EyeRemember: Memory Aid App for Google Glass

Tracey Wallace, MS, John T. Morris, PhD, Scott Bradshaw, BSCS

Rehabilitation Engineering Research Center for Wireless Technologies, Shepherd Center

Tracey_Wallace@shepherd.org, John_Morris@shepherd.org, swbradshaw@gmail.com

Abstract

Changes in memory are one of the most frequently reported cognitive deficits among people with traumatic brain injury (TBI) and are one of the factors with the greatest impact on independence and quality of life following injury. Evidence supports the use of external aids in the treatment of memory impairments in adults following TBI. This article describes the development and initial user-testing of a mobile app designed to run on Google Glass to serve as an external memory aid for people recovering from and living with TBI. The app works in conjunction with Bluetooth low energy (BLE) beacons, small transmitters about the size of an automobile key fob, that are carried by friends and family of the person with TBI. Results from this research and development effort show considerable receptivity on the part of individuals with TBI, their family and therapists for a Glass-based memory aid using Bluetooth beacons. Continued development of the Glass platform and beacon technology is needed to support easier adoption and use. Knowledge and experience gained throughout the research will inform development of future accessible wearable technologies and apps.

Keywords

Memory, brain injury, wearable technology, Google Glass, Bluetooth low energy beacon

Introduction

Changes in memory are one of the most frequently reported cognitive deficits among people with brain injury (TBI) and are one of the factors with the greatest impact on independence and quality of life following injury (Mateer, Sohlberg & Crinean 1987). Memory impairments can rob a person of their independence and negatively impact social relationships, thereby reducing the quality and quantity of their participation in meaningful activities at home, work, school, or in their community. Mobile apps on smart devices, including new wearable devices, may help people compensate for memory deficits.

Systematic reviews of the literature have generated guidelines for treating memory after traumatic brain injury (TBI). In 2007 the Academy of Neurologic Communication Disorders & Sciences recommended the use of "external aids in the treatment of memory impairments as a rehabilitation practice guideline for adults with memory impairment following TBI" (Sohlberg, et al. 2007). More recently, the Cognitive Rehabilitation Task Force of the Brain Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine published a Cognitive Rehabilitation Manual containing a similar practice guideline. It states, "For those with moderate to severe memory impairment, the committee recommends only the use of external compensations (including notebooks, electronic devices, etc.) with direct application to functional activities" (Haskins 2011). This manual also contains a practice standard recommending the use of external memory compensations for people with mild memory impairment.

The use of external aids is a widely practiced means of compensating for memory impairments. Memory notebooks, pill boxes and alarm watches are described in the literature as successful low tech options, while voice recorders, PDAs and pagers are common high tech devices. More recently, the evolution of smartphones and tablet computers, has opened the door

to new opportunities for using memory aids (Kim, et al. 2000; Wade and Troy 2001; Dry, et al. 2006; McDonald, et al. 2011). The emergence of downloadable applications, "apps", has increased the functionality of mobile devices. Widespread consumer use makes this technology more socially accepted and more available. Many people own wireless technology that can be incorporated into therapy with little delay, potentially relieving some of the financial restrictions and other barriers that sometimes impede interventions using external aids.

The recent proliferation of wearable technology, especially glasses and wristwatches, offers the prospect for even more choice for people needing memory aids. The wearable design of these platforms could make memory aids more usable and useful. Using these devices, the person with a memory deficit will have information readily available, rather than having to pull out and activate a smartphone or other mobile device that is carried rather than worn.

This article describes the development and initial user-testing of EyeRemember, an app designed for Google Glass to serve as an external memory aid for people living with TBI. The app works in conjunction with Bluetooth low energy (BLE) beacons, small transmitters about the size of an automobile key fob carried by friends and family of the person with TBI. Research and development occurred in distinct phases: 1) initial specification of a Glass-based solution for memory app; 2) development of a working prototype; 3) focus group and in-depth interviews with stakeholders; 4) incorporation of feedback into the beta version of the EyeRemember app.

Discussion

Google Glass was chosen as the development platform because its head mounted wearable display is designed for brief reference and immediate access to information with minimal interruption to ongoing social interactions. It provides both visual feedback via its small prism display, and auditory feedback via the bone-conducting speaker built into the right temple of the frame. Out-of-the-box functions include picture taking, video recording, Google

web search, email, phone calling, text messaging, and direction finding. Many functions require

a Wi-Fi connection or Bluetooth pairing to a user's smartphone. The functionality of Glass can

be enhanced with downloadable apps known as Glassware.

Development of the EyeRemember app

The development team was awarded a competitive grant for initial development through

Google's Glass Accessibility Awards program in May 2014. Additional support was provided

by the Rehabilitation Engineering Research Center for Wireless Technologies (Wireless RERC,

Grant number H133E110002), funded by the National Institute on Disability and Rehabilitation

Research (NIDRR).

Glass and BLE beacons are both emerging technologies undergoing continued

development. Neither has been well studied as assistive technology for people with TBI. The

accessibility features of Glass make it attractive as a possible platform to perform assistive

functions to users, especially users with disabilities. The design of the current version of Glass

permits many functions to be completed hands-free with visual and/or auditory prompting to

access context-specific information at a glance, with minimal interruption to ongoing activities

and conversations, allowing the user to stay in the moment. Input options include the use of

hand/finger swipes and taps on a trackpad, head movements, eye winking and voice input.

Visual outputs on the screen are complemented by audio outputs through a bone-conduction

speaker (and optional earphone) which includes chime notification sounds and voicing of text on

the screen. It has numerous sensors built into the compact enclosure on the right temple,

including gyroscope, accelerometer, rotation vector, light sensor, and linear acceleration sensor.

Initial specifications and design concept of a Glass-based memory app were influenced

by the existing evidence base on the use of high-tech assistive devices and apps used to support

memory, the clinically relevant experience of team members, and Glass features and

functionality. End-user input was gathered after this initial design stage. The novelty of Glass made it necessary to build a working prototype of the memory app first in order to be able to demonstrate how a Glass-based memory aid would function.

EyeRemember Architecture

The EyeRemember app was developed to help people with memory deficits after TBI by allowing them to voice-record important information related to individuals in their circle of family, friends and caregivers (referred to as "contacts" in EyeRemember). Users are reminded of the recorded information through cued prompts presented when contacts are present and by scrolling through a "timeline" of "cards" containing the information. Contacts are pre-populated into the app using the camera and voice input functionality on Glass. Each contact is associated with a specific Bluetooth low energy beacon, which is clipped onto key rings or belt loops and carried or worn by the person represented by the "contact card." Initial setup for each contact also includes a field for identifying the relationship of the person to the user. Once setup of a contact is complete, users can add voice-recorded notes containing other important information. Later, when a contact wearing a beacon is within a predefined distance established in the app's settings, the app will provide the user with a visual and auditory notification that the person is nearby. The notification cues the user of the contact name, photo, and relationship. It also gives the option to access notes and to have the information on the screen read aloud to them.
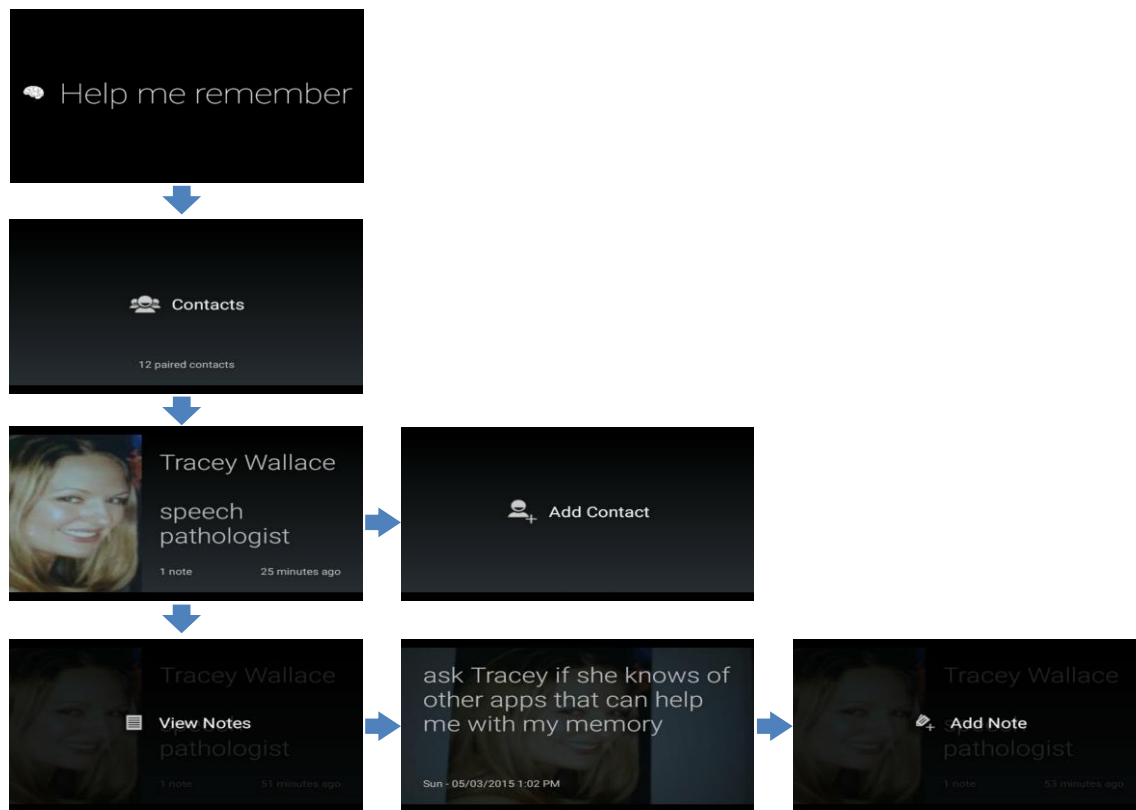
Fig. 1. Screenflow for adding new contact and view of existing contact.

The five main EyeRemember settings include: 1) scan time, 2) sleep time between scans,

3) contact distance for detection/notification, 4) notification away time, 5) off/on toggle for

adding notes for contacts, and 6) on/off toggle for reporting use data to Google Analytics (see

figure 2). The first two settings used together allow control to ensure that scanning is successful

in the user's local environment (home, clinic, etc.), while simultaneously conserving battery.

The next two settings (contact distance and notification away time) also are generally used

together to optimize the app for the user's particular memory deficit and local environment.

Controlling the ability to add notes was a late addition to the Setting menu, so that

EyeRemember could be used just for identification of the user's therapy team members in a

clinical setting. Reporting use data to Google Analytics informs R&D on EyeRemember, and

could also be used by the therapy team trying to train a patient to use this external memory aid.
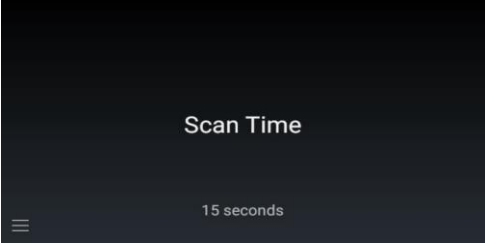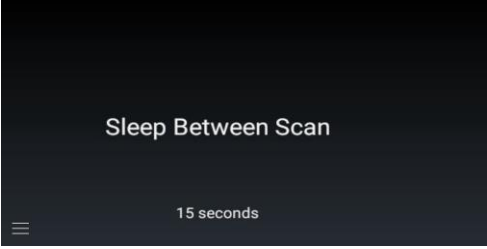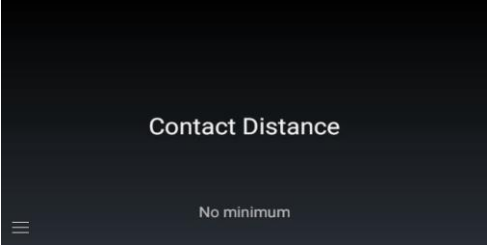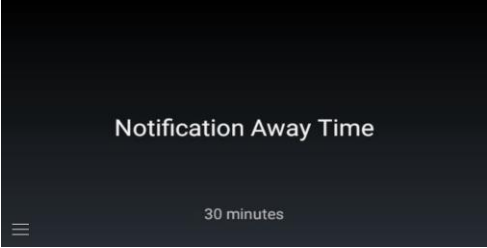
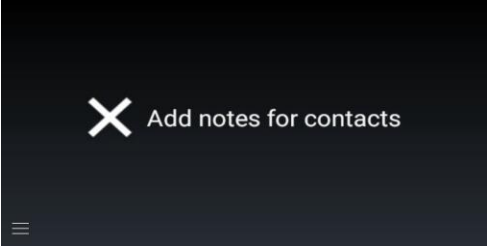|	
Scan Time 15 seconds	**Scan time** - Duration of scanning for contacts before resting • settings for 3 to 15 seconds • shorter scan times save battery
Sleep Between Scan 15 seconds	**Sleep between scan** – Length of time that the app rests between scanning again • Settings for 3 to 15 seconds • Longer sleep times save batter, especially when combined with shorter scan times
Contact Distance No minimum	**Contact distance** – Distance of contact from app user at which notifications are triggered • Options include unlimited distance (as allowed by broadcast range of beacon), or settings for distance ranging from 1 to 20 feet
Notification Away Time 30 minutes	**Notification away time** – Time between notifications of a contact's presence • Allows contact to enter and exit notification range (contact distance) without triggering new notifications until notification away time has expired
✕ Add notes for contacts	**Add notes for contacts** – On/off toggle for controlling ability of user to add notes • Setting was added for testing app in a brain injury day program to test app's usefulness for reminding patients of the names and roles of the members of their therapy team
✓ Toggle Reporting	**Toggle reporting** – On/off switch for reporting use data (number of sessions, duration of sessions, screens viewed, etc.) to Google Analytics • Can be used for research/evaluation of the app • Also could be used for therapy

Fig. 2. EyeRemember settings options.

Enhancements to the initial prototype during in-house testing resulted in 6 "builds" of the app before it was demonstrated to stakeholders for input. BLE beacons were selected for use during stakeholder user-testing based on in-house experiences. Several beacons were selected initially based on online reviews, price and features. Specific desired features included: constant broadcasting of the Bluetooth signal, small size and the ability to be clipped onto a key ring or belt loop. Although several beacons were identified with these features, only 2 of the tested beacons were sufficiently durable and reliably broadcasted the Bluetooth signal during testing; Pally Smart Finder KF 4A and Tile, both of which retail at about $25.

Stakeholder Feedback

EyeRemember is useful in the following contexts: 1) recall of the name, relationship or other information about a contact; 2) recall of information to share with a contact (e.g., a reminder to tell a spouse that a medication was changed by the doctor during an appointment); and 3) recall of information previously shared by a contact in order to support social communicative interactions (e.g., a reminder that a friend told the user she got engaged). Stakeholder feedback was gathered via focus groups and sit-by user testing. The protocol was approved by the local institutional review board at Shepherd Center.

Feedback from Clinicians

Clinician feedback was gathered formally through a 90-minute Focus Group and less formally through information provided by attendees at a an brain injury rehabilitation inservice on Glass as an assistive technology. Four speech-language pathologists with an average of 9 years specializing in brain injury rehabilitation, and four occupational therapists with an average of 5 years specializing in brain injury rehabilitation, volunteered to attend. Glass and the EyeRemember app were demonstrated followed by a structured discussion.

Overall responses were favorable, and all participants indicated they feel Glass and EyeRemember have potential to assist people with brain injury. Concerns expressed throughout the discussion included lack of clinician experience with Glass, which would limit their ability to train people with brain injury to use the technology effectively and caregivers to provide needed support. Several participants also expressed concern regarding the cost of Glass (the beta version was priced at $1500), as well as the potential for loss or damage to the device. The use of an eyeglass neck strap was suggested as a potential intervention to minimize the risk of damage from dropping the Glass.

When asked about recommendations for testing the use of Glass and EyeRemember with patients with brain injury, participants in the focus group suggested beginning first in a controlled environment, such as a rehabilitation hospital or outpatient therapy clinic, before considering take-home-use. Reasons given for this include the lack of overall knowledge and experience about user preferences and abilities regarding Glass use, the desire to minimize requirements for caregiver training during exploratory stages of development, and the lack of evening and weekend support that would be available to users. Discussing this recommendation uncovered concerns about the broadcast ranges of the two beacons chosen for the study (Pally Smart Finder and Tile beacon) which broadcast 150 and 100 feet, respectively. This resulted in an enhancement to the app that allows the proximity of the beacon to be set.

Clinician feedback was also gathered at an in-service of Shepherd Pathways brain injury day program staff, including physical, occupational and recreational therapists, as well as speech language pathologists, and clinical psychologists. Possible uses mentioned across professional specialties focused on reminders for task sequencing, scheduling, and note taking. Additionally, therapy professionals suggested that Glass and Google Now provided possible accessibility options for individuals with limited gross and fine motor skills.

Table 1. Suggestions for additional ways Google Glass and EyeRemember app could be used in

clinical practice (by therapist specialization)

Physical Therapists	Occupational Therapists
• Assistance with physical tasks such as sequencing with transfers/gait (i.e., cueing) • Assistance with home exercise programs • Reminders for client's schedule, location of therapy or orientation information • Note-taking on therapy sessions	• Listing steps of functional activities like brushing teeth etc. • Modified for eye-gaze control for clients with verbal communication • Help for clients who have only gross hand movement for computer access
Recreation Therapists	Speech-Language Pathologists
• Set timers for completion of therapy sessions or tasks • Leisure interests - photography, computer use, socialization • Use Google translate for written activities to decrease use of interpreters in therapy/community	• Therapy session notes • Google Glass could be used by higher level clients with mild TBI including those returning to work or school • Schedules + schedule reminders, routing • Prospective memory tasks

Feedback from People with Brain Injury and Their Caregivers

Three sit-by interviews were completed with people with memory challenges following

TBI and their caregivers. Participants included a 21-year-old female and her mom as caregiver,

a 34-year-old male and his fiancée as caregiver, and a 62-year-old male with his wife as

caregiver. Glass and EyeRemember were demonstrated and all participants spent time wearing

the device and testing the app. Comments on user experiences and structured interview

responses were recorded for qualitative analysis. Participants provided input on the display of

information on the contact card and notes card. They also provided feedback on the usefulness

of including the contact picture on the screen during note-taking input. Most other comments

were made regarding the design and use of Glass. Concerns noted by participants were primarily related to cost and durability. One participant's eye was observed to tear slightly after a few minutes of use, although he reported he experiences teary eyes periodically throughout the day. Other feedback is summarized in the Tables 2 and 3. Stakeholder feedback was incorporated into the beta version of EyeRemember, the eighth build of the app. Ongoing research includes end-user testing of the finalized beta version with clinicians and people with memory problems following brain injury in an outpatient brain injury rehabilitation program. Results may lead to in additional enhancements to the app and will be reported to directly to Google at other forums in order to promote inclusion of the needs of people with cognitive limitations in ongoing Glass development. The EyeRemember app may also be developed for other wearable platforms, such as smart watches.

Table 2. Feedback and observations of people with TBI

Age/sex	Observations	Overall Reception	Would wear it with peers?	Overall assessment
21 female	Seemed to wear it naturally	Favorable Interested	Yes	"It would be a lot easier and faster" to use for note-taking
34 male	Struggled with swipes/taps	Favorable Interested	Yes	"It would help, so I would wear it"
62 male	Intuitive use of gestures	Favorable Interested	Yes	"I think it's a great idea" and wearing it all day, "would be comfortable."

Table 3. Feedback and observations of caregivers of people with TBI

Age/Relation	Would EyeRemember be helpful for your loved one?	Would you and other friends/family wear beacons?	Thoughts on Learning to Use it
Mom of 21-year-old female	Yes – she could use it to remember her professors	Yes – all would be willing	Daughter could learn to use it despite poor memory since she grew up with similar technology
Fiancée of 34-year-old male	Yes – "It's great", fiancé could really use it to help remember names	Yes	"It was kind of easy and user friendly."
Wife of 62-year-old male	Yes – it could help him remember what he talked to the MD about	Yes	"It's like a phone or anything else. If you are comfortable with other tap and swipe devices it will be very easy to learn."

Conclusion

Developing an app for Google Glass has helped to understand more about the potential of

Glass to be used as an assistive technology for people with memory problems following TBI, as

well as some of the potential limitations. Glass appears to have many of the benefits of a

smartphone and has a slew of accessible features built-in. A notable difference and potential

benefit to using Glass as a memory aid vs a smartphone is that it is wearable, which may increase

accessibility and allow a user to stay "in the moment" when receiving support from the device.

Because it is a new platform, there may be a steep learning curve for some users which may

particularly problematic for users with memory impairments that affect learning. Glass must be

paired to Wi-Fi or a smartphone or tablet in order to access many of the functions. The current

version of Glass is designed only for the right side of the head requiring adequate right sided

vision, hearing and upper extremity use to swipe and tap the control pad. The frames do not

fold, so storage can be cumbersome. Battery life may not be long enough to support heavy use. Furthermore, the battery heats with use, which may be uncomfortable for users and can sometimes cause Glass to become temporarily inoperable when the device requires a break to cool down.

Perhaps the most significant limitation (at the time of this publication) is that Glass is experimental and currently unavailable for consumer purchase. Media reports in January of 2015 indicated Google is working on "future versions of Glass." Regardless of whether or not a new version of Glass is released and becomes widely available to consumers, it is likely that Glass-like wearables will mature rapidly into the marketplace, increasing the value of these initial data findings on app interfaces for wearable displays.

Works Cited

Dry, Abigail, et al. "Technology in the Lives of Women who Live with Memory Impairment as a Result of a Traumatic Brain Injury." *Assistive Technology: The Official Journal of RESNA* 18.2 (2006): 170-180. Print.

Haskins, EC, et al. *Cognitive Rehabilitation Manual: Translating Evidence-Based Recommendations into Practice.* Beta Edition. Reston, VA: ACRM Publishing (2011) (pp.41-68). Print.

Kim, H J, et al. "Electronic Memory Aids for Outpatient Brain Injury: Follow-Up Findings." *Brain Injury* 14.2 (2000): 187-196. Print.

Mateer, CA, MM Sohlberg, and J Crinean. "Focus On Clinical Research: Perceptions Of Memory Function In Individuals With Closed-Head Injury." *Journal Of Head Trauma Rehabilitation* 2.3 (1987): 74-84. Print.

McDonald, A, et al. "Google Calendar: A New Memory Aid To Compensate For Prospective Memory Deficits Following Acquired Brain Injury." *Neuropsychological Rehabilitation* 21.6 (2011): 784-807. Print.

Sohlberg, MM, et al. "ANCDS Bulletin Board. Evidence-Based Practice For The Use Of External Aids As A Memory Compensation Technique." *Journal Of Medical Speech-Language Pathology* 15.1 (2007): xv-li. *CINAHL Plus with Full Text*. Web. 25 Apr. 2015. Print.

Wade, T K, and J C Troy. "Mobile Phones As A New Memory Aid: A Preliminary Investigation Using Case Studies." *Brain Injury* 15.4 (2001): 305-320.