2018
THE JOURNAL ON TECHNOLOGY AND PERSONS WITH DISABILITIES

# Smart Speaker Usability by Military Service Members with mTBI and PTSD

Tracey Wallace, John T. Morris

Rehabilitation Engineering Research Center for Community Living, Health and Function (LiveWell RERC), Shepherd Center

tracey.wallace@shepherd.org, john.morris@shepherd.org

## Abstract

This paper describes the research protocol and results from exploratory usability testing of Amazon Echo and Google Home, voice-activated smart speakers, by military service members with mild traumatic brain injury (mTBI) and post-traumatic stress disorder (PTSD). Usability testing of emerging technology by people with disabilities is critical to gain insight into accessibility of the product design as well as to identify use cases and opportunities the product may offer as an assistive technology. This study was conducted with 12 U.S. military veterans and service members with mTBI and PTSD, all of whom were receiving comprehensive rehabilitation services in the SHARE Military Initiative at Shepherd Center in Atlanta, Georgia, USA. Devices were installed in the temporary residences provided to the participants during their participation in the SHARE program. Participants tested each device for 2 weeks and completed electronic diary entries about their experience. Following study completion participants completed a summative interview about their experience which detailed preferences and usability challenges and identified opportunities for development of in-home smart home speaker assistive technology solutions for this population.

## Keywords

Brain injury, stress, smart speaker. assistive technology, usability, military

## Introduction

Smart speakers, such as Amazon Echo and Google Home, are among a budding group of emerging consumer electronics that offers potential as assistive technology (AT) for people with disabilities. Smart home technologies, including speakers, plugs, appliances and other Internet of Things (IoT) Wi-Fi and Bluetooth connected home technologies, provide multiple ways to collect and retrieve data and control the home environment. Usability testing with people with disabilities is a critical step both in understanding the accessibility of a product's design as well as in identifying use cases and opportunities the product may offer as AT.

Amazon Echo and Google Home are internet connected, voice-activated smart speakers that provide users with hands-free access to voice-controlled intelligent personal assistants (i.e., Amazon's Alexa and Google Assistant). These digital assistants provide information, play music, audiobooks and podcasts, set timers and alarms, integrate with to-do lists and calendars, and allow users to control smart home devices through voice commands. The functionality of the smart speakers can be expanded through enabling or linking applications or "apps"; Amazon Echo apps are called "skills". Since these technologies are intended to aid users, they are logical candidates as AT for a variety of populations.

Post-traumatic stress disorder (PTSD) and mild traumatic brain injury (mTBI), both of which can impact independent living and quality of life, are conditions frequently experienced by military service members returning from recent conflicts in the Middle East (Tschiffely, et al. 2015). Common features of PTSD include anxiety, avoidance, hyper-vigilance or instances of re-experiencing a traumatic event (American Psychiatric Association 2013). People with persistent mTBI symptoms often report experiencing challenges with memory, attention, executive functioning, pain and dizziness. Those who experience both PTSD and persistent symptoms of

mTBI commonly report depression and emotional disturbances in addition to significant challenges managing symptoms of each condition (Tanielian, et al. 2008, Chen, et al. 2011).

While smart speakers may have potential for use as AT by service members with mTBI and PTSD, the usability of these devices and user-preferences in this population is not fully known. A literature review of publications investigating the usability of Echo and Home by users with cognitive and psychological disability yielded limited results, and none of them addressed usability by military service members with TBI and PTSD. A few popular science media outlets have reported that smart speakers are being adopted by some older adults to reduce loneliness, provide supportive reminders, simplify access to audiobooks and offer those with tremors or arthritis a hands-free method of accessing the Web (Woyke 2017, Persuading Your Older Parents 2017, Amazon Echo for Dementia 2017). The opportunities smart speakers might offer to people with disabilities may be attenuated by accessibility and design barriers, especially since rapid advances in technological innovation often lead to frequent redesigns and releases of new generations (Wentz and Lazar 2016; Schroeder and Burton 2010). Systematic assessment of the usability of smart speakers by people with disabilities is needed to help designers and developers ensure equitable access to these technologies as well as inform and guide consumers.

**Discussion**

An in-home usability diary study of Amazon Echo and Google Home smart speakers was conducted with 12 military service members with mTBI and PTSD. Electronic diary entries were used to gather information about usability, user preferences and potential for development of new apps or skills to increase the role of smart speakers as AT in military service members with mTBI and PTSD.

Participants were recruited from the SHARE Military Initiative program, a comprehensive outpatient day rehabilitation program for military service members with mTBI and PTSD at Shepherd Center, a rehabilitation hospital in Atlanta, Georgia. Purposive sampling was utilized to identify participants with mTBI and PTSD who were smartphone users with functional language, speech, hearing and vision. A psychologist and speech-language pathologist in the SHARE Military Initiative assisted the research team with identification of appropriate candidates for the technology testing. Sixteen potential participants were identified; two declined to participate in the study. Of the two that declined, one reported reluctance to having a speaker in his apartment that was "listening to everything" while the other stated he was "not big on technology" because he felt learning to use new technology was frustrating. In total, 14 participants were enrolled in the study; however, two participants discharged from the therapy program before they could complete the study.

Twelve participants, 11 males and 1 female, completed the study. Average age of participant was 45 (ranging from 30 to 57 years) and average time since initial onset of injury was 17 years (ranging from 1.25 to 37 years). All reported one or more trauma events resulting in PTSD and persistent symptoms attributed to mTBI. Many reported experiencing multiple mTBI, most of which were caused by blast exposure, falls or motor vehicle accidents. Several also reported sustaining an initial mTBI during youth, either through sports or violence/abuse. Most participants stated they experienced long-term ongoing difficulties with anger, aggression, anxiety, depression, isolation, memory, attention and pain. Information on each participant's prior experience with computers and smart technology was collected prior to initiation of technology testing (Table 1).

Table 1. Participants' experience with and use of technology (n=12).

| **Do you use any of the following on a regular basis?** | **Percent of participants who responded "Yes"** |
|---|---|
| Smartphone | 100% |
| Laptop or desktop computer | 67% |
| Tablet | 42% |
| Fitness Tracker | 42% |
| Smartwatch | 17% |
| Regular cellphone | 8% |
| Smart plug | 8% |
| Amazon Echo, Dot or Tap | 8% |
| Google Home | 0% |
| Smart home appliance, security or thermostat | 0% |
| Mp3 player (separate from another device) | 0% |
| Google Glass | 0% |

Testing took place in apartments provided by Shepherd Center, where clients live while they participate in the SHARE Military Initiative rehabilitation program. Participants tested each smart speaker, either Amazon Echo or Google Home, for 2-weeks. This resulted in a total of 4 weeks of testing of the 2 devices per participant. Using a cross-over design to minimize bias related to which smart speaker was experienced first, we asked half of the participants to test Echo first and half to test Home first. Each participant was also given 2 TP-Link mini-smart plugs. Ten of the 12 participants used the smart plugs to control one or two lamps in their apartment, and one participant also used a smart plug to add voice and scheduling options for turning off the television. Two of the 12 participants declined use of the smart plugs, both reporting it felt overwhelming to learn two new technologies at one time. Participants were asked to set up the technology (smart speakers and smart plugs) in their apartments and were provided

assistance if they were unsuccessful. They then completed one-on-one interviewing regarding their experience setting up each device.

Following device setup, participants tested each smart speaker for 2 weeks and were asked to complete electronic diary entries about their experience twice weekly. Collection of this information proved to be challenging as most participants completed on average only one diary weekly, despite email reminders and in-person encouragement from one of the researchers with the therapy clinic. Each participant also completed a summative interview about their experience at the end of testing. A combination of closed set questions (including use of a 5-point Likert scale ranging from "very hard" to "very easy" for usability questions) and open-ended questions (such as "What did you like most?", "What would you change?" or "What did you find most useful?") were used in both the electronic diary entry and the summative interview. The aim was to identify preferences and usability challenges to inform development of in-home smart home speaker assistive technology solutions for this population.

**Results**

Most users reported both Amazon Echo and Google Home were easy to setup. Although, 91% reported Echo was either "easy" or "very easy" to set up while only 52% reported Home was either "easy" or "very easy" to set up (see Table 2). Likewise, half of the participants required assistance to set up the Echo devices while two-thirds required assistance to set up the Home devices (see Table 2). The disparity in reports regarding ease of setup is likely attributed, at least in part, to difficulties some users experienced connecting to the Wi-Fi network maintained by Shepherd Center which required 2-step authentication of devices and did not consistently permit attempts to connect to Google Home.

Fifty percent of participants reported the TP-Link smart plugs were either “easy” or “very easy” to set up with Echo while only 30% reported the TP-Link smart plugs were either “easy” or “very easy” to set up with Home. Yet, a greater number of participants reported they required assistance to set up the smart plugs with Echo (55%) than with Home (45%).

When either Echo or Home are plugged in for the first time, the smart speaker prompts the user to download and install an app (either the Alexa app or Google Home app) on their smartphone which then guides the user to complete setup of the speaker. The apps are later used to add smart speaker apps, or enable “skills” as Amazon calls them, as well as connect to smart home devices (such as the TP-Link smart plugs) and access lists created with the speaker. The TP-Link smart plugs are also setup by downloading an app (the Kasa app) and then following the prompts in the app. Several participants stated they would have preferred to have had written instructions with pictures and/or video to guide set up of all of the devices in addition to the guidance provided by the smartphone apps. And one user reported significant anxiety regarding the inability to see how many steps were required to complete the setup of the smart speakers, reporting he did know if the setup would be completed in “2 minutes or 2 hours”.

Table 2. User assessment of the setup process for Amazon Echo and Google Home and connection to TP-Link smart plugs

| **Questions** | **Amazon Echo** | **Google Home** |
|---|---|---|
| How easy/hard was it to set up each device? | Easy or very easy – 91% | Easy or very easy – 52% |
| Did you require assistance to set up the device? | 50% | 66% |
| How easy/hard was it to set up smart plugs with each device? | Easy or very easy – 50% | Easy or very easy – 30% |
| Did you require assistance to set up the smart plugs with the device? | 55% | 45% |

During and after the two-week trial using each smart speaker, 76% of participants reported Amazon Echo was easy to use compared to 65% for Google Home. One participant reported difficulty manually controlling the volume on Google Home, which requires fine motor use of a finger to swipe clockwise or counter clockwise on the top of the device. Another reported challenges with using the timers on both smart speakers, stating that some of the timers he set never went off and on occasions when a timer he set did go off, he did not always notice the timer alert until long after it went off because he was outside, in another room, in the shower, etc. However, several other participants reported high satisfaction with use of the timers on both devices and reported the timer was one of the most useful features. About halfway through study, the Echo received a software update from Amazon that allowed users to begin to label timers, a feature the study participants had already reported as desirable to help them recall what the timer was for and to distinguish multiple different timers.

Participants reported Home correctly understood their voice commands more often than Echo, rating Home at an average of 87% accuracy versus Echo at 80% accuracy. Despite high accuracy ratings, some participants expressed frustration with voice recognition and difficulty recalling specific wording required in some instances for the smart speakers to execute the commands. Participants reported a slight preference for Home's voice, rating it at average of 7.1/10 versus Echo's at 6.9/10. However, they collectively preferred the look and aesthetic design of Echo, giving it a 7.6/10 versus a 6.4/10 for Home. Interestingly, at study conclusion, 9 of the 12 participants stated they preferred Amazon Echo overall to Google Home. Qualatiative analysis of participant feedback revealed this may have been attributed to a number of factors including: 1) more intuitive navigation and clear labeling of functions within the Alexa App, 2) less fine motor control required for manual adjustment of volume of Echo than Home, and 3)

greater personal connection with Echo felt by some due to use of a humanizing wake word for Echo ("Alexa", a person's name) versus Home ("OK Google" or "Hey Google").

All participants reported the smart speakers were useful in their daily life. They described a variety of functions they performed with both devices. Most of the participants used the smart speakers to stream music or play calming sounds, which many found aided them in relaxing, especially when attempting to wind down before sleep. Other functions commonly performed by participants included turning lamps off or on (with connected smart plugs), asking for information (e.g., the time, date, weather or sports scores) and using timers, alerts or calendar integration to recall and complete planned tasks. Several participants reported they sometimes interacted with the smart speaker for companionship, usually by asking interesting questions or requesting a joke or a story. When describing his experience with the smart speakers, one participant stated, "It was like having a personal assistant and sometimes a companion." Another participant said having a smart speaker "provided an unexpected sense of comfort," while another stated it made him "feel not so alone." All participants reported they would be very likely to continue to use one of the smart speakers at study conclusion.

When asked about what they wished the smart speakers could do, trends were evident in requests for more support for relaxation, memory and communication and sharing of important information with family and caregivers. A need for increased customizability when setting calendar events, reminders and alerts was reported, although greater current functionality in this area was reported for Echo versus Home. One participant also reported a desire to be able to choose from a selection of smart assistant voices, stating that some voices are more relaxing and easier to listen to than others. Several participants reported a desire for more integration with

their smartphones and other technology in the home as well as functionality reliant on increased artificial intelligence and contextual awareness.

**Conclusions**

This study discovered some insights into smart speaker usability and the needs of military service members with PTSD and mTBI, and it supports conducting further exploration of usability challenges of smart speakers for this population.. Overall, most participants found both devices easy to use, which is critical for populations who may experience challenges with learning to use new technology and with handling stress associated with using technology perceived to be hard to use. All participants found both devices useful for helping them perform daily tasks and many reported the smart speakers provided them assistance with managing mTBI and PTSD related cognitive challenges and stress.

Several design opportunities were uncovered which could increase the usability of smart speakers for this population and possibly other similar populations. Changing the manual control feature on Google Home to require less fine motor coordination may be helpful. And for both Home and Echo usability could be elevated by providing written instructions for set up and use, improving the labeling and intuitive design of the companion apps, simplifying the process of adding apps and functionality, improving voice recognition and expanding the customizability of calendar and reminder features.

Rehabilitation clinicians and AT specialists should consider the usability and capabilities of smart speakers and connected home devices when feature matching to identify technologies they recommend for use by their patients. In instances when rehabilitation professionals recommend smart speakers and other smart home device options for this population, they should consider providing adequate support for set up of the devices as well as for learning to use them

effectively. Finally, the results of this study imply designers and developers should consider exploring opportunities to further develop the assistive capabilities of smart speakers. For this population, in particular, they should explore opportunities to further develop the capacity of smart speakers to provide support for memory and stress management as well as companionship.

**Acknowledgement**

This exploration and discovery research was supported by the Rehabilitation Engineering Research Center for Community Living, Health and Function (LiveWell RERC), which is funded by the National Institute on Disability, Independent Living and Rehabilitation Research (NIDILRR) of the United States Department of Health and Human Services, grant number 90RE5023. The analysis and opinions contained in this article are those of the authors, and do not necessarily reflect those of NIDILRR or the U.S. Department of Health and Human Services.

**Works Cited**

"Amazon Echo for Dementia: Technology for Seniors." *Daily Caring*, www.dailycaring.com/amazon-echo-for-dementia-technology-for-seniors/ Accessed 22 Nov.2017.

American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorder*. 5th ed. American Psychiatric Publishing, 2013, pp. 271–280.

Capan, Faruk. "Why Amazon Device Is a Gift for Healthcare." Medical Marketing & Media, vol. 51, no. 1, Jan. 2016, p. 20.

Chen, Yun, Huang, Wei (July 2011). "Non-impact, blast-induced, mild TBI and PTSD: Concepts and caveats." *Brain Injury*. 25(7-8): 641-650.

McGregor, J. "An Honest Review of Google Home and Amazon's Alexa." *Forbes*. (April 10, 2017). www.forbes.com/sites/jaymcgregor/2017/04/11/an-honest-review-of-google-home-and-amazons-alexa/#21177a5d5fd4. Accessed June 12, 2017.

"Persuading Your Older Parents to Take the Smart Home Leap." *CNET*, www.cnet.com/news/how-to-have-the-tech-talk-with-your-aging-parents/. Accessed 22 Nov. 2017.

Schroeder, P. and Burton, D. "Microsoft Backtracks on Accessibility in New Mobile Operating System, Commits to Accessibility in Future Windows Phone Platform." Access World, 11, 8, 2010. Web. 27 April 2016.

St. John, A. "Amazon Echo Voice Commands Offer Big Benefits to Users with Disabilities" *Consumer Reports*. (January 20, 2017). www.consumerreports.org/amazon/amazon-echo-voice-commands-offer-big-benefits-to-users-with-disabilities/. Access Accessed June 12, 2017.

Stinson, L. "Alexa is Conquering the World. Now Amazon's Real Challenge Begins" *Wired*. (January 18, 2017). Accessed June 12, 2017.

Tanielian, T and Jaycox, L.H. (Eds.). Invisible Wounds of War: Psychological and Cognitive Injuries, Their Consequences, and Services to Assist Recovery. RAND Corporation Center for Military Health Policy Research, 2018, pp. 35-82.

Tschiffely, A.E., Ahlers, S.T. and Norris, J.N. "Examining The Relationship Between Blast-Induced Mild Traumatic Brain Injury And Posttraumatic Stress-Related Traits." *Journal Of Neuroscience Research* 93.12 (2015): 1769-1777.

Wentz, Brian, Lazar, Jonathan. (2016). "Exploring the Impact of Inaccessible Redesign and Updates." Designing Around People. Ed. Pat Langdon, et al. London: Springer, 2016. 3-12. Print.

Woyke, Elizabeth. "The Octogenarians Who Love Amazon's Alexa." MIT Technology Review, vol. 120, no. 5, Sep/Oct2017, p. 17.