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Smart Home Stress Assist: A Real-Time Intervention for PTSD

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Abstract

This paper details the development and initial testing of Smart Home Stress Assist (SHSA), a real-time intervention strategy for military service members with mild traumatic brain injury (mTBI) and post-traumatic stress disorder (PTSD). Military service members affected by mTBI and PTSD are often taught evidence-based strategies such as grounding, deep breathing, and meditation to manage symptoms associated with physical and psychological trauma. However, many experience barriers to using these strategies in times of stress due to challenges with recalling and initiating the multiple steps in the strategies. SHSA was developed to help alleviate some of these challenges. SHSA uses the Amazon Echo and smart home technologies to provide automated support for implementing grounding strategies by changing a user's physical environment (e.g., light, temperature, sound and smell) to help them reconnect with the present moment. Additionally, pre-recorded audio files (e.g. calming music or a family member reminding the user they are safe), preset SMS messages, and cues to use other stress management strategies are provided in an aim to reduce the intensity of the stress episode. Preliminary sit-by user testing demonstrated acceptance within the target population. Additional testing is planned following completion of updates to the system based on user feedback.

Keywords

Brain Injuries; Stress Disorders, Post-Traumatic; Smart Home; Assistive Technology

Introduction

Hundreds of thousands of United States military service members have been affected by traumatic brain injury (TBI) and post-traumatic stress disorder (PTSD) (Defense and Veterans Brain Injury Center 2017, Analysis of VA Health Care 2014, Lindquist, et al. 2017, Jones, et al. 2010, Brickell et al. 2019). Individuals with PTSD report symptoms associated with anxiety, heightened sensitivity (startle response and perceived threats), and emotion regulation (American Psychiatric Association 2013). Those with mild traumatic brain injury (mTBI) often report physical, cognitive and behavioral side effects. Co-occurring PTSD and TBI can increase symptom effects and decrease independent functioning, participation and quality of life (Tschiffely, et al. 2015). Evidence-based strategies such as grounding, deep relaxation breathing, and meditation are used to help manage symptoms of both PTSD and mTBI. These strategies are designed to assist with stress management and not only help to calm a person but can also help them reconnect with reality to avoid re-experiencing past trauma and pain (Brown et al. 2013, O'Donohue et al. 2009, Ursano et al. 2004, VA/DoD 2010, Morris et al. 2018, Wallace et al. 2017).

Smart Home Stress Assist (SHSA) implements the principles of psychological "grounding" by using a smart speaker hub and home automation devices to control environmental conditions that help manage the onset and effects of stress episodes. While there are a variety of smartphone and watch apps associated with symptom management (e.g. Calm, PTSD Coach, BreatheWell Wear), people with PTSD and mTBI report challenges using existing solutions, and gaps in care remain (Wallace et al. 2017). Problems with executive dysfunction and memory cause barriers to learning to use and initiating assistive tools effectively (Haskins, et al., 2011; Sohlberg & Turkstra, 2011). This is especially true regarding the multistep processes

associated with initiating integrated grounding strategies, which require reconfiguring the environment, initiating strategies and communicating needs to a caregiver. The aim of this project was to develop and test SHSA, an integrated hardware and software technology solution for managing episodes of extreme stress, based on standard care for treating veterans with mTBI and PTSD, through innovative control of smart home devices.

Discussion

Development of SHSA is founded on evidence-based clinical practice and research at Shepherd Center's SHARE Military Initiative, Atlanta, GA and employs user-centered design principles by including target users throughout the design process (Luna at al., 2015; International Organization for Standardization, 2019). Thirteen military veterans with PTSD and mTBI and 3 healthcare providers of veterans with PTSD and mTBI contributed to the development via interviews, sit-by demonstrations and take-home testing.

SHSA is intended to be invoked when a user becomes stressed and at risk of having a dissociative episode (disconnection between thoughts and actions caused by recall of traumatic events). SHSA is an Amazon Echo skill activated by saying a pre-defined phrase. When activated (Fig. 1): 1) Smart devices adjust to preconfigured settings to change the environment (e.g. lights may dim, change color, turn off/on, room temperature adjusts, etc.), 2) Pre-defined SMS message is sent to alert caregivers the system has been activated, 3) Pre-recorded audio files play through the Echo speaker (e.g. recordings of family member, favorite calming song), and 4) Additional grounding strategies are suggested to the user (e.g. deep breathing, other favorite tools). These functions help to "ground" the user by reminding them they are at home and in a safe environment, specifically by changing the physical environment by manipulating audio, visual, environmental, and scents.

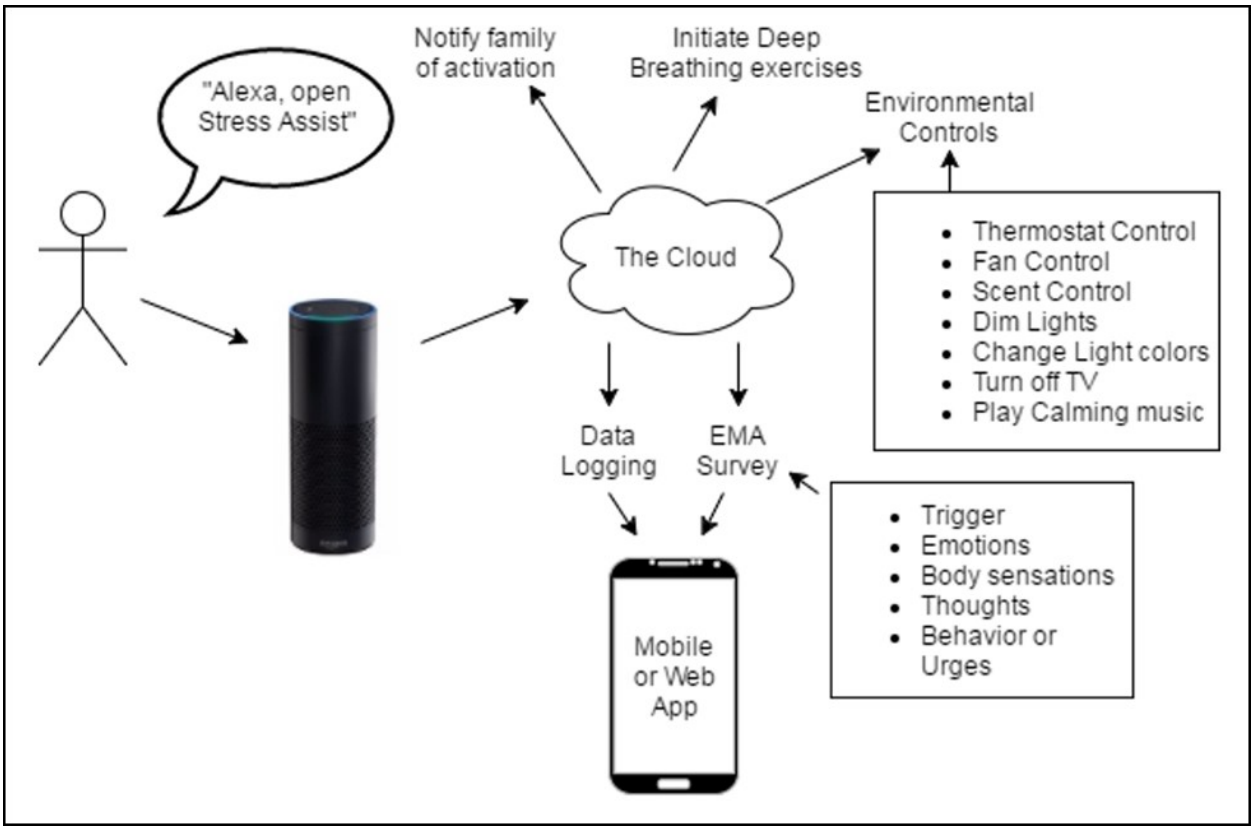

Fig. 1. SHSA Example Feature Options and Data Flow (including features under development).

Development

SHSA uses the Amazon Echo and Samsung SmartThings Platform to control a variety of user-selected Internet of Things (IoT) devices (e.g. outlets, bulbs, etc.). Smart speakers and other IoT provided a unique opportunity to utilize a systems level approach to create a fully customizable voice activated intervention strategy. Prior work investigating smart speaker usability by this population indicated the Amazon Echo would be an appropriate platform for development (Wallace & Morris 2018a, 2018b, 2019). At the start of the project, the Amazon Echo was the only speaker available that allowed for third party development. SmartThings was utilized as a centralized hub to control the IoT devices. SmartThings also allowed for streamlined development of a user customized Smart App and communication to the Echo device via their online integrated development environment (IDE). This user customization is a critical system

feature as it allows for users to create a system unique to their needs. The SmartThings applet allows for third party development and specific task creation within SmartThings.

Initial concept design was informed by a clinician with expertise in mTBI cognitive rehabilitation in collaboration with a psychologist with expertise in PTSD treatment. Interviews were conducted with 12 veterans with TBI and PTSD to gather additional input on the concept and proposed design. All 12 participants reported use of grounding strategies to manage PTSD symptoms. Participants were shown a pictorial description of the prototype and asked whether the proposed system was “worth developing” all 12 responded “yes”. When asked whether they felt a system like SHSA could help them, again all 12 responded “yes”.

Testing

Testing of a working prototype was completed with one target end user, a 47-year-old male veteran with chronic PTSD and mTBI, and a neuropsychologist specialized in TBI and PTSD treatment. Feedback was collected in the form of 60-minute sit-by interviews that incorporated demonstrations and discussions with the development team. Additional background information was collected on the target end user (Table 1) to better understand his use of technology.

Table 1. Background information on target end user.

Question	**Response**
What challenges do you face living with your injuries?	Can’t work, relationship, balance, health, memory, word finding, mobility, and sleep problems, recurrent headaches, nightmares, stress, anxiety, avoidance, paranoia, past suicidal ideation
What technologies do you use on a regular basis?	Laptop, iPad (occasionally), iOS smartphone, Fitbit, Amazon Echo

Question	**Response**
What do you use the technology to do?	Alarm reminders, track calories, track sleep, track walking distance, play music, read news, research, find activities in the community, buy event tickets, scheduling, restaurant reservations, write poetry and book, help kids with homework, publish journal articles, communicate with friends all around the world, watch TV shows
What do you wish you have technologies to help you do?	Walk longer/farther/faster, shopping, interpersonal skills, security things (lock the house, know if I locked my car), find things
What apps or other technologies do you use to help manage stress?	Meditation Timer app, BreatheWell Wear app, Blood pressure monitoring (digital)
Do you use grounding as a technique to manage stress?	Yes, I use visualization, ground through my feet and count colors in the room
How often do you use grounding for relaxation?	Three times / day
How helpful is grounding for relaxation? (1=low, 10=high)	6 or 7
How well do you feel you use the technique? (1=low, 10=high)	9, I have a lot of practice

The neuropsychologist stated he would recommend the system to patients, and the target user stated he felt it was something that could help during times of stress. Both individuals suggested additional population areas that could find this system useful (Table 2a).

Table 2a. What are your overall impressions of the Stress Assist Solution?

What are your overall impressions of the Stress Assist Solution?
I would recommend it as a clinician.
It’s a neat idea. I think it’s something that could help me.
There are other people, like women with postpartum depression, who are also home a lot and could use something like this.

Concerns included complexity of technology setup, length of activation, and messages to family members. Specifically, both individuals reiterated the need for a fully customizable

solution, allowing for changes in grounding strategies and length of activation (Table 2b). Overall, feedback from testers was positive, and concerns and ideas shared will be used to direct the future development.

Table 2b. How can we improve the solution?

How can we improve the solution?
Contacting a family member is good, but there should be some education or choices in the settings around contact, so the family has guidance about what they are supposed to do if they are notified that the solution was used.
Complexity of setup may be a problem. Depending on length of setup time and number of steps some individuals in the target population might have difficulties.
Add customization for how long the solution and adjustments are activated (i.e. how long the room changes color, etc.)
There could be some problems if other people are in the room during a stress episode, so someone may want to activate the system, but not want the entire room to change for everyone. It could help if the user could have the option to just be guided through specific grounding strategies on their phone companion app but not activate the environmental changes in that situation.
I would want it to have voice guided meditation. I would also want to be able to give input about whether we are on the right track to help me calm down and if it's not working or I'm just not digging it, it could offer me to do something else.

Both were in favor of development of additional functionality including the integration of other strategies, such as meditation and the addition of a stress diary to allow the user to record and share important details related to stress events (Table 2c). The neuropsychologist provided recommendations about the timing of diary activation, while the targeted end user expressed interest in answering the diary via different modalities, such as through text or voice.

Table 2c. Would it be helpful for the user to receive a notification to complete a diary of what they were thinking, feeling, etc. when they activate the solution?

Would it be helpful for the user to receive a notification to complete a diary of what they were thinking, feeling, etc., when they activate the solution?	**Comment**
Yes	Absolutely. The diary record would be very useful in psychotherapy sessions. Having an option to do it through guided voice entry would be great. Notification to complete the diary should occur in 10 minutes or less after activation.
Yes	It would be very helpful. And it will be important to have the option to do other stress interventions guided by Alexa or through my phone but prompted and activated by Alexa. Sometimes I might rather type. But sometimes I might rather talk.

Conclusion

The Amazon Echo has garnered attention within healthcare and disablity communities for its assistive and accessibility capabilities and for its prospect for use as assistive technology (Healthcare Technology Today 2018, St. John 2017, Capan 2016). The potential for smart speaker soultions to support people with disabilities will likely be maximized through design that effectively reduces the phsyical or cognitive burden required to operate the solution (Sohlberg & Turkstra 2011, International Organization for Standardization 2019). The main purpose of developing the SHSA system was to provide an easy way to setup a physical environment and provide auditory cues for grounding a user via smart speaker. While this will likely be the targeted feature used by many users, we anticipate acceptance and adoption of other stress management strategies to be used in conjunction with environmental control. Based on our initial user testing and sit-by interviews, targeted users are also interested in deep breathing, meditation, and a user stress diary.

Development centered around user customization, privacy, and stress diary recording is planned based on feedback obtained as well as internal technology reviews. Prior work developing SwapMyMood, an iOS mobile app designed to assist people with brain injury to engage in problem solving and emotion regulation, will be leveraged in the creation of the user stress diary (Morris & Wallace, 2019). Pattern recognition and machine learning will be used to provide intervention suggestions for strategy use based on reported content (e.g. how they are feeling, what they were doing) and other identifiable variables (e.g. time of day, weather, etc.). The diary will also be easily shared with providers so users can receive direction from clinical providers as well.

Due to the sensitive nature of psychological stress episodes, the validity of the system will be evaluated with extended user testing to ensure end users receive appropriate supports. Specifically, we are working with neuropsychologists and targeted end users to create an approach that is appropriate and customizable. At this time the system is intended to be used under the guidance of a clinical professional, such as a behavioral health specialist, whom can provide support for proper identification of grounding strategies and environmental setup.

While the platforms used allowed for the creation of the desired system and resulted in positive feedback from both a clinician and target end user, there are limitations associated with longevity and wide scale distribution. The next phase of development will involve transferring all SmartThings functionality to the recently released Echo Hub. Additionally, a custom mobile app that connects directly to the Alexa skill will be developed to ensure distribution availability and ease of use. Additional testing is planned with target end users in the form of sit-by interviews and take-home testing.

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