Voice-Enabled Privacy Assistant Towards Facilitating Successful Ageing in Smart Homes

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Abstract—In recent years, people have increasingly introduced smart speakers into their living spaces, but many lack an understanding of how their data is collected, processed, and used. In addition, people are often unsure how to configure the privacy settings of their devices. Therefore, we present Privacy Assistant, a novel conversational interface designed to empower people to understand how data is collected, processed and stored and configure their privacy settings. We focused on older people who are at additional risk of low understanding of privacy settings and data handling on voice assistants. We developed an Amazon skill that interacts with users and guides them through the privacy settings of smart speakers. This skill assists people in understanding key features (voice recordings, location, and voice purchasing) so they can make informed decisions about privacy settings. We took a user-design approach to iteratively improve the prototype based on two successive rounds of feedback with end-user (older people who own smart speakers). We found that older people preferred the Privacy Assistant to standard configuration procedures (i.e., through an app or webpage). We also found that the Privacy Assistant increased their knowledge and awareness of privacy settings and data management on voice assistants. (Demo Video)

Index Terms—Smart home, Voice user interface, Voice assistant, Smart speaker, Privacy, Older people

I. INTRODUCTION

As new Internet of Things-enabled technologies emerge, a growing number of devices are introduced into living spaces to facilitate the tasks and routines of daily life. Among these devices are voice assistants, such as smart speakers, which carry out tasks in response to speech commands. Smart speakers may be particularly useful for older people because of their accessible speech-controlled interface (e.g., they are easier to use than screen-based devices) and potential to facilitate aspects of daily living (e.g., for those with sensory, physical, or cognitive impairments). However, a key concern of voice assistant devices is that they collect, store, and share massive amounts of data [1]. These data can contain sensitive information, such as health, finances, and locations [2]. Additionally, users are exposed to various potential privacy risks, such as unauthorized third party access to personal information [3]. Worryingly, awareness of what data are collected and shared is low. For example, most people are unaware that smart devices have the ability to record and send data on speech interactions

[4], and some may not even realize that these recordings are stored in the cloud [5]. Equally concerning is that awareness of how to select and change privacy settings is also very low [6]. For example, users are often unaware that they can review and delete recorded conversations, despite the fact that they are not comfortable with their recordings being permanently retained [6]. Existing privacy settings are complex and difficult to access: Users are required to navigate to specific web pages or sections within an app; Terms and Conditions are often so long and complex that users avoid reading them. Therefore, there is a need to develop effective and accessible privacy controls for voice assistants so people can make informed, independent choices about how their data are managed.

We have developed a new voice interface 'Privacy Assistant' which takes users through the different privacy settings of their voice assistant and describe them in clear, uncomplicated language. Currently, the Privacy Assistant covers settings related to voice recording and storage, location information, and voice purchasing. We focused the design around the needs of older people, because research suggests they are less likely to understand and control their privacy settings on voice assistants than younger people [7]. However, the Privacy Assistant could be used by anyone. We used an interactive user-based design approach where end-users (older people who own smart speakers) provided successive rounds of feedback on how to improve the product.

We asked the following research questions:

- Does a voice-controlled Privacy Assistant increase knowledge and awareness of privacy settings and how data are managed?
- Do older people prefer to use a voice-controlled privacy assistant than standard privacy/data management procedures?
- How can we further optimize the privacy assistant to suit user needs?

II. IMPLEMENTATION

We developed a privacy assistant tool derived from three different components of the Amazon Alexa privacy settings (voice recordings, location and voice purchasing) to allow users to configure the privacy of smart speaker without using

Amazon Alexa App or Amazon web. We first developed scenarios that captured different Alexa privacy settings and explained them in simple and accessible language. We then used the 'voiceflow' website, which simulates Alexa skills, to create a prototype of the Privacy Assistant as shown in Figure 1.
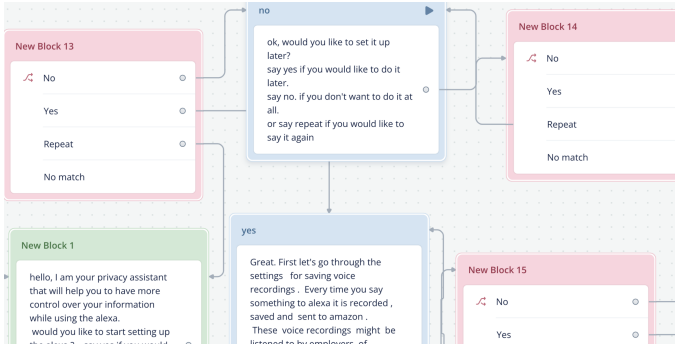

Fig. 1. An Example of Privacy Assistant Interface's Simulation Design

We updated the scenarios after feedback from older people (see Study 1). Next, we created an Alexa Skill, which required the development of both the skill interface and the skill services. The skill interface maps the user's speech requests to intents within the interaction model. Intents are actions taken in response to a spoken request from a user. Each intent has at least one utterance, which is a predefined word, phrase, or sentence that may be used by the user to invoke the intent. By detecting an intent, the skill interface generates a JSON-encoded event that is sent to the skill service. As a result of receiving the JSON-encoded event from the skill interface, the skill service determines what action to take. Skill services return a JSON-encoded response after reaching a decision to skill interfaces. Once processed, the speech response is sent back to the user via the Echo device. use the Alexa platform as a voice interface and connect it to Lambda (serverless) to run our code via this platform , as it shows in Figure 2. We then piloted the new Privacy Assistant with end-users in Study 2.

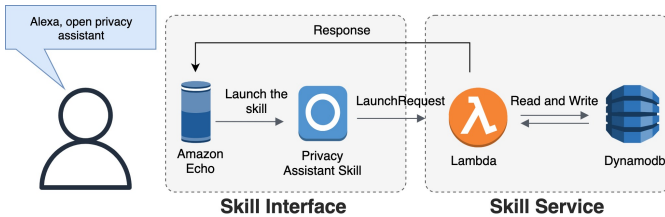Fig. 2. Launching Privacy Assistant Skill

III. STUDY METHODOLOGY

This study was conducted to determine whether and how the proposed Privacy Assistant helped older people gain a better understanding of privacy settings and configure them independently. We have conducted two studies to accomplish this goal.

Study 1: Early Design of Privacy Assistant Interface

Three older people (ages ranged from 65 to 72 years old, the average age was 68 years, 2 males, 1 female) provided feedback on the first Privacy Assistant prototype. Participants completed a survey about their digital skills, knowledge of privacy settings on voice assistants, and current privacy settings. All participants owned a smart speaker before beginning the study. Participants received a £20 voucher for taking part. Participants met with the researcher via Zoom and were asked to pilot the Privacy Assistant. They were then interviewed about their experiences of using the Assistant and asked for feedback on how to improve it. We received feedback from participants to reduce the number of choices given by the assistant for different options, because they found it difficult to remember them. However, all Participants reported that would rather use the privacy assistant than change settings via the app or website. The recommended improvements were implemented into the prototype design.

Study 2: Develop Privacy Assistant Interface (Alexa Skill)

The three participants who took part in study 1 were asked to take part in study 2. In addition, we recruited four new participants. Therefore, a total of seven older people participated (age range from 65 to 72 years old, average age was 69 years, three females, four males). The design was similar to Study 1, although in this study we measured whether privacy awareness had increased after using the Privacy Assistant. Participants completed a questionnaire about digital skills and privacy awareness, then a Zoom interview to pilot the prototype and provide feedback. Participants repeated the privacy awareness questionnaire after using the prototype to see if their awareness improved. As shown in Figure 3 (orange bars), before using the Privacy Assistant, privacy awareness was quite low. Participants were unaware that smart speakers can collect a variety of data (Figure 3.a) and were also unaware of where the device transferred the data (Figure 3.b). Most of the participants were unaware of who could access their data (Figure 3.c), and did not know how to control access and retention of their data (Figure 3.d). After using the Privacy Assistant, we found that awareness of privacy settings on voice assistants improved (Figure 3, blue bars). Another finding of our study was that the participants agreed that using privacy assistant tool to set up their privacy setting was easier than using the mobile app or website. Moreover, six participants felt less confused about the privacy settings on their smart speaker than they did before. One participant reported that his awareness had stayed the same, because of his work experience in an IT field.

IV. DEMONSTRATION

We designed 'Privacy Assistant Skill' to simplify privacy settings configuration and learning about users' data practices. This tool can increase user awareness toward data that has been collected via smart speaker, and enable them to make informed decisions on how to configure their privacy settings. In addition, we believe that the Privacy Assistant skill allows
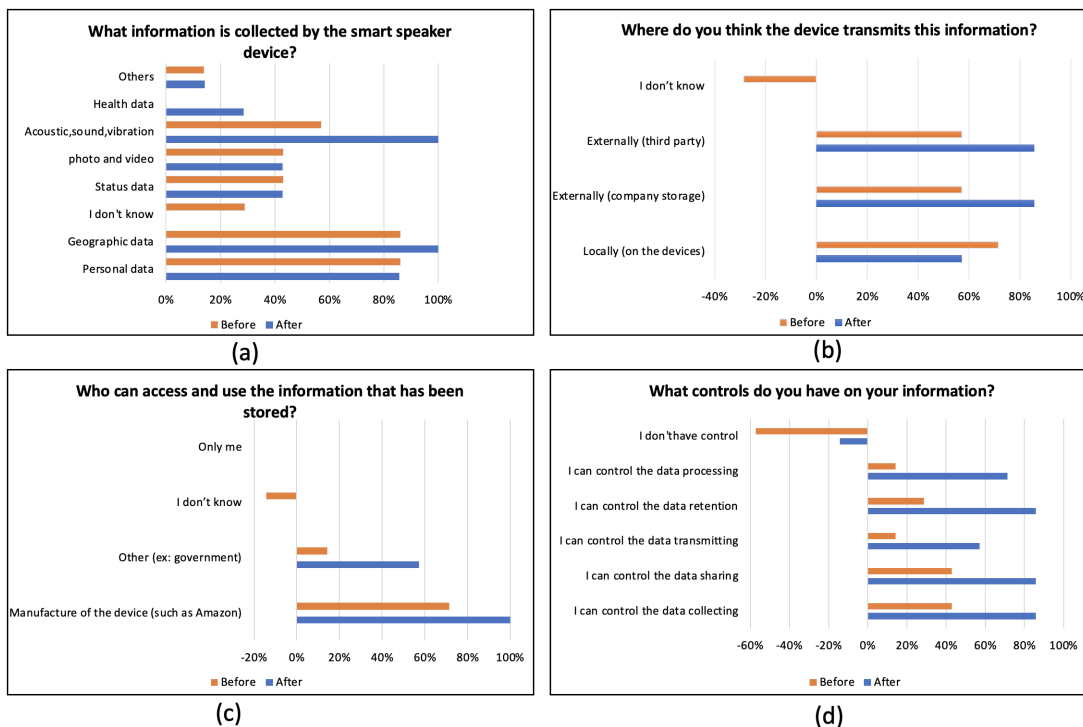
Fig. 3. Awareness of Privacy Settings Among Older People Before and After Using the Tool

older people with lower digital experience to configure their privacy settings more independently and increase their privacy awareness. The following use case, about an individual named John, demonstrates the Privacy Assistant skill functionality and how it increases awareness and agency over data management. John is 65 years old and uses an Amazon Alexa to facilitate daily living (e.g. playing music and setting re- minders) and to control his smart devices. John asked a family member to set up his smart speaker and does not know how to configure the privacy settings. In addition, John was not aware of the data practices of the smart speaker, such as the collection, processing, sharing, retaining, and deleting of data. John participated in our study and completed a survey about his digital skills and privacy awareness surrounding data practices. We then asked him to configure the privacy settings using our Privacy Assistant. The Assistant provided him with the option to learn about and configure privacy settings in three areas (1) voice recording, (2) location (3) voice purchasing. There were multiple options within each area, for example, in 'setup voice recording', he could specify the length of time he desired to save his history (3 months, 18 months, or do not save). In 'setup location privacy', John can choose to turn this on and that will help to receive exact news and weather, or off to deny that but it will affect the retrieve results later. The final option is 'setup purchasing privacy', that asked him to turn this feature on or off (by turning on the user can purchase online through voice command). To prevent accidental voice purchases, we gave the user option to set up pin code for this feature. Moreover, John has an option to set up his privacy

settings now or change them at a later time, and if he does not understand what Alexa is saying, he can ask her to repeat it. In conclusion, awareness and control over privacy settings on smart devices can be low and older people are more likely to face challenges in this area. Our Privacy Assistant Alexa Skill was designed to mitigate these concerns and to enable people to understand and manage their privacy settings more easily (Demo Video). In the case of John, after using our Privacy Assistant Tool, he became more aware of the data practices and was better able to protect his data in a way that was consistent with his own preferences.

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