Usability of Voice Assistants for People with Acquired Brain Injury

Summary of Research Studies

Overview

Voice Assistants (VAs), speech-operated smart assistants like Apple's Siri and Amazon's Alexa, offer the potential to support the everyday functioning of people with Acquired Brain Injury (ABI), bypassing some of the barriers related to currently used cognitive aids. Through their hands-free and eyes-free interaction of their voice user interface (VUI) they provide an alternative way to carry out functions associated with smart mobile devices and computers, thus increasing physical accessibility to different services.

Although the range of functions supported by VAs is very wide, research has shown that the majority of users use them for a limited number of activities, and their frequency of use and user satisfaction can be affected by several factors such as poor speech recognition, privacy concerns and increased mental workload. Additionally, their use in the context of brain injury rehabilitation has not been thoroughly examined in research.

To determine the situations where Voice Assistants can be beneficial for people with ABI and to investigate their usability and overall UX when used by people with cognitive impairments, the following studies were conducted:

- Study 4: a set of **online interviews** with people with ABI (n=10) who use VAs on a regular basis.
- Study 5: a **lab experiment** examining the usability of VAs for people with ABI (n=15), who were asked to use a VA to carry out different tasks and evaluate their experience.

Study 4

This study aimed to acquire information about how people with ABI use Voice Assistants, how they compare VAs to other tools, and what aspects of VAs they find particularly useful or problematic. A semi-structured approach was applied, focusing on: 1) the participant's background (their injury and its effects, and the type of cognitive aids/strategies used); 2) the use of VAs (how they use and experience the interaction with the technology); 3) ideas about potential VA features or applications that can benefit people with ABI.

The recorded data were analysed using Deductive Thematic Analysis, using codes based on the framework created by previous studies. The most common issues with VAs that participants mentioned were related to poor speech recognition, which, however can improve with time and was not regarded as an obstacle pre- venting their use. Another identified issue was the lack of knowledge of the technology's capabilities, mainly due to difficulties in discovering and learning additional features. Regarding privacy and security, although the participants expressed some concerns, they reported that they would be willing to share personal information through a VA for rehabilitation purposes. Privacy, however, can become an issue when using VAs to receive prompts containing sensitive personal information, if these can be heard by other people.

Based on the findings of this study, a set of use cases (situations where the use of VAs is appropriate and beneficial) was created:

Targeted Area	Use Cases
Prospective memory	Reminders, alarms and timers to remind users of upcoming tasks and events
Organisation	Calendar management, reminders, speech-based applications for applying problem solving strategies
Long term memory	Note taking, storing autobiographical memories, self monitoring
Inappropriate behaviour	Prompts to notify users when behaving inappropriately, reminders for relevant rehabilitation strategies
Initiation and motivation	Prompts to encourage activity, self-monitoring and rewards
Communication	Speaking practice and exercises, send/receive messages to/from carers, family members, therapists and other ABI survivors
Cognitive training	Speech-based cognitive rehabilitation exercises
Support from carers/family	Convey messages indirectly from carers/family, to reduce conflict and increase sense of self-dependence
Assessment	Monitor task completion and gather data to inform rehabilitation and therapy sessions
Accessibility of external aids	Provide alternative speech-based interaction method for currently used external aids
Efficiency of external aids	Encourage and facilitate use of other external aids

Study 5

This study aimed to further investigate how people with ABI experience the interaction with VAs in a wider range of tasks, examine the different factors that can affect the usability of VAs, and further explore how the design of a VUI can alleviate the impact of these factors.

During the study, the participants (n=15, people with ABI) were asked to use a Voice Assistant to carry out three sets of tasks, including the most popular tasks among users of VAs as identified in previous research. The tasks ranged from performing simple queries (e.g. asking for the weather) to more complex tasks requiring the exchange of information with the system in a conversational way. The participants evaluated their subjective evaluation of workload of each set of tasks through a NASA-TLX questionnaire. Finally, the participants filled in a User Experience Questionnaire (UEQ) to evaluate their overall experience of interacting with the VA.

Observational analysis was used to investigate the different issues that emerged during the participants' interaction with the VAs, identifying different types of user errors preventing successful task completion. Statistical analysis was used to examine the difference between the three sets of tasks, in the different types of errors identified, and the subjective workload.

Results

Errors which occurred due to participants using incorrect phrasing were generally more prominent than speech recognition errors, leading more often to unsuccessful task completion. The number of total errors, as well as the total workload in all three sets of tasks was generally lower in participants who reported using VAs more frequently, how- ever, there were no statistically significant differences between the two groups of participants. Moreover, the majority of participants had difficulties in completing tasks that required the use of features they were unfamiliar with, regardless of their experience with VAs.

A strong association was found between how participants evaluated the UX of the VA, and how cognitively demanding they perceived the tasks to be, indicating that, in order to improve the usability of VAs for people with ABI it is essential to reduce the complexity of the interaction. The different ways through which this can be achieved include adjusting the amount of conveyed information in the VA's responses to minimise memory load, and providing a more structured interaction where the input of information will be done in smaller chunks.

Finally, the findings of the study showed that, despite the associated challenges, training and experience of use can improve the usability of VAs for people with ABI, by increasing the efficiency of use and reducing the occurrence of different obstacles to successful task completion.

The results of the above studies were analysed to determine the different identified **factors that can affect the usability of VAs**, which designers of technology need to consider, when developing applications for people with ABI:

Factor	Impact on usability
Memory	Forgetting to use the VA Forgetting to carry out the task after receiving a reminder Unable to remember what a prompt is in reference to Forgetting trigger phrase, required keywords/phrases Forgetting how to structure queries/commands Unable to retain required information during input of single-utterance queries Unable to retain responses consisting of lists of items
Complexity of Interaction	Significant association between cognitive difficulties and perceived mental demand Subjective workload affects evaluation of user experience User errors are more often in tasks with longer interactions Input errors are more often in long, single-utterance commands Editing information that has already been inserted is challenging Users prefer to use visual interaction for more complex tasks
Speech Recognition	Can cause frustration Can result in input of incorrect information Common, but does not prevent people with ABI from using VAs Frequency of speech recognition errors can decrease over time Errors due to incorrect phrasing (not knowing how to structure query) are more frequent, but can be prevented with training Single-utterance input is more prone to S.R. errors Speech difficulties can improve over time Users with mild speech impairments can also benefit from VAs
Lack of Motivation/Self Awareness	Not reacting to prompts/notifications Not initiating interaction with system Not recognising the system's benefit Not realising the need for provided support
Change in Abilities	Cognitive functioning can improve during recovery Cognitive performance can fluctuate due to fatigue
Learning Difficulties	Inability to search new features Forgetting how to use them after a certain period Experience does not help with successful completion of unknown tasks
Lack of Portability	Inability to use outside the house (smart speakers) Missing prompts when not in proximity of speaker
Privacy and Security	Security concerns exist, but would not prevent sharing of personal information if adequately informed about data usage Privacy issues when used in front of others