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User Study: Smart Speakers and Visual Disabilities

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Abstract

This study investigates how individuals with visual disabilities and their sighted counterparts perceive user experiences with smart speakers. A sample of 79 participants, including 41 with visual disabilities and 38 sighted individuals, used Amazon Echo 4th Gen smart speakers. After participants used the smart speakers for one week in their daily lives, exit interviews were administered and analyzed, yielding themes of accessibility, effectiveness, enjoyment, efficiency, and privacy. Findings revealed that the voice user interfaces of smart speakers significantly enhanced accessibility and user satisfaction for those with visual disabilities, while the voice assistant Alexa contributed to fostering emotional connections. Sighted participants, while benefiting from the smart speaker's multifunctionality and efficiency, faced challenges with initial setup and advanced features. Individuals with visual disabilities raised privacy concerns. This study underscores the need for inclusive design improvements to address the diverse needs of all users. To improve user experience, future enhancements should focus on refining voice command accuracy, integrating predictive features, optimizing onboarding processes, and strengthening privacy controls.

Keywords

User experience, Accessibility, Usability, Voice assistants

Introduction

Smart technologies are increasingly integrated into the lives of individuals with visual disabilities. In a survey (Watanabe et al.), 81.4% of 43 individuals with blindness and 63.2% of 38 with low vision reported using iPhones, while 16.3% and 28.9% used Androids, respectively. In addition, 80% of 132 survey respondents with visual disabilities used smartphones daily (Crossland et al.). A longitudinal study (2013–2018) showed iOS adoption rates rose from 43.1% to 64.3% and Android adoption rates increased from 18.1% to 23.8% (WebAIM). Jain et al. found extensive smartphone use among individuals with visual disabilities, who engaged with 352 applications (apps) and averaged 19.9 apps daily, spending 2.3 hours on calls and 5.2 hours on apps. Tsurumi et al. reported increasing smart speaker adoption rates among 113 visually impaired respondents, with 47% of those in their 30s, 67% in their 40s, and 58% in their 50s using smart speakers. Daily use rates were also substantial, with 54% of respondents in their 40s and 58% in their 50s using smart speakers daily (Tsurumi et al.).

Smart technologies enhance independence and daily activities for people with visual disabilities. For instance, smart speakers with voice assistants provide eyes-free, hands-free control for accessing information, performing tasks, and managing smart home devices (Sciarretta and Alimenti), contributing to reduced accessibility barriers (Tsurumi et al.). Users with visual disabilities can easily manage various activities through voice commands, e.g., checking the weather, setting reminders, shopping online, and controlling smart home devices (lights and thermostats).

While positive user experience is closely related to technology adoption, there is still a limited understanding of how users with visual disabilities interact with smart technology features (Morris et al.). Pradhan et al. conducted a small-scale user study (16 participants with

disabilities) to examine the user experience of smart speakers. As they did not specifically control for the smart speaker type, participants' feedback varied across different smart speaker models. They identified several issues leading to poor user experiences, including missing desired features, the system's inability to answer users' inquiries, poor color contrast, and a steep learning curve.

Existing research on user experiences with smart speakers provides limited insight into how individuals with visual disabilities use these devices in their daily lives. Therefore, this study aims to address this knowledge gap by observing how people with visual disabilities interact with smart speakers equipped with voice assistants.

Methods

This study included a convenience sample of 79 individuals: 38 sighted participants and 41 participants with visual disabilities, based on a visual acuity criterion of 20/70 or worse with the best possible correction, as defined by the World Health Organization. Each participant received an Amazon Echo 4th Gen smart speaker, with an Apple iPhone 13 Mini used for setting up and linking the smart speaker account.

On day 1, participants received the smart technologies and completed a standardized instructional session. This session covered setup procedures and basic skills, such as button control, setting adjustments, and interaction with the voice assistant (Alexa). As the session was given in person, all participants could receive help as needed. Over the following 7 days, participants used the smart technologies in their own environments (e.g., home and workplace) to facilitate natural user experiences. The study concluded on day 7 with exit interviews to gather feedback on their experiences.

Results

The interview data were analyzed using content analysis, which revealed themes of accessibility, effectiveness, enjoyment, efficiency, and privacy.

Accessibility

Participants with visual disabilities appreciated smart speakers for enabling control and access to information through voice commands rather than relying on graphical user interfaces. They reported that these benefits significantly enhanced their ability to access various features. One participant highlighted, *"Smart speakers are a game-changer for people with visual disabilities. Voice commands let me control the speaker, access information, and even interact with other smart devices, like my smartphone. It would be amazing if all my devices had the same voice control features – that would make everything so much easier!"* In contrast, sighted participants expressed concerns about the smart speakers' ability to provide accurate and complete information. They expected smart speakers to offer the same level of reliability as emerging technologies such as ChatGPT. This perceived inadequacy in information provision led to a sense of insufficient access to the information they needed.

Effectiveness

Participants with visual disabilities valued the smart speaker's multifunctionality, which allowed them to perform various tasks through its all-in-one system, thereby reducing the need to learn and manage multiple devices. They also appreciated Alexa's ease of use, especially for those who rely on auditory interactions due to vision loss. One noted, "*I find Alexa very handy because I can do a lot of things. Using my voice, I can ask for the weather, listen to music, set the alarm, check spelling, etc."* However, concerns were raised about poor voice command recognition, as voice prompts were often misinterpreted, which hindered task completion. One

participant expressed this frustration, "*I tried to use voice commands, but it was so frustrating! Sometimes it did not understand what I was saying, and I had to keep repeating myself."* This highlights a critical area for improvement in enhancing the reliability of voice recognition technology.

In addition to the smart speaker's multifunctionality, sighted participants appreciated its sensitive speech detection, which facilitated effective communication even in low tones and noise-sensitive environments (e.g., bedrooms, shared spaces) without raising their voices. Nonetheless, they encountered challenges with the complex initial setup of Alexa and synchronization errors between the smart speakers and smartphones.

Enjoyment

In contrast to sighted participants, who did not explicitly mention emotional interactions, participants with visual disabilities reported significant enjoyment and a sense of companionship from Alexa. They perceived Alexa as an "e-friend," reflecting a strong emotional connection and appreciation for its interactive features. One participant noted, "*I think it is a good thing to sit around and play with the smart speaker. I think Alexa is quite fun to use.*" This positive user experience highlights the potential of smart speakers to enhance emotional well-being.

Efficiency

Participants with visual disabilities appreciated the smart speaker's efficiency, highlighting its prompt responses to user inquiries and the convenience of eyes-free operation, which eliminated the need to navigate complex visual menus. One participant stated, "*The smart speaker picks up well and does not take long to work."* Sighted participants found the smart speaker manageable after an initial familiarization period, although they encountered challenges in learning advanced features.

Privacy

Participants with visual disabilities expressed concerns about privacy, fearing that smart speakers might listen to and record personal conversations. One participant stated, *"I am uncomfortable with the level of personal information shared with smart speakers through conversations between users and the smart speaker. I do not trust their security measures and prefer not to use them in my home."* Conversely, sighted participants did not report similar concerns.

Discussion

Accessibility

Participants with visual disabilities found smart speakers highly beneficial for addressing accessibility challenges through hands-free, eyes-free, and voice-controlled interactions, which align with their reliance on auditory cues. Conversely, sighted participants expressed concerns about access to reliable information provided by the voice assistant Alexa, particularly in comparison to Generative AI technologies (ChatGPT). This concern could potentially be addressed by integrating voice assistants with Generative AI. In fact, Kuzdeuov et al. have previously explored the integration of ChatGPT with voice technology. However, further research is needed to evaluate the effectiveness of these integrations with smart speakers, particularly in terms of usability for users with visual disabilities.

To enhance the user experience for both groups, it is essential to improve voice command capabilities and refine AI algorithms. For instance, the development of a comprehensive voice command library could increase response accuracy (Kuhn et al.). These improvements are anticipated to boost adoption rates and user satisfaction.

Effectiveness

Both participants with visual disabilities and sighted participants valued the smart speaker's multifunctionality, appreciating its ability to process various tasks. This *all-in-one* feature facilitated effective task management.

Participants with visual disabilities, however, encountered significant frustration due to poor voice command recognition, leading to misinterpretations and repeated attempts. Further research should systematically investigate the specific prompts vocalized by them to better understand these challenges.

In contrast, sighted participants reported positive experiences with sensitive speech detection, which functioned well even at low tones. However, additional studies are necessary to evaluate its effectiveness in various environmental conditions, as sensitivity may vary depending on various real-world factors such as distance from the smart speaker and ambient noise, including traffic, conversations, and other common sounds in daily life (Vacher et al.).

Moreover, Vacher et al. demonstrated a correlation between the size of machine training data and smart speaker identification performance, suggesting that improvements in voice command recognition may be linked to technical factors, such as increased data availability for machine learning. Future research should address both user context and technical advancements to enhance voice command accuracy.

To enhance user experience for both groups, voice commands should be designed to be user-friendly. This includes using short, concise phrases and avoiding technical jargon. Implementation of a confirmation step — where the smart speaker repeats the command and requests user verification — could also improve the effectiveness.

Enjoyment

Sighted participants did not explicitly mention enjoyment, whereas participants with visual disabilities reported that smart speakers greatly enhanced their satisfaction by providing interactive and engaging experiences. They viewed the smart speakers as "e-friends," indicating a deeper emotional connection. This aligns with previous research on the companionship role of smart speakers – e.g., caregivers of individuals with dementia (O'Brien et al.) and residents in long-term care facilities (Edwards et al.) valued smart speakers for becoming trusted companions and reducing isolation. Abdolrahmani et al. also discovered that individuals with visual disabilities regarded voice-enabled applications as convenient companions and were willing to share even personal stories with them. These findings suggest that smart speakers can foster a sense of connection and companionship, particularly for those experiencing social isolation.

To enhance user enjoyment, especially for individuals with visual disabilities, smart speakers should offer customizable voice assistant personalities. Customizable voice tones, conversational styles, and interactive elements (e.g., personalized greetings and gamified features) may improve engagement (Bräuer and Mazarakis; Braun et al.). Regular content updates for users may sustain interest and satisfaction, making the smart speaker a more integral part of daily life.

Efficiency

Participants with visual disabilities valued the quick response times and hands-free operation of smart speakers, which eliminate the need for visual navigation and integrate seamlessly into their daily routines. Mun et al. found that delays of over three seconds negatively impacted user experience with smart speakers, highlighting the importance of optimizing

response times. Our study aligns with Mun et al.'s findings, showing that efficient and quick responses enhance efficiency.

Sighted participants faced a learning curve with the smart speaker's advanced features. Although they became comfortable managing basic functions, mastery of more complex functions still remained challenging. This finding aligns with Doi and Nishikawa's research, which demonstrated that users of Amazon smart speakers struggled with complex features. Through considerable trial and error, those users could gradually improve their ability to navigate these features, but high initial error rates were observed. Furthermore, their research highlighted that insufficient feedback hindered learning. Hence, the implementation of enhanced feedback mechanisms could make the system more user-friendly and facilitate the mastery of advanced features.

Further enhancement of efficiency can be achieved by implementing predictive features that leverage user behavior and preferences to suggest relevant content, reducing wait times and optimizing interactions. Additionally, proficiency with the device may increase more quickly when the onboarding process is redesigned to include interactive tutorials, context-sensitive help, and consistent user interface elements.

Privacy

Participants with visual disabilities expressed concerns about privacy, fearing eavesdropping and mishandling of personal information. In contrast, sighted participants did not explicitly report similar concerns. This discrepancy may stem from sighted participants' ability to use multiple modalities (voice, touch, and visual) to monitor the system.

Previous studies have elaborated on the factors influencing user attitudes toward privacy (Kim; Ahmed et al.). Smart speakers often become a normalized part of daily routines, leading

users to become habituated to their presence and less aware of potential privacy risks (Brause and Blank). Users may experience a privacy paradox, where concerns about data privacy do not always translate into protective actions. This could be due to the perceived benefits, social pressures, or lack of understanding of risks (Barth and De Jong). Certain users tend to simply believe that major IT companies (e.g., Amazon, Google) will handle their information securely (Pridmore et al.), which leads them to lower their guard and reduce perceived risk and privacy concerns. This diminished caution can result in less proactive behavior regarding privacy. To address these issues, it is crucial to implement robust privacy features, such as accessible physical mute buttons and clear feedback on privacy settings. Increasing transparency about data handling can also build trust and alleviate privacy concerns for all users.

Conclusion

This study highlights how smart speakers impact user experiences across accessibility, effectiveness, enjoyment, efficiency, and privacy. For individuals with visual disabilities, smart speakers significantly enhance accessibility and satisfaction by enabling eyes-free, hands-free, voice-controlled interactions and fostering emotional connections. However, challenges remain with voice command recognition and privacy concerns. Sighted participants also benefit from smart speakers' multifunctionality but encounter difficulties with setup and advanced features. They appreciate the device's efficiency but face a learning curve, suggesting a need for better onboarding and feedback systems. Overall, these challenges can be addressed by enhancing voice command accuracy, integrating predictive features to anticipate user needs and actions, refining onboarding processes, and improving privacy controls.

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