"Goodnight Alexa" – Theorising interactions between people with visual impairments and digital voice assistants

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Short Paper

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Abstract

Visually impaired individuals face various physical, digital, and social challenges. While specialised technologies such as screen readers can mitigate some of these challenges, they are associated with unresolved dilemmas including stigma. Digital voice assistants, which were not intentionally developed for people with visual impairments, have a large potential to offer desirable benefits without a negative stereotype. Yet, there is a lack of knowledge of how people with visual impairments perceive this technology, how they interact with it, for which tasks they use it and what are the respective outcomes. To address these questions, we conducted a qualitative study and interviewed 21 people with visual impairments who use digital voice assistants. Relying on a sociotechnical perspective and the concept of IS delegation, we identified six different roles of voice assistants that differ based on their agentic capabilities, their delegation mechanisms, the tasks they execute, and the associated instrumental or humanistic outcomes.

Keywords: Digital voice assistants, IS delegation, people with visual impairments, instrumental outcomes, humanistic outcomes

Introduction

Approximately 2.2 billion people worldwide are estimated to be visually impaired (World Health Organisation, 2022). Visual impairments are associated with loss of vision, colour blindness or a combination of both. Individuals with visual impairments encounter many challenges in their daily lives, such as physical and digital navigation, recognising faces, reading, participating in social settings, and identifying physical objects (Pereira et al., 2015). Subsequently, they often require assistance for daily tasks that sighted individuals can do independently, leading to risks of injuries, depression, and isolation. (Salleh and Zainal, 2010).

Over the years, various technologies have been developed that help visually impaired individuals, e.g., text-to-speech software, screen readers, and enlargers (Pethig and Kroenung, 2019; Suomi and Sachdeva, 2016). Yet, there are issues with high costs of acquiring the technology, high cognitive load, inaccuracies due to limitations in their functionalities, and stigma due to the specialised design of these technologies for people with visual impairments (Pethig and Kroenung, 2019; Poggi and Mattoccia, 2016).

Artificial intelligence (AI) advancements have introduced new tools to address the limitations of specialised technologies (Hoy, 2018). Particularly, AI-powered digital voice assistants (DVA) or voice assistants (VA) like Siri, Alexa, Google Assistant, Bixby, and Cortana offer verbal task assistance, such as booking reservations, controlling smart homes, and managing communication channels like emails and messages (Hoy, 2018). These cloud-based tools have voice recognition capabilities, enabling interaction with speech (Hoy, 2018). They convert speech to text, answer queries, perform tasks, and have conversations in real-time (Chung et al., 2017). Their natural language processing, user-friendly personality, and broad availability make digital voice assistants seem more practical and approachable than specialised assistive technologies (Araujo, 2018), therefore having the potential to address some of the challenges faced by visually impaired individuals (Rochford, 2019).

Despite digital voice assistants' promising benefits for people with visual impairments (Hoy, 2018), understanding how visually impaired users interact with this technology and the implications of their use is lacking. These insights matter as leveraging the full potential of digital voice assistants relies on knowing their usage. To investigate this, we rely on the concept of IS delegation, which describes "transferring rights and responsibilities for task execution and outcomes to another agent" (Baird and Maruping, 2021, p. 317). Drawing on a sociotechnical perspective, we explore the dualistic impacts of these interactions, namely instrumental and humanistic outcomes (Sarker et al., 2019). Our study extends the concept of IS delegation by providing rich contextualised accounts of how visually impaired use voice assistants daily, explaining human-technology dynamics (Baird and Maruping, 2021) and the resulting outcomes. The findings can help enhance the use of voice assistants among the visually impaired for battling isolation and fostering independence (Rochford, 2019).

Hence, we ask:

1) How do people with visual impairments interact with digital voice assistants to support their daily activities?
2) What are some of the instrumental and humanistic outcomes generated from these interactions?

Theoretical Background

We first review the literature on the multi-dimensional challenges of people with visual impairments and how digital technologies deliver functional capabilities to mitigate their lack of functional vision. Next, we present the concept of IS delegation (Baird and Maruping, 2021) and instrumental and humanistic outcomes that emerge from sociotechnical interactions between users and digital technologies (Sarker et al., 2019).

Digital, physical and social challenges faced by people with visual impairments

Visually impaired people face various challenges related to navigating digital environments, using digital technologies, recognising physical objects and environments, and engaging in social interactions. Limited functional vision hinders their computer and web usage compared to sighted individuals (Cullen, 2001). Some common issues when navigating the internet are images with text on them, images without alternative

text, pop-up windows, tables containing information, drop-down menus with multiple options, inaccessible PDFs, and video control buttons (Tomlinson, 2016).

Besides digital navigation challenges, visually impaired individuals struggle with mobility and physical navigation due to a lack of visual cues (Poggi and Mattoccia, 2016). Specifically, they struggle with obstacle avoidance and finding and maintaining paths (Poggi and Mattoccia, 2016). Identifying physical objects like clothing, information on supermarket aisles, grocery details, or bus schedules is challenging due to inadequate infrastructure in most cities, affecting seemingly mundane activities such as shopping, cooking, and socialising (Kacorri et al., 2017).

Visual impairments also lead to exclusion from essential life aspects like education, work, and community engagement. Learning is restricted due to limited vision since 85% of social learning relies on sight (Salleh and Zainal, 2010). In addition, visually impaired individuals who do not manage to grasp accepted norms in social interactions are likely to suffer seclusion (Celeste, 2006), thus exacerbating discrimination experiences in the workplace and hindering their social participation (Ta and Leng, 2013).

Digital technologies and people with visual impairments

Various digital technologies aid visually impaired individuals in their daily life (Suomi and Sachdeva, 2016). These technologies are assistive or specialised, like screen readers, and more recently, general-purpose AI-based tools such as digital voice assistants.

Traditionally, specialised tools like braille displays, screen magnifiers and screen readers are available to help people with visual impairments with better access to online information. These technologies support them by converting web pages to audio, tactile, or magnified formats (Ray and Ray, 1998). Access to these technologies and technological progress has led to more systems being developed to help the visually impaired in navigation, obstacle avoidance, and object recognition. Additionally, AI applications like Seeing AI support them with an understanding of physical objects (Ilag and Athave, 2019).

While specialised technologies offer several benefits to the visually impaired (Gerber, 2003), they pose a dilemma. Due to their purposeful design to support people with visual impairments, their use may lead to stigma and fear of being marked as disadvantaged (Pething and Kroenung, 2019). Additionally, they are costly, need learning time, require additional support, can increase cognitive load and limit their accessibility (Kulyukin et al., 2002). AI-powered technologies designed to be used by the general population, such as digital voice assistants, have promising benefits for people with visual impairments. This is evidenced in the increasing number of not-for-profit organisations recommending the use of voice assistants for people with visual impairments in countries like New Zealand and the U.K., among others (Blind Low Vision NZ, 2023; Blind Veterans UK, 2023).

Human-Conversational agent interactions

AI-based conversational agents, such as digital voice assistants, have been increasingly used by individuals to support their daily activities (Schmitt et al., 2023). Due to their humanlike conversational ability, adaptive and learning capabilities, some users may attribute these devices with the ability to act autonomously in a goal-directed manner and develop strong emotional attachments similar to the way they connect to other humans (Schmitt et al., 2023). For example, users consider Amazon's Alexa their new best friend (Purington et al., 2017) and Google's Duplex users believe they are talking to a human (O'Learly, 2019). With the use of verbal instructions, voice assistants such as Siri, Alexa, Google, and Bixby can help both sighted individuals and those with visual impairments to perform seemingly mundane activities such as booking taxis, making restaurant reservations, playing music, controlling smart home appliances, and managing emails and calendars. For people with visual impairments, digital voice assistants' friendly, caring, and patient nature may help combat social isolation and encourage independent living (Rochford, 2019). However, research on the role of these technologies in the lives of people with visual impairments and the benefits they can bring is still nascent. Hence, our study will address this gap by providing a rich explanation of how and why people with visual impairments use voice assistants, how they perceive and interact with them, and the resulting outcomes.

Theoretical lens

Most IS use research takes a human agent perspective by assuming that IS artefacts are tools that human agents use to perform a task (Orlikowski and Iacono, 2001). However, emerging technologies like the Internet of Things and AI have disrupted this paradigm as they show characteristics of technological agency and hence can be classified as agentic IS. For instance, route planning agents instruct drivers to follow optimal routes. Agentic IS artefacts are rational software-based agents that can perceive and act autonomously, make decisions, and take on or transfer rights and responsibilities to human agents (Russell, 2019). Such artefacts include smart surgical tools, predictive models used in legal decisions, and autonomous vehicles (Baird and Maruping, 2021). Digital voice assistants that can act and react to queries and stimuli, respond autonomously and even make creative suggestions, such as recommender algorithms used on YouTube or Netflix, can also be regarded as agentic IS (Russell, 2019).

To better understand human interactions with these agentic IS artefacts, Baird and Maruping (2021) argue that it is insufficient to solely recognise human agency and that more emphasis needs to be put on the technological agency in these interactions. Hence, they introduce the concept of IS delegation, which involves transferring the rights and responsibilities of task execution and outcomes to another agent as a powerful lens to study human agentic IS artefact relationships.

In our study, the delegation lens can provide rich insights into user-digital voice assistant relationships as it puts equal weight on human and technological agency and hence can better explain how tasks are executed by the human and IS agent and which outcomes result from those interactions. We rely on two delegation mechanisms, transfer (distribution) and coordination, to explain interactions between users and digital voice assistants. While transfer refers to delegating rights and responsibilities to perform a task entirely to the voice assistant, coordination refers to correlating the sequencing and interdependence of actions and tasks between the user and the voice assistant to achieve desired outcomes (Baird and Maruping, 2021).

To explore the outcomes of the interactions between digital voice assistants and visually impaired individuals, we rely on a sociotechnical perspective that considers outcomes to result from the interactions between two agents (Sarker et al., 2019). The outcomes can be classified as instrumental or humanistic (Sarker et al., 2019). While instrumental outcomes are related to efficiency, competency and productivity (Sarker et al., 2019), humanistic outcomes are subjective positive effects promoting human well-being, life quality, independence, and overall betterment (Post, 2014). Similar to a recent study on algorithmic unfairness (Schulze et al., 2022), we have also adopted the IS delegation framework in conjunction with the sociotechnical perspective for our study. This allows us to better understand the interactions between people with visual impairments and voice assistants and the resulting outcomes that emerge from those interactions.

Methodology

Data collection

To answer our research questions, we conducted a qualitative study building on the theoretical underpinnings of interpretivism (Klein and Myers, 1999). Semi-structured interviews were conducted with 21 visually impaired individuals in Australia and New Zealand who use voice assistants regularly on a daily basis. The interviews allowed us to gain an understanding of the participant's experiences of interacting with voice assistants and to allow for new insights to emerge through conversation (Gray, 2014; Rowley, 2012). Among those with low vision were three males (one aged 20-30s, two aged 50-60s) and four females (three aged 20-30s, one aged 50-60s). For those with full blindness, six males were included (two aged 30-40s, one aged 50-60s, one aged 60-70s, and one aged 70-80s), along with eight females (five aged 30-40s, one aged 40-50s, one aged 50-60s, and one aged 60-70s).

The main topics of the semi-structured interviews were the challenges visually impaired people experience in their daily lives, the reasons why they choose to use digital voice assistants, how they interact with digital voice assistants and the impacts of their interactions. The interviews took approximately 60 to 90 minutes and were conducted online or in person. The recorded interviews were transcribed by a professional transcriber after all the interviews were conducted.

Qualitative research centres on a population's social context and significance (Gobo, 2004). It focuses on information-rich cases and employs targeted sampling strategies to deeply understand a phenomenon (Patton, 1990). For our research, we selected 21 participants who met our criteria and considered contextual factors such as gender, age, frequency of use, and the type of voice assistant utilised. We achieved theoretical saturation after data collection and analysis of the 21 interviews. This means that we reached a point where no new insights emerged, and additional information no longer contributed to a better understanding of the phenomenon being studied (Urquhart and Fernández, 2013).

Data analysis

To analyse our interview data, we adopted a systematic coding approach following the guidelines by Strauss (1990). The method involves systematically evaluating the data, recognising patterns, and attributing codes for each data segment corresponding to a specific idea or theme (Strauss, 1990).

To theorise the interactions of visually impaired people with voice assistants and the resulting outcomes, we adopted an abductive approach (Tavory and Timmermans, 2014), which unfolded in four stages. After replacing the personal information of the participants with pseudonyms (e.g., Interviewee A), we proceeded with the first stage of the analysis by closely reading the interview transcripts and applying the open coding technique with the help of NVIVO software (Fernández, 2004), wherein we segmented the data according to the research focus and other interesting insights without any preconceived theoretical frameworks. The open codes centred around the various tasks the users engage with the voice assistants and the resulting outcomes. Some examples of open codes for tasks included 'make calls', 'exchange conversation', 'turn lights on/off', 'set alarms', and examples of outcomes included 'increase competence', 'decrease everyday struggles', 'save time and effort', 'facilitate independence'.

In the second stage of our analysis, we grouped the open codes into use cases based on the similar nature of tasks as well as the similar nature of the outcomes. Some task-related use cases were 'operating smart home appliances', 'entertaining users', and 'helping with physical navigation activities.' Some outcomes-related use cases were 'effort and time saving', 'independence related', and 'emotional connection'. We continuously compared and refined these use cases until they were conceptually coherent. We then scrutinised the tasks within each use case according to the nature of the interactions between the user and the voice assistants. Here, we realised the different ways in which users interacted with their voice assistants in each task to achieve different outcomes. For instance, we found that in some cases, the user and the voice assistant worked collaboratively to complete a task, such as when playing games, while in other cases, the user relied entirely on the voice assistant to accomplish a task, for example when turning on/off home appliances.

In the third stage, we sought out theoretical concepts to help us better understand the nature of these interactions and their resulting outcomes. Considering the patterns that emerged in the previous stage, we regarded the concept of information systems (IS) delegation (Baird and Maruping, 2021) and the concepts of humanistic and instrumental outcomes, which are part of the sociotechnical perspective (Sarker et al., 2019) as useful analytical frameworks. We found that two main mechanisms of delegation, namely 'transfer' and 'coordination', offer the best explanation for how visually impaired users interact with various voice assistants to accomplish specific tasks. The 'transfer' delegation mechanism refers to delegating rights and responsibilities for task execution from the user to the IS agent (voice assistant). This mechanism is used to perform tasks (e.g., turn on/off lights) that are menial and do not require much effort or expertise from the voice assistant. Whereas the 'coordination' delegation mechanism refers to the joint efforts of the user and voice assistant that work together towards accomplishing goals for the human agent. The interaction focuses on back-and-forth exchange of information between the two agents (e.g., creating shopping lists). Drawing on the tenet of a sociotechnical perspective, we then classified the resulting outcomes into instrumental outcomes, such as convenience and efficiency, and humanistic outcomes, such as independence and well-being.

In the fourth stage, we utilised the notion of IS delegation and the two kinds of outcomes to theorise the different agentic capabilities of digital voice assistants. We associated the group of tasks as part of the use cases (e.g., operating smart home appliances, playing games) with either 'transfer' or 'coordination' delegation mechanisms, and decided whether these interactions generate salient instrumental or humanistic outcomes. Finally, we looked at the key tasks, their delegation mechanisms, and the salient outcomes holistically to determine the distinct agentic roles that digital voice assistants fulfil for individuals

with visual impairments. These included roles like 'a family member,' 'an assistant,' or 'a navigator'. We concluded that agentic roles that conduct simple tasks and follow a 'transfer' mechanism mostly generate instrumental outcomes, and agentic roles that complete tasks that involve back and forth exchanges and follow a 'coordination' mechanism mostly generate humanistic outcomes.

Findings

Our analysis identified six roles that digital voice assistants play in the lives of people with visual impairments. For each identified role, we offer some preliminary findings using the concept of IS delegation to explain how visually impaired individuals interact with digital voice assistants to accomplish specific tasks that yield instrumental outcomes, humanistic outcomes, or both.

Voice assistant as a smart home refers to visually impaired individuals viewing their voice assistants as devices to seamlessly facilitate the activation and management of smart home appliances like light switches, heat pumps, and TVs, thus contributing to several instrumental outcomes. In this role, participants view voice assistants as an easy-to-use remote control for their smart home as they can simply activate smart home devices with a single command: *"They allowed the ability to put in the smart technology into the house when we built it. The smart lights that we can use Alexa to turn on and off, I played around and learned how to turn on the TV via voice assistant, turn on and off our stereo, turn on and off the air conditioning unit, and I've been adding in some pieces as we've gone along"* (Interviewee E). When the user delegates tasks to the voice assistants for controlling smart home appliances, they transfer the responsibility of performing those tasks to the voice assistants without further involvement, thereby using the 'transfer' mechanism. These interactions lead to salient instrumental outcomes such as reducing daily struggles, saving time and effort, and increasing competence.

Voice assistant as a companion or family member refers to visually impaired individuals developing strong emotional connections with their voice assistants due to their natural-sounding voices and constant availability. They also appreciate the companionship and support their voice assistants provide, which mostly contribute to humanistic outcomes. In this role, participants use their voice assistants to play games, joke around, or have conversations. One user explained, *"It's a routine thing to say, "Good morning, Alexa," she'll go, "Good morning," and she gives you a fact of the day from a hundred years ago. Every night when I turn off my lights and I go to bed, I say, "Goodnight, Alexa," and she says, "Goodnight. Sleep well." I find her friendly and polite and she keeps me company and I like that" (*Interviewee K). In contrast to voice assistant as a smart home where visually impaired users command the voice assistants to execute the tasks, in this role participants converse with their voice assistants as if they were close companions or family members. Users truly collaborate with the voice assistants by using the 'coordination' mechanism to accomplish tasks. These comforting conversations contribute to mostly humanistic outcomes, such as reducing boredom and loneliness and providing emotional support.

Voice assistant as a personal assistant refers to visually impaired individuals viewing their voice assistants as multi-functional devices, which serve as their aide to perform everyday functional tasks that contribute to humanistic outcomes. These easy-to-command devices meet the user's needs and often provide instantaneous results. There are certain tasks, such as customising a shopping list, where the user and the digital voice assistant work together to accomplish the task: *"I actually like her prompting me because she will say, "I see the same shopping list." I keep saying, "Alexa, add to my grocery list this product," which is my favourite thing about Alexa when I'm cooking or looking to make a meal. Oh, I'm out of salt or I'm out of tomato sauce, "Alexa, add to shopping list, tomato sauce, or delete from shopping list" and she does it*" (Interviewee K). Here, Alexa and the user are working together and prompt each other to co-create a shopping list, which represents the 'coordination' mechanism. These interactions often lead to humanistic outcomes such as increasing the user's self-confidence to do things independently, making them feel empowered, and enabling them to complete everyday tasks with similar ease as sighted individuals.

In the case of **voice assistant as a social agent,** they are viewed as tools for not only solo activities but also communal experiences, such as facilitating social connections with their family, friends, and others online or in person, thus contributing to mostly humanistic outcomes: A user mentioned: *"Making calls, sending text messages, reading, and replying. It reads my messages and while I'm doing other stuff, I can just say, "Yes, reply." And it replies. Yes, it's really assisted in keeping communication and contact with*

so many people." (Interviewee D). Regarding text messages, visually impaired users often prompt the voice assistant to read incoming messages, command the voice assistant to reply, dictate a response, and send off the message, which often requires a back-and-forth between the user and the device, signalling the 'coordination' mechanism. These interactions produce salient humanistic outcomes such as promoting social bonds, maintaining social connections, and enhancing well-being: *"Especially during this lockdown, these things helped me to keep in touch with all my family and friends all over the world as well. Just give them a call, have a chat, and all those things. It's definitely for well-being and mental health. You keep connected with everyone."* (Interviewee P).

Voice assistant as an entertainment medium refers to visually impaired individuals viewing their voice assistants as a means to provide convenient access to sources of entertainment such as music, radio, podcasts, or audiobooks, which are associated with several humanistic outcomes: *"You basically have to tell Alexa what book you want to read or what author you want to read. If you don't know what you want to read, you can just say "recommended books". Then it'll start reading out to you what books other people may have recommended. For example, "I recommend Harry Potter." Then you can be like, "Oh, I want to read that too." It helps me when I'm bored or just feeling lonely and want something to keep me occupied"* (Interviewee E). The action of the digital voice assistant to recommend books to the user illustrates its agentic capability. When voice assistants are perceived as an entertainment medium, users usually work together with them to accomplish tasks such as skipping a music track they don't want to hear, listening to a song again or listening to their audiobook without having to physically manipulate a device. These kinds of interactions can be classified as 'coordination' and usually generate positive humanistic outcomes, including reducing boredom, providing companionship, and helping to combat loneliness.

Voice assistant as a navigator refers to visually impaired individuals viewing their devices as a guide to help them safely get around particularly unfamiliar locations, which lead to significant humanistic outcomes. Interviewee P mentioned, *"Siri, I have used a couple of times to find the location for some places, I asked Siri and Siri gave me the direction, address, everything. It also directs me to the website that I can go through as well. It makes me feel like I can go to places on my own."* When using voice assistants for navigation, the user collaborates with the voice assistant to get accurate directions to navigate to their destination, which often involves multiple rounds of actions and reactions between them. For example, the user asks for their specific location, and the voice assistant provides real-time updates on the user's coordinates. The repeated interactions between the user and the voice assistant are necessary to reach the destination safely and efficiently, thereby using the 'coordination' mechanism. Through these interactions, noteworthy humanistic outcomes are achieved, such as increased self-confidence in travelling to new places, greater independence, and a feeling of empowerment.

Discussion and Expected Contributions

This study contributes to the body of knowledge on human-CA interactions, specifically for individuals with visual impairments. The initial findings reveal six roles that visually impaired individuals associate with voice assistants, highlighting their agentic capabilities and extending the concept of IS delegation (Baird and Maruping, 2021). This research delves into 'transfer' and 'coordination' delegation mechanisms, shedding light on how these mechanisms influence user interactions and allowing us to better explain why they interact with their voice assistants in the way they do. Transfer mechanisms typically lead to instrumental outcomes, while coordination mechanisms often result in salient humanistic outcomes (Sarker et al., 2019). We intend to further explore humanistic outcomes through the theoretical lens of human values (Chughtai and Myers, 2023). This study has implications for encouraging a comprehensive use of digital voice assistants to empower visually impaired users to perform daily tasks more independently, combat social isolation, and improve their well-being (Rochford, 2019).

Furthermore, our findings provide rich insights into visually impaired people as a user group of voice assistants and their specific use cases. The insights gained also offer guidance to designers and developers in adapting features to cater to the needs of this user group (e.g., improving intent classification). There exist ample opportunities to expand upon the current findings in future research. These could include a study comparing how voice assistant use impacts individuals with visual impairments versus sighted individuals. Further analysis could provide an in-depth understanding of the agentic roles of digital voice assistants, the different dimensions of the delegation mechanisms, and their impact on empowering and enhancing social interactions for the visually impaired. Additionally, there is also scope for elaborating on

instrumental and humanistic outcomes, and the challenges faced by visually impaired users when using voice assistants.

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