Chapter

Understanding the Assistive Potential of Consumer Technologies: A Case Example of Smartphones, Smart Speakers, and Internet of Things Technologies

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Abstract

Assistive technology by its very design seeks to maintain, improve, or facilitate the functional capabilities of people with disabilities and older people. Traditionally, assistive technologies have been specialist in nature defined by the functional capabilities that it is linked to. However, digital consumer technologies such Digital Voice Assistants are increasingly building ever greater functionality in efforts to appeal to users, including those with disabilities. Aimed at a general market as opposed to being restricted to people with a disability, consumer products, with their lower cost thresholds, can provide a good ratio of social return on investment. Furthermore, the growing interoperability of technologies such as smartphones, smart speakers, and internet of things is building hitherto unanticipated opportunities for people with disabilities. This chapter examines the assistive potential of a range of consumer digital technologies and explores how they can benefit people with disabilities and older people. Issues pertaining to risks to personal information, autonomy as well as consent while using these technologies are also outlined. Finally, this chapter concludes with reflections as to how future consumer products can seek to balance the benefits that can be accrued from their use with concerns for respecting the privacy of people with disabilities.

Keywords: consumer technology, mainstream, digital technologies, disability, privacy, autonomy

1. Introduction

As the number of people with disabilities actively using technology to support their day-to-day activities increases, the benefits afforded by these technologies are ever more evident [1].[1] As the use of technology by people with disabilities

[1] Assistive Technology for People with Disabilities and Older People (2016) Available from: https://www.enableireland.ie/sites/default/files/publication/AT%20Paper%20final%20version.pdf

increases opportunities for communication, accessing information and engaging with online services are extended. Much of the technology used by people with disabilities is often characterized as assistive technology (AT) which is designed and developed to address the specific needs of people with disabilities. Such AT is often designed for a specific group of people with disabilities and aims to address a specific need or requirement. For example, people with visual disabilities may seek to use specialist text-to-speech software to present text-based information available in auditory form. For many people with disabilities however, they are excluded from using AT by factors such as the awareness of the technology, the prohibitive cost of specialist technology, and the requirement for installation, training, and support [2–4].

In contrast to AT which is focused on serving the needs of people with disabilities, consumer digital technology refers to those technologies that are developed for use by the general public [ref]. Increasingly, digital consumer technologies are building ever greater functionality in efforts to appeal to as wide a range of users as possible.

Such digital consumer devices include computers [5], smartphones [6], tablets [7], smart TVs [8], and smart speakers [9]. Aimed at a general market as opposed to being restricted to people with a disability, consumer products, with their lower price points, can significantly reduce costs and provide a good ratio of social return on investment [10]. The increased awareness of digital consumer technologies by the general population has served to increase awareness of new and previously unimagined opportunities for people with disabilities [11]. Despite the evident potential of technology for people with disabilities some ethical concerns relating to the use of such consumer technologies remain, although some ethical issues apply equally those with and without disabilities some aspects are particular to persons with disabilities and merit consideration.

The forthcoming sections will explore the assistive potential of a range of exemplar consumer digital technology, smartphones, smart speakers, and internet of things. While highlighting the potential benefits that can be accrued by people with disabilities, we will also explore some of the incumbent risks that consumers with disabilities may need to be aware of and consider when making decisions about using such technologies to support them in their day-to-day lives.

2. Background

A non-discriminatory analysis of the Convention on the Rights of People with Disabilities suggests that the right to affordable and accessible technologies to support participation by citizens with a disability should be seen as a national and international requirement for those to sign up to the ambitions of the convention [12]. Despite such commitments to ensure equitable provision for all people with a disability many see their needs regarding technology remaining unmet [13]. Research has highlighted several barriers that still limit the provision of technology for those with a disability who would benefit most from it. These barriers include lack of information, the probative cost, and the support requirements for specialist assistive technologies [2]. As accessing assistive technology has become more challenging for people with disabilities, awareness has increased as to the potential for mainstream consumer technologies to meet those needs previously addressed by specialist assistive technologies [11].

3. Smartphone: supporting communication and digital experiences for people with disabilities

For many people with disabilities, smartphones are central to their day-to-day digital experiences [14]. Smartphones refer to a category of mobile technologies primarily used for telephony that typically have the processing power to perform many functions associated with personal computers including providing users with multimedia functions such as photos, audio, and video. Smartphones afford users internet access, email, and web-browsing alongside features such as location detection and navigation. Many of the devices that proliferate the smartphone market are equipped with touchscreens, which allow users of different abilities to modify the ways in which they interact with and control the functions available. Coupled with the presence of digital voice assistants such as SIRI and Google Assistant the functionality offered by modern smartphones is accessible for a broad range of people with motor, sensory, and cognitive disabilities [15–17].

The capacity to install and use third-party apps on smartphones further extends their assistive potential for people with disabilities. A significant proportion of devices in the smartphone market utilize one of two main operating systems, IOS for Apple products and the Android operating system which is licensed for use by such brands as Sony, Samsung, and Huawei. These two operating platforms come with a range of "native" features and apps including a range of accessibility features such as magnification and text to speech for users with visual impairments, visual alerts, and hearing aid connectivity for those with hearing disabilities and voice, switch, and gesture control for those with mobility challenges.

Both operating systems have designed a relatively straightforward application ecosystem to allow users to purchase and/or install apps for their own phone and in many cases personalize these for their own use. The range of apps available across both platforms has grown exponentially over the past number of years with many specialized assistive technology products such as screen-readers for visually impaired users and text-to-speech apps for those with communication disabilities becoming available as apps. The availability of alternative and augmentative communication (AAC) apps alongside the native functions in smartphones offers those with communication disabilities a relatively low-cost solution to support them in expressing needs and engaging in social discourse with others [18–20, 21, 22]. Those designing AAC apps are also seeking to harness the additional functionality available on smartphones such as location awareness and context history to build communication solutions that are more responsive to the needs of those with language impairments as they seek to communicate across different environments with different people [23]. For users with developmental challenges and cognitive disabilities, the features available on most smartphones alongside a range of specifically chosen apps can support the performance of activities of daily living [19, 24] and improve their self-management skills [25].

4. Case Study 1: "fitting in," using a smartphone as an alternative to specialist technology for a teenager with a visual impairment

Rosalie describes herself as a "blind teenager" who is currently preparing for her state exams and hopes to progress to university to study Economics and Political Science. She uses a range of technology including a laptop and braille notetaker. It is however her iPhone that she insists is of most value to her.

> *"Because of the native text to speech and the apps that I have added, there is pretty much nothing my phone can't do. WhatsApp keeps me in touch with my friends, the map and navigation apps stop me from getting lost and having the internet in my pocket is all that I need when I am in school and with my friends. Oh and of course, I can always use it as a phone if I need to talk to my parents, but not so much."*

She has had technology in various guises since early childhood but reflects on the advantages she accrues from using a smartphone:

> *"I was always a child with so much equipment, I had a braille keyboard another braille reader and a laptop from the time that I was very young. All were incredibly useful, but if I'm honest I don't miss any of them. I feel like all my equipment has shrunk and has been sucked into my phone. I prefer being the girl with a phone instead of the girl with all the tech, that is just way more normal in my world."*

5. Smart Speakers to support safety and independence in the homes of people with disabilities

Smart Speakers, otherwise referred to as digital voice assistants, refer to devices and applications that constitute data-based programs and devices, which can communicate with human users and respond to their requests primarily through voice commands [26]. For many users, the primary function for smart speakers in a home environment includes offering voice control of daily tasks such as setting alarms, reminding of schedule, and playing music. Manufacturers of smart speakers such as Amazon have also sought to offer users new opportunities for online shopping and e-commerce [27]. Beyond scheduling, setting alarms, and shopping, other uses of smart speakers include accessing media, hands-free information retrieval, and controlling third-party technologies such as smart bulbs, sockets, and media devices [28].

A scoping review of published literature has highlighted the potential for smart speakers to be utilized in a diverse range of interventions and provide functional opportunities for people with sensory, motor, cognitive, and emotional disabilities [29]. Smart speakers are increasingly seen in use across a wide range of services for people with disabilities including in healthcare, rehabilitation, and education. An example of one such application saw smart speakers used as an element of a music-guided stress reduction program that allowed personalization of one's intervention [30]. Other studies highlight the use of smart speakers to improve verbal and social interaction skills for autistic children [31]. During the COVID pandemic, therapists looked to use smart speakers as a way of maintaining provision of services such as Speech and Language Therapy [32].

Although smart speakers are clearly not designed with the needs of people with visual disabilities in mind, the fact that they are operated and controlled by voice offers a range of possibilities. A recently published study describes the use of smart speakers to offer people with visual impairments in educational contexts ways in which they can easily study texts, listen to course content, and get answers to basic queries [33]. Marvin describes the development of a smart speaker application that utilizes the voice interaction and audio feedback functions to provide people with a visual impairment help recognizing text displayed on real world [34]. For users with intellectual or cognitive disabilities interacting with technology using voice offers a

new way of accessing information and services from the web [35]. Smart speakers can function as a cognitive "assistant" supporting concentration and attention when performing tasks [36]. Similarly, harnessing smart speakers' auditory and conversational feedback may have potential in supporting older people in home environments particularly those experiencing declining cognitive functions [37]. Further applications exploiting the functions of smart speakers for older people include supporting management of type II diabetes [38] and in avoiding the effects of sedentarism through active monitoring and prompting for regular physical activity [39]. Research focused on the assistive features and functionality of such devices appears to be increasing and offers manufacturers a potential roadmap for further expansion of their consumer reach among people with a disability and older people.

6. Case study 2: freedom and security at home using smart speakers

Jim is a 29-year-old who has a diagnosis of cerebral palsy. This affects his mobility such that he uses a power wheelchair to mobilize in his home and out in his community. He lives with his partner Imelda who has spina-bifida. Similarly, Imelda uses a power wheelchair to support her mobility. They both live in an apartment that has been built adjacent to Jim's parent's home and they have paid carers who help them with activities of daily living in their homes. With the help of some of their family and friends they have installed an Amazon Echo Show smart speaker with screen and have replaced all household lights with Philips Hue Smart Bulbs and all electrical sockets can be operated *via* their smart speaker. They have recently installed a Ring video doorbell and can now see who is calling at their door *via* the visual display on their Echo Show smart speaker.

> *"My main motivation was security, there is no point in denying it, we're both what you might consider vulnerable and I didn't want to trust carers with keys to my home, being able to see who's at the door and to choose to let them in or not makes me feel more secure": Imelda*

> *"People would probably describe me as a 'geek', but I've always been interested in technology because it has allowed me to do things that my hands and legs won't allow me to."*

> *"For me it's the freedom that it gives us to switch off the lights in our own home at night and the ability to just use our voice to switch on some music or the TV, you can't put a prices on that freedom."*
> *Jim*

7. The Internet of Things: the promise of affordable "smart-homes" for people with disabilities

Developments in recent years in networked, wireless, and internet-based technologies including what is referred to as Internet of Things (IoT) have opened a realm of possibilities for people with disabilities. IoT has seen a range of technologies previously referred to as "smart-home technologies" come to the mainstream market at a price threshold well below that of specialist, disability-specific technology [40]. Advances

in cloud computing have ensured stable connectivity and data exchange between ever more household objects. Within a typical home environment, the IoT often refers to the connectivity between common appliances such as kettles, fridges, lights, doors, cookers [41]. It can often refer to devices that support the running and maintenance of the building including alarms, heating, energy management, and water [42, 43]. It also serves to provide control and access to home entertainment systems and even toys [44]. For people with disabilities and older people, connecting everyday objects and changing how we as human operators interact and engage with these offer a broad scope for future development of applications in domains such as accessing information and services, manufacturing, logistics and transportation, eHealth, and smart homes and cities.

A recent European Commission report summarized some potential areas where emergent, networked technologies (IoT) might support people with a disability. These include the following:

1. Seeking assistance and help from outside the home environment.

2. Monitoring health conditions and identifying emergent health issues.

3. Supporting the delivery of medication and other health interventions.

4. Environmental automation—automatically adjusting the immediate ambient conditions, e.g., light, heat, ventilation.

5. Intelligent transportation [45].

Much of the reported research pertaining to the use IoT technologies for people with disabilities and older people examines and explores its application in smart-home solutions. Many of those smart-home solutions see IoT technologies paired with voice-controlled technologies such as smart speakers or smartphones thus extending the application of this range of consumer devices. The benefits of IoT for those with mobility difficulties include savings in exertion and decreased risk that devices such as smart-plugs and remotely controlled lights [46]. For those whose disability impacts their mobility IoT technologies can play a role in providing greater independence outside of their homes and throughout their communities [47].

Published literature also describes how the application of IoT technologies can support people with visual disabilities [48], people with cognitive or intellectual disabilities [49], people who are deaf or hard of hearing [50], and those with mental health issues [51]. For older people and those who spend more times in their homes due to their disabilities applications for IoT technologies include calling for help in emergencies, staying in contact with relatives and friends, monitoring their health status [52], and controlling lights and home temperature [53]. IoT offers vulnerable users and their families with opportunities to increase safety in home environments using technologies to detect falls and alert others [54, 55].

Much has been made of the possibilities available when most household objects can be incorporated into the IoT, including smart fridges that can support activities such as shopping, health eating, and budgeting [56, 57]. Similarly, developments in other objects such as the shower [58], cooker [59], and washing machines [60]. Despite reports of the potential of such connected IoT devices, to date there has been limited transfer of this potential to market ready consumer technologies. The reported benefits of IoT technologies currently available to consumers are limited to a narrow range of functions including

controlling lighting and electrical sockets. This can be seen as reflective of the limited number of "smart-devices" currently available to the mainstream market.

The potential of IoT technologies remains somewhat speculative, as such how they may potentially serve the needs of people with disabilities remains unexplored. It is likely that the full potential of these emergent technologies will unfold as more and more products come to market and is more readily available to all consumers. It must be remembered, however, that as with smartphone and smart speakers it is likely that the applications of IoT technology for people with disabilities will be led by the emerging functionality of the technology rather than the expressed needs of users [49, 61].

8. Ethics and privacy considerations for people with disabilities

In examining some of the ethical issues that pertain to the use of many of the consumer digital technologies described here, it is worth considering their use within a broader political and economic context. As mentioned previously, people with disabilities are not the constituency for which many of these technologies are designed for. Rather they have been developed for widescale use by broad swathes of the general consumer market and are motivated by the commercial imperatives of large-scale corporations such as Amazon, Google/Alphabet, or Apple. One commercial rationale for such technologies is to leverage their ability assist large companies and corporations to compete, to varying degrees, for people's data to better attract, retain, and direct users' attention. The ease at which consumer technologies are used to gather user data, the extent of the data harvested, and the uses to which it is put is not easy to determine. This may partially be understood when we consider that large tech corporations are coy about exactly how their technologies are designed to detect our voices and why. In the case of Amazon, the developer of the Echo smart speaker range, much of their technologies are based on patents that list a range of traits they might collect, including identity and feelings [62].

A primary concern for those interested in examining the ethics of using consumer technologies use by people with disabilities is how an individual's privacy may be impacted. Privacy is a complicated and contested construct, one which must be considered from a broad range of perspectives. It is often considered that privacy is not only subjective but is interpreted differently in legislative and cultural contexts [63, 64]. Despite these challenges with definition, there exists a consensus that privacy is of great importance across all societies. This is reflected in several international documents that enshrine privacy as a basic human right [65, 66]. According to these documents, states, institutions, and individuals have a general obligation to respect privacy. For smartphones and smart speakers in particular, their functioning depends on their ability to listen to users and to store and manipulate this data. In the case of smart speakers, these technologies are designed to have the capacity to continuously listen to users and to events in their homes thus creating risks to and potentially a significant threat to people with disabilities' privacy. Different datasets have the potential to reveal much about the user, including information that could be revealing of habits, preferences (political, cultural, sexual), psychological well-being, and physical health. When considered in combination with each other, smartphones, smart speakers, and internet of things technologies can be seen to represent an aural network capable of impacting a person's confidentiality, anonymity, and accountability in the process becoming a new burden on the user. For people with disabilities their rights to decisional privacy highlight the importance of being able to decide

without (undue) influence from third parties such as healthcare providers, insurance companies, or commercial entities, for example, online shopping or financial services. A further dimension worth considering for people with disabilities is the right to physical privacy which is concerned with issues such as bodily modesty and intimate events. Access to data and the ability to draw inferences from such data could potentially reveal a person's care needs and their vulnerabilities, information that could present as attractive to malevolent agents. Similarly, associational privacy relates to an individual's ability to choose with whom one associates. Smartphones, by the nature of their functionality and the data they store locally and across networks, risk disguising new associations with those that store or whoever might buy that data.

Large corporate entities such as Amazon, Google, and Apple are not oblivious to the potential ways in which using their products can impose upon an individual's privacy, including that of people with disabilities. In efforts to address these risks, and potentially to minimize the liability of such risks using their technologies, services are conditional on the user agreeing to the terms and conditions of using a DVA, i.e., they have given their consent. This, however, presupposes that the user has read or understood the terms of the contract. For some people with disabilities where their cognition or capacity for understanding is compromised, the explicit provision of consent that is informed and offered willingly can be problematic. Furthermore, it is also possible to question the fairness of such a contract between technology provider and user in the first instance. The provision of consent implies that users are fully informed about what is being recorded and a requirement to determine how the data gathered may potentially be used. While the value of ensuring transparent processes to support the informed consent for people with disabilities has been recognized in medical ethics for the past few decades, it has only recently entered debates around big data, data mining, and novel technologies [67–69]. Informed consent "is usually understood as informed, voluntary and competent consent" [70]. In the event that a person is using a technology that is capable of recording, storing, and re-purposing information about a person's disability or functioning the issue of informed consent is even more pertinent. Disabilities and those that experience them are varied, forming a wide spectrum of capacity and ability. Within any cohort of people with a disability, some will have the ability to provide informed consent. For others, fully informed consent may only be possible under the right conditions and where everything has explained clearly. For some however, it may be that the ability to consent to one's what may happen to one's data when using such consumer technologies may not be possible. As the risks associated with using consumer products that have the capability of harvesting personal data increase, it is conceivable that the market may contract as individuals become more concerned with the risks to the autonomy of their own data and to their privacy. For segments of the consumer market with additional vulnerabilities in terms of the risks, they may face manufacturers and service providers such as large corporations may need to move beyond a one-size-fits-all model of how data is collected and managed. The procedures around informed consent for commercially available digital technologies such as smartphones, smart speakers, and internet of things may need to be adapted to accommodate these requirements.

9. Case study 3: benefits and risks: trading privacy for independence

Damian works as a freelance journalist and lives at home with his wife and two young children. He was diagnosed 7 years with Multiple Sclerosis which has had

an impact on his mobility and how he manages his fatigue. He uses a smartphone primarily as a means of doing his job as a journalist and uses Google Hub with a Hive thermostat to control his home heating and with smart plug sockets so he can minimize physical exertion in activities in his home.

> *"Maybe because of the work that I do, I am more aware of the risks, there is a sense, particularly with the Google Hub that someone is listening all the time. But I remind myself that the benefit to me, to these devices help me manage my energy during the day, it outweighs the risk that someone is listening in to my conversations with contacts or studying what I am doing here in my own home. I don't spend a great deal of time worrying about it, but I do have to be aware that I have an incurable neurological condition and that is not something that I want everyone to necessarily know about, I do have concerns that information might get out there. That is something that I do need to consider."*

10. Summary and conclusions

The uptake of consumer digital technologies by people with disabilities suggests that accessibility and equality goals can best be met through leveraging the potential of these technologies [71]. It must, however, be recognized that the assistive potential of many of these technologies were never designed to ensure equity of access for people with disabilities, rather they were designed to appeal to as broad a swathe of the consumer market as possible. Features such as voice-control, touchscreen access, text to speech, and other features provided opportunities for those with diverse motor, sensory, and cognitive needs to use the technology. Furthermore, the ability to access the technology ensured that users with diverse needs could in turn exploit the broad functionality of these "connected" devices. It may be too soon to herald the decline of very specialized assistive technologies in favor of what must be considered "accessible" consumer technologies. It is clear, however, that the availability and costs associated with consumer digital technologies should result in more people with disabilities using these, perhaps alongside more specialist, bespoke solutions. It is reasonable to assume that as awareness increases of people with disabilities as a sizeable market segment further attention will be given to developing expanded functionality aimed at addressing some of their specific needs.

Consumer digital technologies undoubtedly present opportunities for many users with diverse needs and requirements. This includes making it easier to access the online world, control other devices, communicate readily with others, and live their best digital lives. There is, however, a growing debate about the potentially intrusive nature of such "connected" devices and the use of the data captured. The potential technology can offer people with a disability must be balanced against the need to ensure their right to information privacy and security [10]. Concerns regarding safety, privacy, and autonomy have the potential to erode the confidence people with a disability have in the choice making and control available to them. Companies such as Amazon, Apple, and Microsoft, among others, may see the market for their products diminish if the concerns of people with disabilities begin to outweigh the perceived benefits of using these technologies. Leading analysts such as Forbes have estimated that anywhere between $10 and $16 billion will be spent on realizing accessibility requirement for consumer digital products[2]. Recent online debates, however, point to a growing awareness of the

[2] https://www.forbes.com/sites/forrester/2021/07/01/how-10b-in-design-spending-will-soon-be-up-for-grabs-annually/?sh=2bda56611ea9 (accessed January 2023).

problems associated with disassociating ethical considerations from the design of new technologies[3]. A recognition that people with disabilities and older people are a market segment for consumer technologies that is likely to grow exponentially over the next few years has focused the attention of these companies. Legislative changes in Europe including the eAccessibility Act [72] promise more market opportunities for accessible technologies and accompanying services. Furthermore, such legislation builds upon previous efforts to ensure that safeguards are in place to assure all citizens as to their rights to digital privacy [73]. Efforts are also underway by advocacy bodies such as the European Disability Platform have sought to increase awareness of the issue through the publication of policy and guidance statements.[4]

While legislation alone may not fully address some of the concerns of people with disabilities, it is, however, likely to increase their opportunities to purchase these technologies with the same consumer rights as all other users. It is likely that an increased uptake in these consumer devices by people with disabilities will open greater opportunities for discussion and debate as to how greater access to the benefits of the technology can be balanced with the need to ensure the privacy and autonomy of consumers with disabilities.

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Conflict of interest

The authors declare no conflict of interest.

[3] https://medium.com/tribalscale/design-ethics-and-technology-d294ce15f29d (accessed January 2023).

[4] https://www.edf-feph.org/data-protection-policy/ (accessed January 2023).

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