed the ISA device as an “it”. This reinforces the views expressed by the participants that the ISA device does not have a consciousness and does not behave like humans.

On the other hand, participant 3 felt very strongly about attributing human characteristics to ISA devices, according to her “Attributing a personality to a box of tricks (AN: ISA device) is analogous to giving your car a name and believing it has a personality. I have never done



either". It is interesting to note that participant 3 was the only participant who responded negatively towards using an ISA device in the future.

However, some participants did enjoy the different candid replies from the ISA devices. So, it can be stated that identification and assignment of agency to ISA devices will not affect the attitude towards intention to adopt the ISA device (RP22).

### Emotional Attachment

According to Knijnenburg et al. (2012) interaction method or appearance of a technological device can affect the perception of its performance as well as the hedonic aspects of the interaction with the device, like pleasure and emotion. As the ISA device interacts in a novel way via natural language, it could lead to the formation of an emotional attachment to the devices. Therefore, this research proposes that (RP23) the greater the emotional attachment to the ISA devices, the stronger the attitude towards intention to adopt the ISA device.

The participants were questioned about the conversational abilities of the ISA device. They were also asked about their personalisation preferences regarding the ISA device and how their device is addressed.

Only a few participants considered the ISA device as a conversational partner. According to participant 2 "You can talk to it [AN: ISA device], it will tell you jokes". Participant 10 acknowledged that he has reacted differently to the ISA device depending upon the replies he got from the device. For example, participant 10, a male, was questioned about what pronoun he used for addressing the ISA device he said "It depends if I'm angry, if it is not understanding. Then I'd probably use 'She'. So, it depends...". Although this comments from participant 10 demonstrates that emotions may change the user attitude and behaviour towards the ISA depending on the situation, genderising the ISA as female when angry or disappointed by the performance of the device, is in contrast with what this research expected, e.g., that participants would allocate gender to devices as terms of endearment rather than derogatorily.

The Rest of the participants did not think that the ISA device is a conversational partner at all. According to them it is just a device that responds to instructions, and they cannot have a proper conversation involving emotions with the ISA device. Participant 4 gave a rating of

1 to the ISA device as a conversational partner on the scale of 1 to 5. According to him, "You could not have a real conversation with it involving emotions and feelings".

Participant 4 acknowledged that she had a good user experience with ISA devices as there is a fun and entertainment aspect attached to ISA device usage. According to her "I use that [AN: ISA device] for some games, quizzes, everything. I use google more for the radio than the Alexa".

Majority of the participants were satisfied with the physical design of smart speakers and would not want to change it. Two participants talked about changing the voice of the smart speaker. They wanted to change the voice to someone more personal, their mother in one case. Participants who had speech impairments, feared that they will lose their voice one day, so they wanted the ISA device to answer back in their own voices so as to preserve their own voices.

Some participants, on the other hand, were worried about treating smart speakers as conversational partners. According to them this can lead to confusion on the part of people who are marginalised already, they can confuse a device with human contact. For example, participant 9 stated: "Not necessarily for me, but I would worry about other people that did not have independence and did rely on technology. Especially if it had more human element to it, confusing people mentally. If they got an attachment to it because it's that human connection". Moreover, participant 8 feared statutory services being replaced by technology. She felt that government or policy makers can use this human connection property of the device to replace human contacts, in which professionals used to come and check up on people who are isolated already. According to her, "we don't see technology as replacement of human contact. We should be very mindful about that, but at the same time I do appreciate it where people need that human sound. If somebody did that to facilitate communication. I think that's extremely important that if that's what somebody wants".

All of the participants were clear about the fact that the ISA device is just a technological device that can help them in different tasks. The participants were clear about the fact that the ISA device is not another person and none of them said that they would treat it as their best friend or confidant. Despite this clarity, some participants still wanted to assign different personalised voices to the ISA device, to add to their user experience. The

participants also realised that the normal conversational style of an ISA device could cause confusion for some vulnerable people, who can get emotionally attached to it. However, according to the all the participants in the study no such strong emotional attachment would be formed by them with the ISA device.

The participants also acknowledged the fact that the ISA device can be used for several additional features that the EC device cannot be used for. Some participants would joke with their ISA devices for example participant 6 said “I have great fun. Just sometimes talking at it and saying very controversial words like explosives and AK47”. Participant 6 joked with the ISA device to see its reaction. Some participants would use the ISA device for entertainment purposes too. According to participant 4 “I use some games, quizzes, everything. I listen to the radio on it”. The association of fun with the ISA devices made them more desirable to the participants as compared to the EC devices.

In the light of these findings, RP23 is altered to state that, The novelty and ease of the voice interaction, and the entertainment value positively affects the attitude towards adoption of an ISA device (RP23).

Table 4: Findings for Voice Interaction Experience Research Propositions

<b>RP No</b>	<b>RP</b>	<b>Accepted Or Rejected</b>	<b>Altered</b>
RP22	Identification and assignment of agency to ISA devices will positively affect the attitude towards intention to adopt the ISA device.	Rejected	
RP23	The greater the emotional attachment to the ISA devices, the	Altered	The novelty and ease of the voice interaction, and the entertainment value

	stronger the attitude towards intention to adopt the ISA device.		positively affects the attitude towards adoption of an ISA device (RP23).
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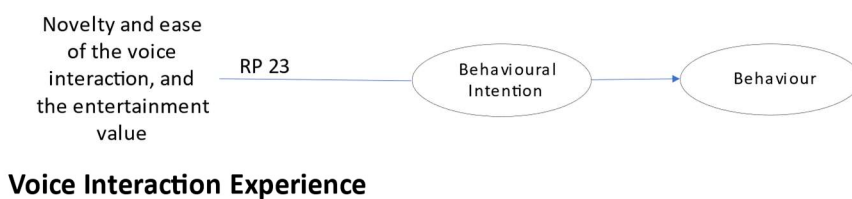


Figure 9: Modified Voice Interaction Experience Research Propositions

## 4.4 Emerging Themes

During the analysis of the data, in addition to the codes identified in the proposed model, several other themes also emerged. These themes are described in the sections below.

### 4.4.1 Mobility Impairment or Disability as User Characteristics

During the interviews one thing that almost all the participants pointed out is the impact of their mobility impairment or disability on the perceived difficulties in using different types of technological devices.

Participant 1 was worried about his voice quality being different at different times, which can result in non-recognition by the devices. As mentioned above in section 4.3, under the heading of Age, participant 1 said, “I'm a bit worried about my voice. When I give the voice to a machine? Is it gonna say not recognizable, wrong thing”?

Participant 4 for instance said, also as mentioned above in section 4.3, under the heading of Age, “I have thought about getting those emergency buttons or pendants bracelets? But then how? I had them but then I couldn’t press the button”.

According to participant 7, as also mentioned above in section 4.3, under the heading of Voluntariness, “Because of my illness, I can't always stay in the same position. Because every time I use it [AN: eye gaze, mouse controlled by eye movement], you have to re calibrate.”

Participant 9 was apprehensive about using new devices as she has almost no mobility left in her hands. According to her, as also mentioned above in section 4.3, under the heading of Gender, “So one of the reasons I used Home Sense [AN: EC device] is to call my carers during the night. But I need to do that from my phone [AN: phone acts as EC controller]. I'm unable to reach, so I have to have my phone popped up in front of me”.

Participant 10 had similar issues, whilst talking about video game controllers, according to him, as also mentioned above in section 4.3, under the heading of Gender, “I've got limited hand function, so I need certain adaptations”.

In the discussion of the user characteristic variables, it is mentioned repeatedly that mobility impairments or disabilities of the user had an effect on PBCs. However, none of the RPs explicitly explore mobility impairment or disability for its effect on PBCs. Hence in the light of the data, it is recommended that mobility impairments has a negative effect on the PBCs.

#### 4.4.2 Universality of Technology

Another interesting theme that came to light during the analysis of data was the universality of technology. During the interviews, some of the participants talked about the marginalisation of facilities and technologies designed for the disabled people. They were of the view that everything should be designed universally, catering for people, regardless of their disabilities. This way the disabled people will feel less marginalised. A technology that is universal will be more readily available at a lower cost, making its adoption easier for people with disabilities (disabled people). Hence, a technology which is universal will have positive effect on the attitude towards its adoption.

For example, participant 1 pointed out the condition of disabled toilets in the hospitals. According to participant 1 “It’s been 50 years trying to get some companies and businesses to make it an even playing field for all disabilities. It's very poor all over. If I really needed to go to a toilet, it's no good in any hospital that I know of. There is no electric toilets in any hospital but the whole of Japan's got one in every house. The hospital I go to, it's got two disabled toilets. In the 10 years, I've been in, I've never known the two to be working and a lot of times they're both out of order. But I mean if you were in Japan then everything is like that [AN: accessible for all]. The whole of the National Health has been changed for big people. If you go into a waiting room now you'll find double size chairs and you have got double sized wheelchairs. And I'm sorry, but they don't do it for the disability, they don't do it on the voice side, and they don't do it for sight.”

Similarly, according to participant 8 “I'm noticing a lot of the technology that disabled people were using is what we are seeing [AN: in the mainstream]. I think the problem is that we have made technology medical and medical technology is never going to be mainstreamed. Technology should be seen as universal, and I think what draws me to Apple is Apple made it accessible for everybody. They didn't do it in a way that's only going to benefit non-disabled people. We think technology is not medical, It shouldn't be seen in that way. It should be saying like let's improve everyone’s lives, like we saw with door opener [AN: Mechanical door openers] which has now become mainstream. So as soon as a technology becomes something that is not medical, the price becomes reasonable too”.

So, taking into consideration the thoughts shared by the participants it can be stated that medical devices are not designed with the same attention to the users and because of a niche market there is not enough development towards making it more universal.

#### 4.4.3 Replacement of Human Contact

ISA devices interact with the users using natural conversation style. These devices respond to the voice-based queries emulating human voice. Some participants in this study were apprehensive regarding this feature of the ISA devices. According to them, the conversational feature of the ISA device can make a user confuse the device for an actual human. They also pointed out that the ISA device can then be used to replace human contact by exploiting this conversational feature of the ISA devices. According to the

participants, using the ISA device in such a way can lead to further isolation of an already vulnerable population. So perceived replacement of human contact can negatively affect the attitude towards the adoption of a technology.

According to participant 9 “I actually think that it [AN: treating ISA device as a conversational partner] would be detrimental to the function. I think that it can really be dangerous in the future. If people used those devices for conversation and human interaction”.

This point was further emphasised by participant 8. According to her “I'm aware that if people are using assistive devices for communication it is important to have a human sound. But I'm very mindful that we don't see technology as replacing human contact”. She further goes on to say that “If the technology is being implemented in a way that is going to be assisting, empowering, and liberating then that's different in my experience. If It's been implemented in a way to fill that human void, without even thinking about how much is that creating more segregation, exclusion from society then, that's problematic”.

Hence, the perceived replacement of human contact can raise certain issues which have not been foresighted before.

#### 4.4.4 Cost of Technological Devices

During the interviews, two participants mentioned the cost of using ISA devices to control the electrical equipment around their house. One of the participants was under the impression that the cost of ISA device would be much more per head as compared to what the EC equipment is costing the NTRECES. Another participant pointed out that cost of installation of ISA device will not only include the purchase of the ISA device but also its setup and installation and in some cases structural changes as well like change of wiring. So, there was apprehension and lack of information about the actual cost of the ISA device, its peripherals, and their installation. This lack of information can lead to a hindrance in the purchase and adoption of ISA devices. Hence, perceived cost of technological devices can have a negative effect on the adoption of ISA device.

During his interview participant 1 shared that “The cost of Alexa compared with what the cost of the possum [AN: EC device] is... I don't know what the price of possum is, but I know it's going to be a lot cheaper than Alexa”.

According to participant 3, as also mentioned above in section 4.3, under the heading of Openness to Innovation, “I know you can use it (AN: ISA device) to control your central heating and all these sorts of things. But if you want to do that you got to change all the wiring, So I wasn't up for that”.

The participants were apprehensive about the actual cost of the ISA device and its installation which was making it difficult for them to purchase the device and use it. However, the actual cost of EC devices for the participants is zero, as it is being provided free of cost via NHS. So, an interesting issue is observed that it doesn't matter if the actual cost of a device is too much but if it is being provided free of cost then it would be acceptable for the participants.

#### 4.5 Modified Model

The underlying assumption of this research project was that the factors that influence users' behaviour may directly impact the design of the technologies in both their functional and non-functional requirements and may suggest improvements in the service provided by RECES in the UK. The proposed research model was based on Theory of Planned Behaviour (TPB). With the help of literature and initial ethnographic observations, the factors affecting the behaviour of the user were further elaborated and expanded. The proposed research model was then validated against the data that was collected during the project (refer to section 2.2, Figure. 4). After the analysis of the research propositions one by one, the emerging themes that were discovered during the data analysis were also presented. As a result of which, the proposed research model is now modified to reflect the validated, modified, and emerging themes. This modified model is presented in the figure below:



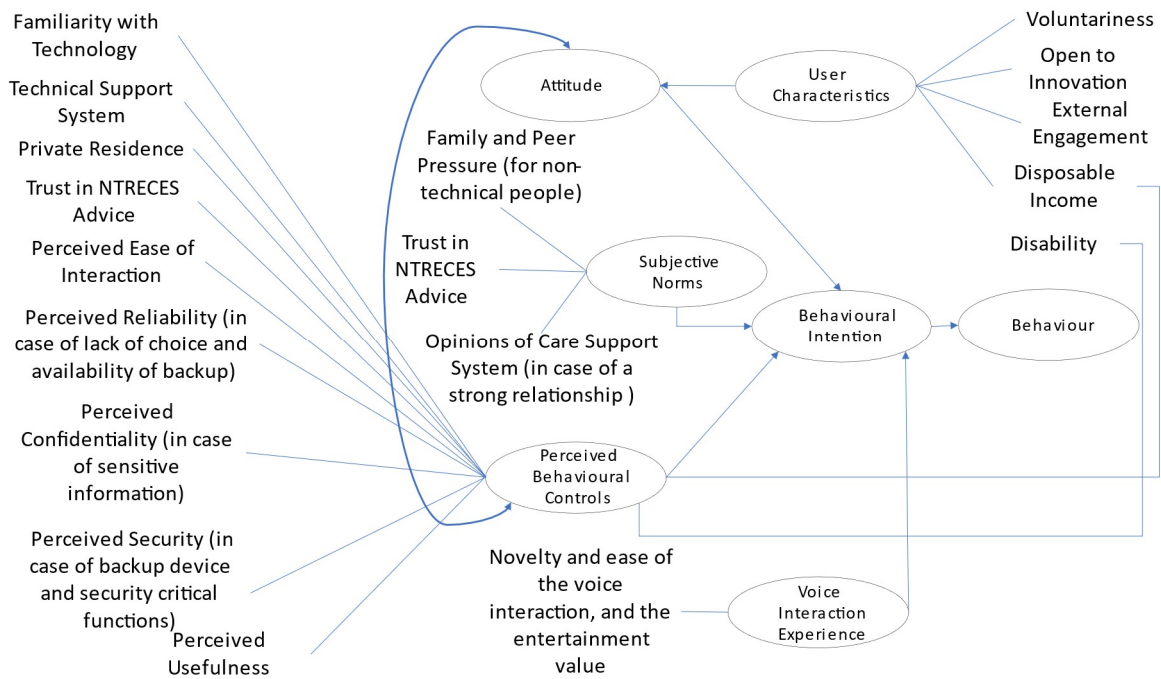


Figure 10: Modified Model after Data Analysis

It is supported by the data collected in this study that the main constructs of TPB, Attitude, Perceived Behavioural Controls and Subjective Norms play a role in determining the behavioural intention of the user. In addition to these constructs, another factor that also plays a role in determining the behavioural intention of the users, whilst adopting an ISA device, is the Voice Interaction Experience.

These main constructs affecting the Behavioural Intention are further divided into numerous categories. As stated in TPB, attitude is affected by user characteristic, which is defined by numerous subcategories. After analysing the data collected via the research study it was concluded that Voluntariness, Open to innovation, External Engagement, and Disposable Income and Disability are the factors of user characteristics that affect the attitude, which in turn influences the behavioural intention, which ultimately affects the behaviour to adopt an ISA device. It must be noted here that, the factor Income has been modified to disposable income to reflect the results from the data analysis. Moreover, disability is a new factor that is added to the model based on the emerging themes in the data.

The second main construct in the model, Perceived Behaviour Controls (PBCs) which consists of numerous factors. These factors influence the PBCs which in turn have an effect

on Behavioural Intention and Attitude as stated in TPB. The Behavioural Intention then influences the behaviour to adopt an ISA device. In this modified model, the factors that make up PBCs are Familiarity with Technology, Technical Support System, Private Residence, Trust in NTRECES Advice, Perceived Ease of Interaction, Perceived Reliability (Only in case of lack of choice and availability of backup), Perceived Confidentiality (Only in case of sensitive information), Perceived Security (Only in case of backup device and security critical functions), Perceived Usefulness, Disposable Income and Disability. It must be noted here that, compared to the proposed research model, two new factor disability and disposable income have been added as emerging themes from the data. Moreover, some factors like Perceived Reliability, Perceived Confidentiality and Perceived Security are modified stating that their effect on Behavioural Intention and Attitude is dictated by certain conditions now.

The Third main construct is the Subjective Norms, which are also made up of several factors like Family and Peer Pressure (For non-technical people), Trust in NTRECES Advice and Opinions of Care Support System (Only in case of a strong relationship). The Subjective Norms affect the Behavioural Intention, which in turn influence the behaviour to adopt an ISA device. In comparison to the proposed model, it must be noted that, the construct of Family and Peer Pressure is now modified, and it is stated that it will now influence the Behavioural Intention only in the case of users, who are not very tech savvy.

The fourth and novel construct which has not been part of the TPB before, is the Voice Interaction Experience. In this model it the Voice Interaction Experience is influenced by Novelty and ease of use of the voice interaction and the entertainment value. The Voice Interaction Experience then influences the Behavioural Intention, which in turn affects the behaviour to adopt an ISA device.

## Chapter 5. Discussion

This chapter revolves around the discussion of the research study by focusing on the findings of this thesis in the context of the academic literature, and their relevance for future research.

### 5.1 Original Findings of the Research

As mentioned in section 2.1, the Theory of Planned Behaviour (TPB) is used as blueprint for a technology adoption model presented in this work. As discussed in Ajzen (1991) TPB states that that an individual's behaviour is determined by the individual's intention to perform that behaviour. This behavioural intention is in turn affected by an individual's Attitude, Subjective Norms and Perceived Behavioural Controls (PBCs). This study extends the TPB by defining another factor, Voice Interaction Experience, that influences the behavioural intention. The inclusion of this factor reflects the innovative nature of voice interaction.

Section 2.1 also explained how different studies expanded upon different behaviour prediction models like, Technology Acceptance Model (TAM) Easwara Moorthy et al. (2015) and TPB Yang et al. (2017). Given a steady stream of innovative technology, technology adoption literature also reflects this by modifying the technology adoption models. The extension in behaviour prediction models caters for the new and emerging technologies by introducing new factors that affect Behavioural Intention and Users Attitude. Another such example looks at the adoption of wearable technology Chuah et al. (2016), which expands TAM by suggesting that the factors like visibility also affect the users' attitude towards the adoption of a technology. Same pattern has been observed whilst exploring technology adoption literature for smart speakers, for example TAM was extended to cater for the unique functionality provided by the smart speakers Pal et al. (2021). Different theoretical basis were used to study technology adoption of smart speakers like TAM Pal et al. (2021), Kowalczyk (2018) Cha et al. (2021), Diffusion Innovation Theory Kim (2021), Normalization Process Theory (NPT) Edwards et al. (2021), Parasocial Relationship Theory (PSR) Han & Yang (2018), Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) Zaharia & Würfel (2021). However, technology adoption literature has little contribution to make towards the understanding of technology adoption behaviour by users with severe mobility

impairments Djamasbi et al. (2006) and this is the intellectual gap that this research contributed to.

### 5.1.1 Additional Components Affecting Behavioural Intention

This research project supplements the literature on smart speakers' adoption by users with severe mobility impairments by presenting a theoretical model that extends TPB. The extension of TPB is twofold. The First addition to TPB is with regards to the addition of a factor, Voice Interaction Experience, as an influence on the behavioural intention. The second addition is the inclusion of components constituting and affecting users' attitude, perceived behavioural controls, subjective norms, and voice interaction experience.

### 5.1.2 Additional Factors Constituting Components Affecting Behavioural Intention

In section 3.3.1, it is discussed, how various factors are considered in technology adoption literature. These factors exert influence over users' attitude, perceived behavioural controls and subjective norms. It is also stated that, in addition to the factors supported by existing literature, some additional factors have been included in the proposed research model. The inclusion of these additional factors was supported by initial ethnographic observations. All of these factors attempted to cover almost all aspects of technology adoption of a relatively emerging device, with novel interaction method through voice, by a user base of people with severe mobility impairments. For reference see figure 4 and figure 8 in Chapter 2, subsection 2.2.1. Some of these factors, like age, gender, voluntariness, experience with technology, have been used in UTAUT Venkatesh et al. (2003), other factors such as perceived ease of use, perceived usefulness have been used in TAM Ajzen (1991). Some factors have been used by studies that have extended the technology adoption theories. For example, Kowalczyk (2018) considered security and privacy risk as an influence on adoption intention. However, in this study the factors that had been proposed for the first time in the context of technology adoption (especially assistive technology adoption) of ISA devices were the following: lack of access to the open market, external engagement, residence type, trust in NTRECES advice. In the modified model (see figure 10 in chapter 4, subsection 4.5) after the data analysis, three kinds of results were drawn regarding the influence of the factors proposed in the model. First of all, several factors like age, gender etc. that have

been known to have some influence on the behavioural intention in previous studies Venkatesh et al. (2003), appeared to not have similar influence in this research project. Secondly, some factors like perceived usefulness Ajzen (1991), showed similar influence on behavioural intention as in the previous studies. Thirdly, other factors like perceived security Kowalczyk (2018), were altered to account for the specific technology and the selected type of end users involved in the study. An example of an amended factor is the presence of a backup device and using security critical functions, in this research study. Participants in the study were not concerned about perceived security as they believed that the functions that they will use the ISA device for will not be security critical. For example, they will not be using the ISA device for executing online banking or controlling main door entrance lock etc. Similarly, perceived reliability was less of a concern for the participants of this study as they assumed that there will always be a trusted EC device present as a backup to the ISA device. Table 5 below account for each factor included in the model within the context of extant literature.

### 5.1.3 Review of Study Findings in Comparison to Current Literature

Comprehensive review of current literature is given as a summary in Table 5 below, together with a brief overview of this research findings. This is with the intent to facilitate the links between the findings and the existing research in the area.

Table 5: Summarised findings in context of current literature

<b>Variable and RP</b>	<b>Current Literature</b>	<b>Study Findings</b>
Age (RP02 a&b)	In case of adoption of ISA devices or smart speakers, studies found out that older individuals were not apprehensive about this technology as opposed to common perception Balasubramanian et al. (2021)	The findings of this study also support that age does not have a negative effect on the adoption of a smart speaker or ISA device.
Gender (RP03 a&b)	In a study done by Cha et al. (2021) gender was used as a control	In this study however, it was concluded that, the Majority of

	variable in the research model. However, a specific study that investigates effect of gender on the adoption of ISA devices could not be found.	female participants were positive about adopting an ISA device. Being female did not have a negative impact on the attitude towards intention to adopt and ISA device.
Desire for Independence (RP04 a&b)	Abdolrahmani et al. (2018) stated that ISA devices increased a feeling of independence in blind users but evidence of investigating the effects of desire for independence on the adoption of an ISA device could not be found in the literature.	In this study the effects of the desire of independence on the adoption of an ISA device were explored but it was found out that desire for independence did not play a part in the adoption of an ISA device.
Voluntariness (RP05 a&b)	Voluntariness or willingness to adopt a smart speaker was not investigated as a factor in the limited literature that was surveyed during the span of this research project.	In this study it was discovered that Voluntariness of the participant to try a new technology positively influences their attitude towards the intention to adopt an ISA device.
Openness to Innovation (RP06 a&b)	Although openness to innovation had been discussed as a factor in technology adoption as mentioned in chapter 2, evidence could not be found where openness to innovation is investigated as a factor in adoption of smart speakers or ISA devices in current literature.	In this research project after the analysis of the data it was concluded that Openness to innovation leads to a positive attitude towards intention to adopt ISA device, in line with research on the effect of Openness to innovation for technology in general.
External Engagement (RP07 a&b)	During the initial ethnographic observations, whilst shadowing the NTRECES staff on their patient visits it was observed that, patients who	In this research study, it was observed that participants with higher external engagement have positive attitude towards intention to adopt ISA device.

	<p>have higher external engagement, for example, work, hobbies, support groups etc. have a positive attitude towards technology. However, studies investigating the effect of external engagement on the adoption of smart speakers could not be found.</p>	
Income (RP08 a&b)	<p>Pal et al. (2021) considered income as a moderator that can affect the faster purchase of the smart speakers and can indirectly affect the adoption.</p>	<p>Similarly in this study it was discovered that participants with higher disposable income will be more prone to purchase an ISA device and hence will have a positive attitude towards intention to adopt an ISA device.</p>
Family and Peer Pressure (RP09a)	<p>In some studies, Ashfaq et al. (2021) the social aspect of the adoption of smart speaker was considered. However, research looked at the resultant social effect after the purchase of the speaker instead of the effect of social pressure resulting in the purchase and adoption of a smart speaker.</p>	<p>In this study however, the effect of social factors such as family and peer pressure was investigated and it was concluded that, if the participants lacked technical expertise then family, and peer pressure (advice) did play a positive part in the intention to adopt an ISA device</p>
Trust in NTRECES advice (RP09b)	<p>This variable was included in the proposed research model after taking into consideration initial ethnographic observations. In the literature, however, not the exact variable can be found. Evidence was found that, trust in the advice</p>	<p>It was concluded in this research project that, trust in the advice of the NTRECES staff positively affects the intention to adopt ISA devices.</p>

	of local experts can influence the adoption of different in various NHS Trust sites Kyratsis et al. (2012).	
Care Support System (RP09c)	As stated above although efforts were made to find evidence related to social factors playing a part in the purchase and adoption of smart speakers, no such study was found that looked at the effects of relationship with the caregivers.	This study suggests that, depending on the strength of the relationship of the participant with the caregiver, opinion of the individuals who are part of the care support system will positively affect the adoption of an ISA device.
Familiarity with Technology (RP11)	In the reviewed literature no studies could be found that have explored familiarity with technology as variable effecting the adoption of smart speakers.	In this study it was concluded that, there is a positive relationship between familiarity with technology in general and intention to adopt ISA devices.
Technical Support System (RP12)	Goodman et al. (2002) talked about the importance of having a good technical support system for the adoption of a technology. However, the studies regarding smart speaker adoption did not investigate this variable's role towards adoption.	This study concluded that users with a good technical support network will have a positive effect on the attitude towards intention to adopt ISA device.
Residence Type (RP13)	This variable is very specific to this research study. Hence, it is not a variable of interest in any of the smart speaker adoption studies found in the current literature.	In this study it was concluded that, users' residence owned by a housing association negatively effects the attitude towards the intention to adopt ISA devices.
Lack of Access to Open Market (RP14)	This variable too is very specific to this research study. Hence, it is not a variable of interest in any of the	In this study it was found that, the lack of access to the open market has a negative effect on attitude toward intention to adopt ISA devices.



	<p>smart speaker adoption studies found in the current literature.</p>	<p>During the initial ethnographic observations, it was noticed that it is often logistically difficult for NTRECES subscribers to directly explore the new technological devices available on the market. The only way they can physically interact with a device is when friends and family or the clinical staff of NTRECES bring the device(s) to them. Their exposure was limited both in range, as they couldn't explore the full variety of the devices on sale, and in depth, as their physical interaction is limited because it is controlled and mediated by a third party.</p>
<p>Perceived Ease of Interaction (RP15)</p>	<p>Cha et al. (2021) investigated effects of perceived ease of use on the intention to adopt smart speakers. According to Cha et al. (2021) if a device is easy to use then it will be perceived more useful and more enjoyable to use. A device being more useful and enjoyable to use will then have a positive impact on the intention to adopt a smart speaker.</p>	<p>In this research project it was discovered that perceived ease of interaction leads to positive attitude towards intention to adopt ISA device.</p>
<p>Perceived Reliability (RP16)</p>	<p>Zaharia &amp; Würfel (2021) considered performance expectancy instead of perceived reliability. This was also</p>	<p>In this study it was found that, perceived reliability does affect the attitude towards intention to adopt ISA device, but other factors such as</p>

	<p>listed as one of the most significant factors affecting user behaviour.</p>	<p>lack of choice and availability of backup device should also be considered.</p>
<p>Perceived Confidentiality (RP17)</p>	<p>According to a study Huag et al. (2020), concerns about privacy did not affect the adoption of smart speakers. However, Lau et al. (2018), stated that non-users of smart speakers are concerned about their privacy. On the other hand, users of smart speakers either don't understand the privacy risks or trust the device manufacturers. Cha et al. (2021) discovered that, increased perceived usefulness counterbalances the impact of perceived risk on the intention to adopt. Pal et al. (2021) stated that protection of privacy did not affect the purchase intention.</p>	<p>In this study it was concluded that, perceived confidentiality does not negatively affect the intention to adopt an ISA device unless other factors are considered. If the information in question is not very sensitive, then the benefits of the ISA device outweigh the breach in confidentiality.</p>
<p>Perceived Security (RP18)</p>	<p>Kowalczyk (2018), Huag et al. (2020) stated that security risk played a significant role in the adoption of smart speakers. Cha et al. (2021) however, this research stated that perceived security risk is counterbalanced by perceived usefulness. Zaharia &amp; Würfel (2021) also stated that intention to adopt</p>	<p>In this study it is stated that, perceived security will negatively affect the attitude towards intention to adopt an ISA device when the user does not have a secure alternative device or when the device is being used for security critical functions.</p>

	is negatively influenced by perceived risk.	
Perceived Usefulness (RP19)	Kowalczyk (2018) deemed usefulness as one of the most important factors affecting the behavioural intentions of the user. Cha et al. (2021) and Pal et al. (2021) stated that perceived usefulness has a positive effect on the intention to adopt.	In this study it was concluded that higher perceived usefulness leads to a positive attitude towards intention to adopt an ISA device.
Perceived Trust in Service Provider (RP21)	Although evidence was found in literature about trust in service provider playing a part in the adoption of technology Chung et al. (2017), studies related to adoption of smart speakers did not research into trust in service provider as a factor effecting adoption.	In this study too it was found out that perceived trust in service provider does not affect the attitude towards intention to adopt ISA device.
Identification and Assignment of Agency (RP22 a&b)	Han & Yang (2018) conducted a study in which the results indicated creating "human-like" and "professional" assistants is critical for increasing the adoption of ISA devices.	In this study it was concluded that Identification and assignment of agency to ISA devices does not affect the attitude towards intention to adopt the ISA device.
Emotional Attachment (RP23 a&b)	Kowalczyk (2018) considered enjoyment as a factor in adoption of smart speaker. Enjoyment is different from emotional attachment but can play a part in it. Ashfaq et al. (2021) also discussed	After the analysis of the data collected in this study, it can be stated that, instead of the participants developing an emotional attachment, it is the novelty, ease of the voice interaction, and the entertainment

	effects of hedonic values on user behaviour, but not specifically emotional attachment. These were the two closest examples of research related to emotional attachment that were found in the current literature related to adoption of smart speakers.	value of ISA that positively affects the attitude towards adoption of an ISA device.
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Despite the number of research participants in this research study was limited, the qualitative insights have provided valuable insights into the definition of a clearer technology adoption model for specific technology, voice-controlled devices, and by a niche user group, e.g. service users with severe mobility impairments.

## Chapter 6. Conclusion

### 6.1 Discussion of Research Objectives

The discussion chapter focuses on addressing the research objectives one by one, to draw the final conclusion from this research project. These research objectives aimed to understand integration of Interactive Smart Agents (ISA)s through a person-centred design approach to improve (Environmental Control) EC design and services.

#### 6.1.1 Objective 1

Objective 1: To identify and study the current user's experience when controlling the environment, including the use of current EC devices and services, applying a User Centred Design (UCD) methodology.

In order to achieve objective 1, preliminary ethnographic observations were conducted. This was followed by semi-structured online interviews and online questionnaire.

The First step was to understand EC and ISA devices usage via ethnographic observations and literature review. Further study of literature on technology adoption, especially assistive technology, led to the proposal of a research model for the adoption of ISA devices, focusing on users with mobility impairments. In order to collect data using the proposed research model, a data collection tool was developed with the help of existing literature and preliminary ethnographic observations. Using the data collection tool, 11 semi-structured interviews were conducted online. After the data analysis, the findings were presented in chapter 4. These findings were categorised under four main constructs of user characteristics, subjective norms, perceived behavioural controls, and voice interaction experience. Each construct consists of further variables. These findings helped in the understanding of participants' experience whilst using EC devices and services. The semi-structured interview findings supported the preliminary ethnographic observations.

The participants of the study used EC devices on a daily basis regardless of their age, gender, social engagements, and level of disposable income. The usage of EC devices on their own volition by the participants demonstrated their desire for independence and openness to innovation. However, all of the participants perceived difficulties in using their EC devices due to their current or increasing mobility impairments. The use of EC devices via

conventional single click “switch” button, became cumbersome and caused fatigue, especially in participants with severe and increasing mobility impairments.

Investigating the daily usage of EC devices by the participants also highlighted their relationship with their friends, family, caregivers and the NTRECES staff. Studying the user experience of participants whilst using EC devices, pointed out that one of the motivating factors behind the usage of EC devices to gain some independence and give some relief to their family and caregivers. The participants also demonstrated their trust in the advice of NTRECES staff by accepting the EC devices issued to them and using them in their daily lives as assistive technology.

The semi-structured interviews also focused on what qualities, features, and functionalities the participants perceived in their EC devices that enabled their use of EC devices. In addition to that, barriers due to their surroundings, abilities and support system were also explored. The Majority of the participants were tech savvy and had access to technical support for EC devices via NTRECES. All the participants resided in private residential settings and had no issues with receiving permissions for the installation of EC devices. The EC devices were prescribed by NTRECES free of charge, these devices are available only through specialist companies. The NTRECES staff demonstrated the EC devices in the first demo visit, so the participants did not feel the need to interact with the devices in a market setting. The participants of the study trusted the advice of the NTRECES staff and the lack of financial investment in the EC devices made it easier for them to start using it. The participants were of the view that the EC devices are fairly straightforward to use, however, prolonged use can lead to fatigue. The EC devices are battery operated and rely on infrared waves to communicate with the electrical devices around the house and are not dependent on internet and Wi-Fi. So, the EC devices were considered to be more reliable by the participant. Similarly, non-reliance on the internet, communicated to the participants, that EC devices do not have access to their information and hence are more secure. As mentioned before, these EC devices allowed the participants to be a little bit independent and gave a little bit of freedom to their caregivers. This ability of the EC devices made them very useful for the participants.

it can be concluded through the evidence collected in the study, that the participants used EC devices because of the lack of alternative and to gain some independence. Another

major factor in the usage of EC devices is the lack of investment in their procurement. Participants perceived the EC devices to be reliable and secure but perceived difficulties due to their increasing and current mobility impairment.

### 6.1.2 Objective 2

Objective 2: To create a data collection tool to reflect the factors identified in the model.

To achieve objective 2, with the help of literature review and preliminary ethnographic observations, a data collection tool was created. It acted as a guide for the semi-structured interviews and online questionnaire.

The proposed research model acted as framework and all the variables of the model were studied in the context of current literature one by one. Previous studies pointed out how the different variables were investigated. The formulated questions were then divided into two parts, semi-structured interview, and questionnaire. This was done to keep the duration of the interview short. As during the pandemic, it was not possible to visit the participants in person, so participating in long interviews online can be difficult for the study participants. Hence, questions that can be answered via a questionnaire were then emailed to the participants to reduce the length of the interview. Details of this process is mentioned in Chapter 3.

### 6.1.3 Objective 3

Objective 3: To identify the functionalities and requirements that Interactive Smart Agent (ISA) based device can deliver to support new user's experience.

To achieve objective 3 detailed analysis of the data collected through semi-structured interviews and questionnaire, was carried out. This resulted in highlighting the expectations of the participants with respect to an ISA based device.

The proposed research model acted as a framework for data analysis. Some of the research propositions held up in light the data collected, whilst some did not. However, it helped in pointing out what the participants thought about the ISA based device, their reservations, fears, and expectations.

The Majority of the participants in this study were of the view that the ISA devices are relatively easier to use. The participants felt that their increasing mobility impairment will make the use of their current EC device more difficult.

In addition to that the participants assumed that there is a provision of a backup device. The participants perceived low reliability, confidentiality, and security in ISA based device, due to its dependence on the internet and Wi-Fi. However, the participants were positive about adoption of ISA based device as they assumed that their EC device or another backup device will be with them in the case of emergency, for example if internet goes down or power failure.

The smart devices controlled by ISA, form a smart home network based on Wi-Fi. Whereas EC devices controlled the electronic devices around the house via InfraRed waves. Participants believed considerable financial investment would be required to purchase new peripheral devices as well as for their installation. The participants were unaware of the devices available nowadays that can act as a bridge between the ISA based device and existing electronic devices, without the need to buy new smart devices. Moreover, some participants believed the ISA devices to be more expensive than the EC devices that are being provided by the NTRECES.

Hence, along with some expectations there were some reservations about the ISA based device. A few of the misconceptions (for example, the actual cost of the device, peripheral devices and installation) that are present can be cleared away with the provision of correct facts and figures.

#### 6.1.4 Objective 4

Objective 4: To identify a set of research propositions integrated in a theoretical model that can explain the relationship between severely disabled users and voice-controlled ISAs.

To achieve this objective literature review of technology adoption especially assistive technology was carried out. In addition to that, the preliminary ethnographic observations also helped in identifying factors that can affect the relationship between severely disabled users and ISA devices. This process was explained in detail in chapter 2.



The proposed research propositions were then approved, rejected, and altered according to the findings from the semi-structured interviews. The modified research propositions in the new model are shown above in Figure 11. In addition to the existing research propositions a few more were added that addressed the themes that emerged during the data analysis. These research propositions are also shown in Figure 11.

## 6.2 Study Limitations

Although best efforts were made to recruit at least 15 participants from the service users of NTRECES, due to various issues like deteriorating health of the participants, the study was carried out with 11 participants. Moreover, all the participants were from London and surrounding areas and do not reflect a very diverse geographical spread. Similarly, efforts were made to recruit participants who are suffering from different neurological ailments, but the majority of the participants were suffering either from Multiple Sclerosis or from Spinal Cord Injury.

Due to the limited number of participants, the qualitative findings of this study do not aim to seek statistical validity, but to identify a specific and more developed model of technology adoption for ISA devices among a disabled population of service users. The factors discovered in this study may also be relevant in the design of future ISA devices for people with severe mobility impairments.

## 6.3 Future Work

The factors identified in the proposed model can act as a guide for the design of the prototype. This prototype could then be taken to the study participants and a comparative study could be done against the existing EC devices. The results of this comparison can then further refine the prototype, and after a few iterations a finalised product can be developed. This product can then be used as a safe replacement for EC devices.

Looking in from an academic development's point of view, one extension of this study could be executed by conducted a quantitative study at a national level. It can help in advising the service with statistical validity.

Another aspect of future work could also look at the methods used by the NTRECES for assessing perspective users and evaluating current ISA users and differences between them.

## 6.4 Conclusion

This research project addressed a gap in the current literature by proposing a model for the adoption of ISA devices by users with severe mobility impairments. As discussed above, some research propositions were rejected, some were accepted, and some were altered. As a result of which a modified model was presented by the end of this project. By using this modified research model, designers and manufacturers can make changes in their future ISA devices so that they can be better suited to the needs of users with severe mobility impairments. With so much advancement in science and technology it should be possible to improve how people with mobility impairments interact with their environment and with others through the use of ISA devices which provide, if well considered, a valid alternative to more obsolete and cumbersome methods of interaction.

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## Appendix 1: Participant Information Document

### Enabling by Voice: An Exploratory Study on How Interactive Smart Agents (ISA) can Change the Design of Environmental Control (EC) Equipment and Service.

#### Participant Information Document

This study is a collaboration between North Thames Regional Environmental Control Equipment Service (NTRECES), Hillingdon Hospital and the College of Engineering, Design and Physical Sciences, Brunel University, London. You are invited to participate in a research study, which is being conducted as part of a MPhil Thesis. Your decision to participate in the study is entirely voluntary. In order for you to make an informed decision please read through this document. Please take your time to decide. For more information and questions please ask a member of the research team.

#### Study Overview

What is the purpose of the study?

Patients suffering from severe neurological impairment are issued with Environmental Control (EC) devices. These devices help the patients in controlling TV, phone, lights. at their home. The majority of EC devices are controlled by a single click switch input system. However Interactive Smart agents (ISA) like Amazon Echo are rapidly becoming part of our households. These devices are controlled by the user by conversing with them in natural language. These agents in turn control other smart devices around the house, providing the same functionality as the EC devices but controlled by voice instead.

This study will explore whether an ISA (for example Amazon Echo, Alexa) can be used as an EC device and what will be the effect of it on the design of conventional EC equipment and service.

Why have I been invited to participate?

As an EC user who meets the inclusion criteria for this study, we believe you may be able to control your EC equipment by a voice activated ISA. We are hoping to recruit 15 users who are registered with NTRECES.

Who can take part in the study?

Patients registered with NTRECES aged 18 and over, with severe neurological impairments can take part in the study if they:

Are a motivated EC user and willing to participate in the study.

Have a good voice quality, as the research is looking at voice -controlled equipment.

Are curious, mentally aware and have good communicative abilities. It is vital for the research that potential participants are able to understand the questions put forward to them and reply with clarity of thought and communication.

Do I have to take part?

Participation is entirely voluntary. If you do decide to participate, you will be briefed by the research team using the information sheet. Participants will be given a copy of this document for future reference. You will be asked to sign an informed consent sheet indicating your willingness to participate. You are free to change your mind at any time and withdraw your participation without stating a reason. This will not affect the care you receive any way.

What will happen to me if I take part?

All the patients who agree to take part in the study should sign the consent forms and send them back by post. If you are unable to sign the forms, then you should send an email back that you give your consent for taking part in the study. In addition to that you should ask your caregiver to sign the forms on your behalf and post back to the researcher. Upon receiving the consent, the researcher will organise an appointment with you via phone, to conduct an online interview with the help of secure video consultation link for example, "Attend Anywhere" or MS Teams. Due to COVID19 restrictions and social distancing measures, the original face to face interview has been adapted to include an online interview and a questionnaire (included with the invitation email) that the researcher will ask you to fill in after the online interview.

Apart from internet access, all you need to use Attend Anywhere is the Chrome or Safari web browsers on a computer or mobile device. You will need a web camera (usually built

into laptops). It may be helpful to use a headset or speakers. This interview may take up to two hours and will be during your most active part of the day. A carer or family member can assist you in this interview. The trust has access to other video consultation modalities such as Microsoft Teams, FaceTime, Skype or WhatsApp video which can be used if more convenient for the user.

#### Online Interview (session1)

After the initial introduction, you will have the chance to clarify any issues with the researcher. The researcher will document your name and age, which will be followed by the interview.

The researcher will ask you about certain things of interest highlighted during the interview.

Personal information such as age, gender, Environmental equipment you have.

Daily routine including some aspects of your social life.

Your views on independence and how much it matters to you.

Your views on how difficult is to select and buy technology.

Your views on the advice you receive from caregivers and NTRECES staff.

The Equipment you use.

Current EC equipment usage and issues. How is this different from the above?

The use of technology in your life.

What obstacles you encounter when you use technologies.

Smart speakers and their usage and issues.

The following activities might also take place during the interview:

You will be asked to perform certain tasks using your EC devices for example switching the TV on or off, calling a friend on the phone.

You will be presented with a map of devices connected to your EC. You will be asked to comment about each device.

If you feel that you are too tired to continue, you can let the researcher know and the interview will be postponed.

### Visit at your home (session 2)

The second session will be centred around the evaluation of a prototype. This prototype will be designed with the help of the data gathered during the online interviews.

This prototype will not replace any of the existing EC equipment being used by you, instead it will be used to better understand your preferences.. The prototype will be evaluated against the criteria for success identified in the first session.

A comparison between the conventional and the ISA based EC device will take place in the second visit:

You will be asked to perform certain tasks on your EC device as well as ISA based EC device prototype for example using both devices to switch channels on your TV, using both devices to switch the light on and off.

You will be asked focused questions about your usage experience of the ISA based EC device prototype.

You will be asked to explore many functionalities available in the ISA based EC device prototype, which the conventional EC device does not offer.

The data generated in the second observation will be analysed to help re-design the prototype.

However, by the time of second visit if residential visits are not possible, as a last resort, doorstep installation of the prototype might be attempted. A short training installation video will be made to guide you and your caregiver to set up the prototype. The researcher will be on call with you and your caregiver to guide you through the installation process. After the prototype have been installed, an online virtual observation visit will be carried out.

### Second Visit at your home (session 3)

The third visit will revolve around the evaluation of a redesigned prototype, based on the feedback that you and other patients have provided The evaluation will be done with the



help of the previously developed evaluation criteria. The tasks you will be asked to perform will be similar to the first visit and will be used to refine the prototype. As this is just a prototype, you will not be left with it at the end of the study. However, if no residence visits are allowed at that time, a doorstep installation will be carried out followed by a virtual observation session.

Due to covid-19, it is not however possible to conduct residential visits as normal. The first session is now an online interview, but the two subsequent sessions, as they require a minimum of installation will need to be real visits to your home.

NTRECES has put in place protocols for device installation and troubleshooting and the same will be followed. NTRECES has two risk assessment and clinical screening forms that will be filled out before a visit. By filling out these forms it is made sure that you as well as the healthcare provider have not been infected with, or have come into contact with someone who had confirmed covid-19, wear appropriate Personal Protective Equipment (PPE) and observe social distancing rules. All the equipment is cleaned after wearing PPE and cleaned after leaving your residence also. The researcher will make sure that all the protocols are followed. Moreover, during the visit the researcher will not need to touch any of your equipment. However, if there is a need to do so, the researcher will seek the help of your caregiver. If that is not possible, the device will be cleaned thoroughly before and after the contact.

Given the nature and duration of the observations, the researcher will give you privacy for matters of personal care and hygiene. You can choose to have your carer, friend or relative present throughout the study. You can choose to not answer a question or to stop at any time if you don't want to continue. If you feel distressed or tired you can ask the researcher to stop and take a break. The researcher will be more than happy to stop and maybe continue at a later time. The researcher will contact your carer, friend or relative for you before leaving the house. Your wellbeing takes priority over the study.

With your consent, the researcher will be taking notes, capturing some pictures and recording video snippets of certain activities. Whereas, audio recording of the entire session will be made. This data will be stored on secure university servers using ID numbers and it can only be accessed by the researchers. Original recordings will be deleted immediately

following this. These records will be destroyed within 12 months of completion of the study to allow time for the final viva for the researcher's thesis. It must be emphasised that this data will be solely used for the study. Participants will remain anonymous; their names and pictures will not be included in the research results. This project and data collection methods have been approved by Ethical Committee, Brunel University London and NHS Research Ethics Committee.

What happens after each visit?

After the online interview you will be asked if you would like to make an appointment for a second session. You can take time to make your decision and let the researcher know at a later date. If you are willing to continue, an appropriate date suitable to you will be set for the next visit.

Similarly, after the first visit at your home you will be asked again if you want to continue your participation in the study. If you are willing to continue an appointment will be booked for the third visit.

What are the possible disadvantages?

The decision to participate or not to participate will not in any way effect your current or future medical care. However, participating in the study will take up some of your time and can be inconvenient. Given the nature of the observation, you may feel that your privacy is being affected and you can feel vulnerable. If you feel that you are not comfortable, you can discontinue your participation in the study without any consequences.

What are the possible benefits of taking part?

It must be clarified that the prototype device will not be left with you. However, you will receive high street vouchers worth £30 as a token of gratitude for your participation in the whole study. By taking part in this study you can get to know of alternative options to operate your EC equipment. If you want to be made aware of the results of the study, please let the researcher know.

What are the possible risks associated with taking part?

Participants can experience extra fatigue and tiredness due to a busy day. The risks are not greater than what you anticipate in daily life. Participants can become distressed or slightly stressed when asked to perform a task under observation. If these symptoms occur, they are only anticipated to be temporary effects. If you find any part of the research study distressing or stressful, you can let the researcher know, and the session will be stopped, to be continued later depending on your wishes. The researcher will also contact your carer, friend or relative for you, if you so wish.

#### Further Information

This section contains information about the organisation of the study and the complaint procedures if you are not happy with the conduct of the study.

#### What will happen to my data?

All members of the research team and study site staff will comply with the requirements of General Data Protection Regulation (GDPR) 2018 and Data Protection Act 1998 with regards to the collection, storage, processing and disclosure of personal information and will uphold the Act's core principles.

Brunel University London is the sponsor for this study based in the United Kingdom. The university will be responsible for the storage and proper usage of the information. Your data will be stored in secured university servers for minimum 36 months and maximum 120 months after the study is finished and then destroyed. Your rights to access, change or remove your information are limited, as it can affect the reliability and accuracy of the study. In case you wish to withdraw from the study, please refer to the "what would happen if I don't want to continue with the study?" section below. In order to protect your identity, all the information will be completely anonymised. Your information will not be used for commercial purposes. Further information regarding the use of your information can be found out by contacting the research team.

Brunel University London will collect information from you for this research study in accordance with our instructions. Brunel University London may use your name and contact details to contact you about the research study, and make sure that relevant information about the study is recorded for your care and to oversee the quality of the study. Individuals

from Brunel University London and regulatory organisations may look at your medical and research records to check the accuracy of the research study. The only people in Brunel University London who will have access to information that identifies you will be people who need to contact you about participating in the study or audit the data collection process. The people who analyse the information will not be able to identify you and will not be able to find out your name or contact details.

Your information could be used for research in any aspect of health or care and could be combined with information about you from other sources held by researchers, the NHS or government. Where this information could identify you, the information will be held securely with strict arrangements about who can access the information. The information will only be used for the purpose of health and care research or to contact you about future opportunities to participate in research. It will not be used to make decisions about future services available to you, such as insurance. Where there is a risk that you can be identified your data will only be used in research that has been independently reviewed by an ethics committee.

Will my taking part in this study be kept confidential?

All information, which is collected about you during the research, will be kept strictly confidential. Paper copies of personal data will be stored in a locked filing cabinet in a locked room, with access only to the member of the research team who require the use of this data. Electronic files will be kept on a password protected computer. We will give all data we collect on you a unique ID code and your name will not be recorded on the data. Where your name is recorded on a document, i.e. the consent form, we will store this separately to contact your other data and will not record your ID number on this. Similarly, we will store your contact details separately to all other data we collect on you in password protected files. All information will be securely retained for minimum 36 months and maximum 120 months after the study has ended and then be destroyed. We will remove any personal information from the audio recordings and give this data an ID code rather than storing it with your names, to protect your identity. We may use quotes from your interview in any publications. If we do this, we will assign you a pseudonym so that you are not identifiable.

What will happen to the results of the research study?

The results of the study will be written up in reports for the sponsor and may be published in recognised journals. In any report or publication, we will not use your name or give any information that could identify you. If you wish you can request a summary of the results when the study is complete.

What would happen if I don't want to continue with the study?

You can withdraw from the study at any point, without giving reason. If you choose to withdraw you will be asked which type of withdrawal you would prefer – you can choose between leaving the study and allowing the information already given to be used by the study team OR leaving the study and asking for the information already given by to be destroyed. If you withdraw from the study this will not affect your future medical care in any way.

Who is organising and funding the research?

The research is being organised by Dr Gabriella Spinelli from the College of Engineering, Design and Physical Sciences in Brunel University London. Brunel University London is acting as the sponsor. The research is not being funded by any external organisations.

What are the indemnity arrangements?

Brunel University London holds insurance policies which apply to this study. If you can demonstrate that you experienced harm as a result of your participation in this study, you may be able to claim compensation. Please contact Dr Derek Healy, the Chair of the University Research Ethics Committee (Derek.Healy@brunel.ac.uk) if you would like further information about the insurance arrangements which apply to this study.

Who has reviewed the study?

This research has been reviewed at by independent group of people, called a Research Ethics Committee (REC) which is there to protect your safety, rights, wellbeing and dignity. This study has been reviewed and given a favourable opinion by Brunel University London REC and by Health Research Authority (HRA).

Contact for further information and complaints

For general information

Dr Gabriella Spinelli; Email: [gabriella.spinelli@brunel.ac.uk](mailto:gabriella.spinelli@brunel.ac.uk); Tel: +44(0)1895 267544

Umber Shamim; Email: [umber.shamim@brunel.ac.uk](mailto:umber.shamim@brunel.ac.uk); Tel: +44(0) 7508 213139

For complaints and questions about the conduct of the research

Dr Derek M. Healy, Chair of the University Research Ethics Committee; Email:  
[derek.healy@brunel.ac.uk](mailto:derek.healy@brunel.ac.uk); Tel: + 44 (0)1895 266416.

Brunel University is committed to compliance with Universities UK Research Integrity Concordat. You are entitled to expect the highest level of integrity from our researcher during the course of their research.

What do I do now?

If you would like any further details about this study, would like to ask us any questions or would to express your interest in taking part then please do not hesitate to contact a member of the research team on 07508213139, email [umber.shamim@brunel.ac.uk](mailto:umber.shamim@brunel.ac.uk)

Thank you for taking the time to read this and considering taking part in this study

## Appendix 2: Interview Questions

Name (Code):

Gender:

Age:

Diagnosis:

EC Issued plus Supplier/ company supporting (example, Possum, Steeper, PCbyVoice, NTRECES)

Greetings followed by briefing of the proceedings.

Question 1-4 answers may well be altered by Covid lockdown measures – may have to be ready to note this as a theme. Participants may answer for pre & during restrictions.

1. Can you name a few of the activities for which you have to leave your house? (1.7.2)
2. Are you in paid employment at the moment? (1.3.1) (1.7.1)
  - a. If yes, what is your occupation
  - b. How long you have been working in this occupation.
  - c. How many hours
  - d. Do you always work from home?
  - e. If no, how long has it been since you have undertaken paid work.
  - f. Can I ask you the reason you were unable to continue working?

Next 4 questions are about Purchasing process – topic is returned to Q 40 – 44 and will not be repeated if satisfactory answers has been obtained here.

3. If you want to purchase something what is your preferred way of purchase? (2.5.1)
4. Can you please walk me through a recent process of purchase, preferably a technology or an appliance? (For example, what was it, why you needed it, how did you chose that model..)  
(2.5.2)
5. How would you describe this process? What is effective and what is frustrating?  
(2.5.3)
6. Do you feel that you would have made a different purchase decision if you were able to browse all the variety of products available, and physically interact with it? (2.5.4)
7. Do you feel that if you can browse through the items of your interest, you are more inclined to purchase? (2.5.5)
8. What does independence mean to you? (1.4.1)

9. Can you list the activities that you are able to do and represent independence for you? (with or without EC) (1.4.2)
10. Can you list activities that you are unable to do? (with or without EC) (1.4.3)
11. Does it make you feel less independent? (1.4.4)
12. Do you ask help from your caregivers in those tasks? (1.4.5)
13. What are the tasks that you are currently unable to perform and that would enhance your sense of independence? (1.4.8)
14. Can you please give an example of a decision or action that was influenced by the opinion of your caregivers? (3.3.2)
15. How did you learn about EC service (NTRECES)? Was it recommended by someone? Can you tell me how the EC service was prescribed for you? (1.5.1)
16. During the demonstration visit (first visit of NTRECES staff) did you and the NTRECES staff agree about the devices most suitable for you? (2.4.2) (3.2.2)
17. **On a scale of 1 to 5 (where 1 is very little to 5 is a lot), how much do you trust the advice of NTRECES staff. (2.4.1) (3.2.1)**
  - a. Can you give a reason for your trust or lack thereof?
18. Do you think that trusting the advice of NTRECES has been a factor in your adoption and use of your EC device? (2.4.3) (3.2.3)
19. How did you feel about the EC device before it was installed in your home? (1.5.3)
20. How do you feel about it now? (1.5.4)
21. What EC device was given to you initially? (2.2.5)
22. Are you still using the same device, or has it been replaced or updated? Why? (2.2.6)
23. How long you have had this equipment for? (2.2.7)
24. How did you go about learning to use it? (if they discovered and learnt by themselves there was more voluntariness). (1.5.5)
25. How often do you use it? (2.2.8)
26. What do you use it mainly for? (2.2.9)
27. In your opinion, how have the EC devices helped you in your work tasks and your social life? (1.7.5)
28. Is there anything you would change in the setup to make it easier for you or improve your connectivity to other people and the outside world? (1.7.6)
29. Which feature makes your EC device unreliable or reliable (from i to iv) (2.7.3)
  - i.It performs seamlessly without interruptions.
  - ii.It does not shut down abruptly.
  - iii.It has backup in case of emergency.
  - iv.Alerts you that it is down.
30. Has there been an instance when your EC device failed to perform? If Yes can you, please tell me about the incident. This question will be repeated in Question 51, in case of repetition it will not be asked again at Question 51 (2.7.4)
31. How do you feel about trying new technology? (1.6.1)

Return of topic from before in next 4 questions.

32. Do your family and friends/carers suggest what technology to buy? (3.1.1)
33. Do you welcome their suggestion? (3.1.2)
34. Do you ask for help? If so why. If not, why not? (3.1.3)



35. Can you give me an example of a device that you bought because it was suggested to you? (3.1.4)
36. What was the most recent device you have purchased? (2.3.1)
  - a. Did you make the decision alone or sought someone's help and assistance?
  - b. Did you require some training before starting to use the device? If yes, who provided the training?
  - c. Have you ever abandoned a device on the basis of technical issues, for example, unable to customize font size, cursor speed, change input method from conventional keyboard and mouse to eye gaze or voice?
37. Do you have internet availability at your home? If no, why? (2.2.3) (2.11.1)
38. How did you choose your internet service provider? (This will allow us to understand whose advice they trust). (2.11.2)
39. What were the qualities you looked for when deciding about the internet service provider? (2.11.3)
40. Do you have a PC or a Laptop at home that you use? (2.2.4)
  - a. How often do you use it? Once twice thrice a week daily
  - b. What do you use it for? Email browsing entertainment (music / video) shopping account banking social media work skype hobbies others.
  - c. Do you have any difficulties in operating your PC? Can you tell me the most important one?
  - d. Do you have specialised hardware for using your PC? For example, eye tracking mouse or mouth operated IntegraMouse.
  - e. If answer is yes, what, and why?
41. Can you tell me about any technical issues you had with any of the other technical devices you have? (2.2.2)
42. In case of a technical difficulty either with your EC device or any of your other equipment, who do you contact? (2.3.2)
43. If you are asked to rate different devices in your house on the basis of reliability, on a scale of 1 to 5, which device would you rate the highest? (2.7.1)
44. Can I ask why? Which features of the device makes it most reliable? (2.7.2)
  - i. It performs seamlessly without interruptions.
  - ii. It does not shut down abruptly.
  - iii. It has backup in case of emergency.
  - iv. Alerts you that it is down.
45. Can you tell me of a technology that you use, and you find easy to use? (2.6.1)
46. Have you ever replaced it? (2.6.2)
47. If so, how much on the scale of 1 to 5 (where 1 is very little to 5 is a lot), ease of use counted in your decision to replace it? (2.6.3)
48. Can you describe in your own words what it means for a technological device to be easy to use? (2.6.3)
49. When using different technologies for example your smart phone or internet how concerned are you on a scale of 1 to 5 (where 1 is low and 5 is high), about breach in confidentiality, for instance, your personal data being known by others? (2.9.1)
50. If the user was ever concerned then ask, can you give me an example? (2.9.2)
51. If the user was not concerned then ask, why? (2.9.3)
52. If the user is worried about confidentiality then we can ask, what precautions do they take against the breach in confidentiality? (2.9.4)

Brief about smart speakers, inquire if they own one or not. If they don't have a smart speaker show the demo video and allow some online interaction.

53. On a scale of 1 to 5 how much do you trust the technical giants like Google, Amazon, Facebook etc. with your information? Why? (2.9.7)

54. If you have to install a smart speaker in your house, which room would you choose for its installation and why? (2.9.6)

If they do not have an ISA:

55. On the basis of these qualities that you have discovered in the interaction (demo video and interaction with Alexa online with us) how likely is it that you would use this device from 1 to 5? (4.1.1)

If they have and use an ISA.

56. How much from 1 to 5 did the qualities we have just reviewed (listed in the table)

Characteristics	Rate (EC) 1 to 5	Rate (ISA) 1 to 5	Reason, Why
Looks / sounds like humans			
Presence of consciousness			
Presence of emotionality			
Behaves like humans			
Extraversion e.g., talkative, enthusiastic			
Agreeableness e.g., polite, helpful			
Conscientiousness e.g., reliable, organized			
Neuroticism e.g., moody, tense			

influence towards your purchase and use of the device? (4.1.2)

57. On a scale of 1 to 5 how would you rate the ISA device as a conversational partner? Why? (4.2.1)

58. When addressing the ISA device would you rather use the pronoun it, her, or him? Why? (4.2.2)

59. Would you prefer a male or a female voice for the ISA device? Why? (4.2.3)

60. If I ask you to describe this technology how would you describe it? (4.2.4)

61. Do you think you would like to personalise this device if it was yours? (4.2.5)

62. How? (If they do not come forward with suggestions you can suggest a nick name, or something else) (4.2.6)

63. Why? (By asking why they may say for a stronger link). (4.2.7)

64. Do you think you would develop a strong link with this technology if you used it? (4.2.8)

65. Is there anything you would compare this technology to? (4.2.9)

66. If given a choice, would you like your device to have customized personal touches just for you? For example, in case of ISA device addressing the user by their name. (4.2.10)
67. In your opinion, addition of this emotional aspect of your user experience is a plus in an assistive device, agree or disagree. Why? (4.2.11)
68. Given the choice what method of interaction you would choose for what? voice or conventional? (2.6.5)

## Appendix 3: Questionnaire

Please fill in the questionnaire after the online interview.

1. How often do you connect with people from outside of your household (friends, peers) through phone, email, video call for reasons such as catchup, hobbies, support group, leisure activities)?

Every day or more than once a day	One to three times a week	Twice a month	Less than once a month	Never
5	4	3	2	1

(1.7.3)

2. You feel very connected to the outside world?

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
5	4	3	2	1

(1.7.4)

3. Generally, you feel comfortable with change (in daily routine or life in general)?

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
5	4	3	2	1

(1.6.2)

4. How often do you try new things, For example new technologies like robo-vacuums, doorbell cameras etc.?

At least One every month	One in to 3 months	One in 6 months	One in a year	Never
5	4	3	2	1

(1.6.3)

5. You are the first one to try new technology before your friends and family:

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
5	4	3	2	1

(1.6.4)

6. You feel very independent in your daily life.

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
5	4	3	2	1

(1.4.7)

7. Does The opinion of your caregivers' (family and others?) matter to you a lot?

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
5	4	3	2	1

(3.3.1)

Question 8 and 9 are in the context of the initial assessment and provision of the Environmental Control (EC) device to you, which may have been some time ago now.

8. You feel completely free in the decision of using the EC device?

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
5	4	3	2	1

(1.5.2)

9. You completely trust the advice of NTRECES staff.

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
5	4	3	2	1

(2.4.1) (3.2.1)

10. In the list below please order the tasks that you consider more important for your independence and tick the box if you are able or unable to undertake them:

Task	Importance for independence 1 (very important) to 5 (not important at all)		Able to do. (with EC)	Unable to do
Walking				
Bed / Chair Transfers				
Eating				
Personal Hygiene				
Shopping				
Make and receive calls				
Community Travel				
Medication Management				
Financial Management				
Switch lights on and off				
Use of PC				

Bed Controls				
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(1.4.6)

11. How often do you use the following technologies listed below? including if you use your EC device to undertake the task.

Technology	Once or more than once daily (5)	Once or twice a week (4)	Twice a month (3)	Less than once a month (2)	Never (1)
1. TV					
2. Mobile Phone					
3. Laptop / Desktop					
4. Tablet					
5. Smart Speaker					
6. CCTV					
7. DvD Player					
8. Smart Watch					
9. Games Console					
10. Satellite / Digital Radio					

(2.2.1)

12. You think your Internet Service Provider (ISP) is trustworthy

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
5	4	3	2	1

(2.11.4)

13. You think that the technical giants like Google, Amazon, Facebook etc. can be trusted with your information?

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
5	4	3	2	1

(2.9.7)

14. Do you think ISA devices (such as Alexa, google home etc.) are reliable?

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
5	4	3	2	1

(2.7.5)

15. Do you think your existing EC device is reliable?

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
5	4	3	2	1

(2.7.5)

16. Do you think your most used technical device, for example TV or mobile phone is reliable?

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
5	4	3	2	1

(2.7.5)



17. You think you feel secure whilst using the different technologies listed below (if they use them)?

Name of Technology	Strongly Agree (5)	Agree (4)	Neither Agree or Disagree (3)	Disagree (2)	Strongly Disagree (1)
1. Online Banking					
2. Email					
3. Texting Apps like Whatsapp					
4. Search Engines like Google					
5. EC Device					
6. ISA Device					

(2.8.1)

18. You think Voice Interaction is much easier as compared to conventional input methods?

Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
5	4	3	2	1

(2.6.4)