TBI-Apps.com: Teaching Caregivers How to Use Mobile Applications as Compensatory Cognitive Aids for Traumatic Brain Injury

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Abstract

Long-term cognitive deficits resulting from traumatic brain injury (TBI) can profoundly impact a person's role competence and ability to perform daily activities (AOTA, 2014a). Mobile technologies, including smartphones and tablets, have shown potential as effective compensatory aids for memory and executive functioning in individuals with TBI (Waite, 2012). A website was created to provide caregivers tools to independently select, program, and use Apple iOS devices with TBI survivors. The website featured five tutorials for iOS applications, one tutorial for an iOS accessibility feature, and tips for teaching application use to individuals with TBI. It also included general information on the effects of TBI and ways iOS devices might be adapted for TBI survivors. The website was piloted with five people to assess its effectiveness. Piloters completed a quiz on website content and provided feedback and suggestions for expansion. Resources that encourage using everyday technology to improve the match between a person's abilities, the environment, and occupational demands may help individuals with TBI increase occupational engagement and performance.

Keywords: applications, caregivers, compensatory aids, everyday technology, executive functioning, memory, mobile applications, mobile technology, TBI, traumatic brain injury

Traumatic brain injury (TBI) can result in long-term cognitive deficits that have profound impacts on a person's role competence and ability to perform daily activities (American Occupational Therapy Association [AOTA], 2014a). Deficits in memory and executive functioning are common TBI symptoms, with compensatory approaches needed to overcome their impact and improve an individual's functional performance in activities (AOTA, 2014a). Mobile technologies in the form of smartphones, tablets, and similar touchscreen devices show potential as effective compensatory aids for memory and executive functioning impairments in individuals with traumatic brain injury (Waite, 2012). These devices have the advantage of widespread use. A recent survey found that 56% of all U.S. adults now have smartphones (Smith, 2013) and it has been predicted that ownership of these devices will rise exponentially over the next decade, eventually outnumbering traditional computers 2 to 1 (Gens, 2011). The number of mobile applications (apps) available for these devices is expected to grow similarly, especially in currently untapped areas such as healthcare (Gens, 2011). This paper describes a project for a website to teach caregivers how to implement mobile applications as compensatory cognitive tools for individuals with TBI, featuring step-by-step tutorials and tips based upon occupational therapy cognitive rehabilitation approaches.

Background

Impacts of TBI

TBI is a serious health issue, often resulting in long-term or permanent disability (Centers for Disease Control and Prevention [CDC], 2010). It is estimated that of the 1.7 million people sustaining TBIs annually in the U.S., 80% are treated in emergency rooms and 275,000 require hospitalization (CDC, 2010). Approximately 80,000 to 90,000 of these injuries result in permanent disabilities (Thurman, Alverson, Dunn, Guerrero, & Sniezek, 1999), though the long-

term impact depends to some degree on severity. TBI can be categorized by severity as mild, moderate, or severe based on several scales, most notably, the Glasgow Coma Scale (GCS) which measures level of consciousness following injury using eye opening, verbal, and motor responses (Teasdale & Jennett, 1974).

Slow processing speed, attention deficits, memory problems, reduced verbal fluency, and impairments in executive functioning are common cognitive problems associated with mild to severe TBI (Finnanger et al., 2013; Frencham, Fox, & Maybery, 2005; Mathias & Coats, 1999; Yim, Babbage, Zupan, Neumann, & Willer, 2013). In a longitudinal study of the neurobehavioral effects of TBI on 59 individuals, Lippert-Gruner, Kuchta, Hellmich, and Klug (2006) measured participants' cognitive symptoms 6 and 12 months post-injury, identifying numerous long-term cognitive and behavioral impairments that remained stable 12 months post-injury, including deficits in memory and executive functioning. Chronic cognitive deficits in individuals with TBI often disrupt their ability to resume meaningful roles and independently engage in occupations such as work, maintaining a household, money management, and driving (Erez, Rothschild, Katz, Tuchner, & Hartman-Maeir, 2009; Perna & Loughan, 2012; Sherer et al., 1998). Poor functional outcomes have been associated with TBI including unemployment, re-hospitalization, and lower life expectancies (National Institute on Disability and Rehabilitation Research, 2013).

TBI-related cognitive deficits often persist past the continuum of care individuals currently receive in the United States. The average length of stay for individuals with TBI in 2011 was 21 days in acute care and 25 days in rehabilitative care (Traumatic Brain Injury Model Systems National Data and Statistical Center, 2012). Mellick, Gerhart, and Whiteneck (2003) found that out of 1,059 individuals with TBI discharged from an acute care setting, less than half received treatment after leaving the hospital. Corrigan, Whiteneck, and Mellick (2004) found

that out of 1,802 individuals with TBI, most reported having unmet needs related to cognitive or emotional impairments one year post-injury.

Cognitive and behavioral impairments in individuals with TBI have impacts on the well-being of their caregivers as well. Marsh, Kersel, Havill, and Sleigh (2002) used various questionnaire-based assessments to measure caregiver burden in 52 caregivers of people with TBI six and 12 months post-injury. The researchers found that cognitive and behavioral impairments played a much larger role in caregivers' reported distress than physical injuries did, with over a third of the caregivers experiencing clinically significant levels of depression and anxiety (Marsh et al., 2002). Machamer, Temkin, and Dikmen (2002) reported similar findings in a cross-sectional study of 180 relatives of individuals with TBI; negative experiences by most participants were associated with their family member's level of cognitive impairment (Machamer et al., 2002). Gan, Gargaro, Brandys, Gerber, and Coschen (2010) found the need for education, training, and strategies for dealing with changes in cognition following TBI is high among caregivers. Gan et al. (2010) identified that caregivers wanted easily accessible, concrete, and practical information related to brain injury, including what they can do to help a TBI survivor. The following section discusses instruction methods caregivers may use to help a person with TBI learn strategies to increase independence and occupational engagement.

Systematic Instruction Techniques that Facilitate Learning in Individuals with TBI

Systematic Instruction (SI) is a method of direct instruction specifically created to facilitate learning, maintenance, and generalization of knowledge, facts, and skills in individuals with cognitive impairments (Sohlberg & Turkstra, 2011). SI provides instructional methods designed to help this population learn more efficiently based on specific and practical techniques for teaching multistep procedures, and the use of external aids to compensate for deficits

(Sohlberg & Turkstra, 2011). SI guidelines assist clinicians and caregivers instruction based on the learner's characteristics including the person's familiarity with the device, short and long-term memory impairments, and ability to problem solve. Careful selection of the device based on familiarity, key cognitive challenges (such as deficits in memory and learning), and environmental factors (such as physical and social) are other things to consider when training with use of electronic devices and strategies in individuals with TBI (Sohlberg & Turkstra, 2011). SI also emphasizes that accurately analyzing and selecting the desired outcomes will assist in the best learning outcomes (Ehlhardt et al., 2008).

Erhlhardt and colleagues (2008) performed a literature review of over 20 years of research on neuropsychological interventions and instructional practices for people with TBI (Ehlhardt et al., 2008). Their review suggests that SI is the most effective instructional approach for teaching individuals with TBI, including the use of technology. Further, they found that SI methods included meaningful targets, active learner engagement, careful training plans, and errorless learning (EL). Another study found that participants with TBI who were trained with an SI approach to use a personal digital assistant (PDA) showed greater maintenance and generalization with PDA use at a 30 day follow-up evaluation than those taught with conventional trial-and-error methods (Powell et al., 2012).

Systematic Instruction Techniques

A main tenet of SI is that learning occurs in three basic phases: acquisition, generalization, and maintenance (Sohlberg & Turkstra, 2011). Determining the outcomes and the individual's phase of learning is necessary for designing the best teaching approach.

The acquisition phase is when the individual is acquiring a new skill or information. It focuses on minimizing learner errors and moving from massed to distributed practice (Sohlberg

& Turkstra, 2011). EL is typically important during initial exploration and learning because people with memory impairments remember their own mistakes better then they remember corrections to their mistakes (Gillen, 2009). Massed practice ensures mastery of specific component steps of a task through high volume, repetitive practice of the same skill. Distributed practice breaks up practice into a series of shorter sessions, where the time between practices gradually increases (Sohlberg & Turkstra, 2011). For example, if procedures are the desired outcome, such as how to independently access an app on a smartphone, providing the learner with methods for encoding the information into memory may help. Encoding strategies may include asking the learner to verbalize the actions they are taking for each step, rehearsing without the device, and problem solving with assistance from the trainer (Sohlberg & Turkstra, 2011). After mastery of initial steps, the caregiver or teacher should consider whether mass or distributed practice would ensure acquisition of the task or procedure. Again, the method will differ based on the desired task outcome (Sohlber & Turkstra, 2011). For example, highly procedural, low-cognitive demand tasks may be taught best with distributed practice where the learner is diverted temporarily and then asked to revisit the process (The Center on Brain Injury Research and Training, 2012). By comparison, learning more complex tasks may require massed (i.e., repetitive) practice until each step, and then the sequence of those steps, are mastered (Ehlhardt et al, 2008).

During the generalization phase, after initial basic steps have been mastered, the caregiver should vary task or environmental factors. Fading support and asking the person to practice in different environments helps elicit retention and fluency, with the individual performing the task, or parts of the task, efficiently on their own (The Center on Brain Injury Research and Training, 2012). Throughout generalization, it is important that the caregiver offer

ample support and reinforcement of learned skills. Asking the learner to problem solve, with caregiver assistance, or asking them to judge their own performance will assist in developing insight and problem solving skills (Sohlberg & Turkstra, 2011). Generalization has been shown to be especially effective if the device fits the learner, if tasks were sequenced at the adequate pace, and if training occurred in the natural environments where the device would be used again (Sohlberg & Turkstra, 2011).

The maintenance phase is highly impacted by whether the device is appropriately designed to meet the individual's needs and abilities, whether or not effective training was provided, and the existence of ongoing reinforcement and support for device use (Sohlberg & Turkstra, 2011). Maintenance techniques within the SI approach show results that are more promising when practice is distributed rather than massed, and when training consists of personally relevant outcome targets within the environments where they will typically be performed (Powell et al., 2012). Powell and colleagues (2012) identified several components of SI that aided individuals with TBI to generalize and maintain use of electronic cognitive aids based on the results of a 30-day follow up. Most importantly, the participants were successful because the trainers ensured their ability to remember procedures by ongoing appraisal of component steps mastery, carefully faded support, and high rates of correct, distributed practice (Powell et al., 2012). Occupational therapists (OT) can assist in determining the device fit, and the anticipated benefits and risks of using high technology to compensate for deficits following TBI, as well as provide methods for appraising learner mastery.

Occupational Therapy's Role in Treating TBI-related Cognitive Impairments

OT treatment of individuals with TBI occurs in inpatient, outpatient, and community settings and focuses on increasing clients' independence and engagement in occupation

(LeBorgne, 2014, p. 1185). OT takes a client-centered approach to ensure that outcomes, goals, and tasks used are relevant, meaningful, and specific to the client as well as the caregiver (Gillen, 2009). In cognitive rehabilitation, occupational therapists help remediate cognitive skills and/or implement adaptive or compensatory strategies to facilitate clients' engagement and participation in meaningful life activities (American Occupational Therapy Association [AOTA], 2013). OT interventions for clients with TBI-related cognitive impairments often focus on teaching cognitive strategies, such as the use of schedules, calendars, ordered lists, and other assistive devices, to help compensate for cognitive impairments that limit clients' occupational engagement (AOTA, 2014a). These cognitive strategies can be directed at modifying the task or environment or they can be oriented toward teaching the person skills that could be used in multiple contexts (Toglia, Rodger, & Polatajko, 2012).

Several factors influence whether OT attempts to remediate cognitive impairments or teach compensatory strategies, but paramount is analyzing the client's ability to learn, awareness of errors, and potential to seek solutions to errors (Gillen & Brockman-Rubio, 2004). Occupational therapists have the skills to assess deficits in the aforementioned areas and deficits experienced by individuals with TBI. For instance, functional tasks are used to help determine clients' level of insight into TBI-related deficits and learning potential by giving them opportunities to compare current occupational performance to performance pre-injury (Dirette, 2002). If, based on assessment and observation, new learning is not possible and/or insight is severely impaired, then a compensatory, task-specific training is suggested (Gillen, 2009). For the purposes of this paper the authors will focus on compensatory methods, which include anything that is taught to clients to help them substitute for an impaired skill that cannot be re-established (Geusgens, Winkens, van Heugten, Jolles, & van den Heuvel, 2007).

Radomski and Giles (2014) suggest that external memory and executive functioning strategies can compensate for cognitive deficits. They describe several approaches for this cognitive retraining including task-environment modification, skill-task-habit training, and strategy training. Task-environment modification involves making changes to the task or adapting the environment and/or social dynamics of the task to lessen the cognitive demands for occupational engagement (Radomski & Giles, 2014). For example, wearing noise-cancelling headphones at work may aid in keeping sustained attention to tasks (Gillen, 2009).

According to Radomski and Giles (2014), skill-task-habit training helps individuals develop new habits and routines that improve specific skills by making them more automatic. Establishment of daily routines by way of agendas, checklists, organizers, note taking, or tape recording and delineating tasks into smaller components minimize cognitive demands and stress, and compensate for deficits such as impaired attention or memory (Gillen, 2009). The strategies used in skill-task-habit training have also been shown to increase an individual's independence and participation in desired occupations. Burke and colleagues (1991) identified that the consistent use of checklists, memory books, and timetables increase successful performance of tasks related to self-care and vocation/work. Day planners and technologies can also be used to establish new routines and habits in order to compensate for cognitive deficits by providing daily documented to-do lists of chores and/or appointments to attend, with electronic versions also available. These often include alarm prompts to aid in referring to the needed information on time (Radomski & Giles, 2014).

Radomski and Giles (2014) explain that strategy training emphasizes the use of new methods for handling complex tasks through compensatory task-specific strategies. These compensatory strategies incorporate elements of the previous two treatment approaches. These

are of particular importance as they are the focus of this project. Electronic day planners, personal digital assistants, and mobile apps with alarm prompts, for example, aid the person in referring to needed information for initiating tasks such as mailing rent checks or taking medication. In this way, these technologies can help the person compensate for lost executive functioning. Similarly, personalized electronic memory apps can compensate for forgotten information, increase orientation within tasks and procedures, and assist in remembering processes such as making coffee. A third example is the use of checklists, which are used to compensate for long-term impairments in executive functioning by sequencing steps and avoiding repetition of completed actions (Radomski & Giles, 2014). These external compensatory strategies aid in increased independence and engagement in occupation and the eventual establishment of daily routines (Radomski & Giles, 2014). Determining the functionality of a specific compensatory technique requires the teacher to appraise skills and deficits, especially when insight is required. Compensatory strategies that require too much insight may decrease performance, thus careful selection of the aid and the techniques is necessary (Toglia et al., 2012).

Electronic Devices as Compensatory Cognitive Aids for Individuals with TBI

Research supports the efficacy of electronic devices as means to compensate for impairments in memory and executive functioning as a result of TBI, especially through timed delivery of reminders (Stapleton, Adams, & Atterton, 2007; Van Hulle & Hux, 2006; van den Broek, Downes, Johnson, Dayus, & Hilton, 1999; McDonald et al., 2011). For example, in one study, an electronic device was deemed more efficient and effective than pencil and paper memory aids (van den Broek et al., 1999). In another study, the researchers (Stapleton et al., 2007) reported that one participant's increased functioning as a result of mobile phone reminders

continued after the phone was removed, suggesting the intervention in this case was effective at both compensating for memory problems and facilitating new learning.

Many studies about the use of electronic devices with people with TBI concluded that the effectiveness of technology was partly dependent upon the skills of the participant. For example, Stapleton et al. (2007) found the use of the programmed mobile phone reminders were effective only for people with mild to moderate cases of TBI. Similarly, McDonald et al. (2011) found that participants with more severe memory and executive functioning deficits benefited least from a Google Calendar based compensatory intervention. Finally, Van Hulle and Hux (2006) found that one of their three participants did not benefit from an electronic cueing device due to an apparent lack of motivation. Caregiver support has also been identified as an important factor influencing TBI-impaired individuals' successful usage of technology (Linden, Lexell, & Lund, 2010; Engstrom, Lexell, & Lund, 2010).

Summary

Overall, research suggests that TBI often results in deficits in memory and executive functioning (Finnanger et al., 2013; Frencham et al., 2005; Mathias & Coats, 1999; Yim et al., 2013), that such deficits often persist past the continuum of treatment of individuals with TBI (Lippert-Gruner et al., 2006; Corrigan et al., 2004), and that decreased occupational engagement and quality of life are often results of said deficits (Erez et al., 2009). Where therapy services are limited and cognitive symptoms persist for individuals with TBI, there is a need for accessible resources caregivers can use to support independence in living for TBI survivors. Evidence supports portable electronic devices as effective tools to this end (Stapleton et al., 2007; Van Hulle & Hux, 2006; van den Broek et al., 1999; McDonald et al., 2011) and the familiarity and cultural relevance of today's devices make them appropriate tools that can be easily programmed

without much training. The field of OT offers exceptional perspective suitable to matching mobile applications to the needs of TBI survivors to promote optimal participation and engagement in life, including the delivery of appropriate training methods.

Purpose

The purpose of this project was to increase function in individuals with TBI by providing caregivers a website with information and resources about uses of mobile devices and applications that evidence suggests can be used to compensate for long-term cognitive impairments.

Procedure

This project began with a general investigation into TBI including demographic data, long-term symptoms, and current trends. Project team members conducted informal interviews with TBI survivors, their caregivers, and health professionals to obtain multiple perspectives on the strengths and challenges of technology use with this population. Existing studies investigating the efficacy of compensatory aids for TBI-related cognitive deficits were reviewed.

Based on their findings, the project team decided to create a website to teach caregivers how to select, program, and implement mobile applications as compensatory cognitive aids for TBI survivors with problems with memory and/or executive functioning. The team investigated current best practices in cognitive rehabilitation and caregiver training for TBI. They also researched physical symptoms that might interfere with a TBI survivor's ability to use a touch screen and ways to adapt devices to circumvent such difficulties. Finally, 54 mobile applications were analyzed for their potential usefulness as compensatory cognitive aids based on ease of use and similarities to strategies documented as efficacious in peer-reviewed studies.

Once information was compiled, the project team developed website content including: illustrated tutorials for five mobile applications, tips on implementing their use with a TBI survivor, general information on TBI, and links to adaptive equipment vendors along with descriptions of some strategies that can be used to improve access to mobile technology. All content was written at an approximately eighth grade reading level. The project team collaborated with a University of Puget Sound computer science student to build the website, find a hosting server for it, and obtain a domain name. To pilot the completed website, the project team asked five participants with direct experience with TBI or related cognitive deficits to navigate the site and complete a quiz. The purpose of the piloting was to inform the project team on the TBI-Apps.com's usefulness to its target audience, ascertain how effectively information was presented, and determine whether project goals and objectives were met.

Product Description

TBI-Apps.com is a free, evidence-informed, educational website instructing caregivers in the use of mobile technology as compensatory tools for TBI survivors. It is a resource for increasing participation of individuals with TBI-related memory and executive functioning deficits in various Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) using technology as a modality. TBI-Apps.com provides tutorials for caregivers to learn how to program selected apps, as well as advice on how they can instruct TBI survivors to use the apps to support functioning. For ease of navigation, the website is clearly organized by informational and instructional content.

TBI-Apps.com's content is separated into five tabs. The "Apps" tab provides links to six tutorials for using specific iOS apps and features selected by the project team as appropriate for use by TBI survivors (see Appendix A, Figure 1). These are categorized as "Memory" for three

apps to help compensate for memory deficits, “Planning” for two apps to help compensate for deficits in executive functioning, and “Guided Access in iOS” for a tutorial on Apple’s Guided Access feature. For each tutorial, a short description of the app including suggestions for what ADL or IADL it could be used to support is provided (see example in Appendix A, Figure 2). This is followed by step-by-step instruction on how to generally set up and use the app. Coinciding with each written step are pictures and arrows indicating where to input information. Tips are provided at the end of each tutorial on how caregivers can teach TBI survivors to use the app themselves.

The "Teaching Tips" tab contains instructions for caregivers to help train individuals with TBI to use electronic aids based on Systematic Instruction techniques (see Appendix A, Figure 3). The tips help caregivers facilitate learning, maintenance, and generalization of skills for TBI survivors experiencing cognitive impairments. The caregiver is provided with a list of do's and don'ts for teaching individuals with TBI.

The "Accessibility" tab explains and provides links for various accessibility features within iOS products for impaired vision, hearing, and/or motor skills (see Appendix A, Figure 4). For instance, the Zoom Feature, Subtitles and Captioning, and Assistive touch are some of the accessibility features recommended with external links to more information. Adaptations such as styluses and key guards are also recommended and linked to within the tab for individuals with upper extremity motor impairments.

The "Effects of TBI" tab provides information about common causes of TBI, ranges of TBI severity, as well as the cognitive, physical, sensory, and behavioral/emotional deficits that follow TBI (see Appendix A, Figure 5). For example, effects on cognition such as attention, memory, and executive functioning difficulties are described in detail due to their impact on

individuals' occupational performance. Deficits of TBI that commonly occur long-term and the impact they have on various IADLs are described here as well.

The "About" tab provides information on the website creators, defines occupational therapy, explains who the website is intended for, as well as the unique features the site has to offer its users.

The "Resources" tab provides external links to informational websites, organizations, and networks for individuals with TBI and their caregivers, such as the Brain Injury Network and HeadStrong (see Appendix A, Figure 6). Scholarly article references are also provided that support the use of the teaching techniques described throughout the website and the use of portable electronic devices as helpful tools for TBI survivors to participate in meaningful activities; thereby supporting the use of apps to provide similar compensatory strategies supported in research.

Project Outcome

Goal 1: After accessing TBI-Apps.com, caregivers will be able to use it to implement evidence-informed treatment for individuals with TBI-related cognitive deficits by successfully utilizing highlighted applications with a person with TBI.

Objective 1: After reading the "Apps" tab of the website, caregivers will be able to name one application individuals with TBI may use to compensate for memory deficits.

Objective 2: After reading the "Apps" tab of the website, caregivers will be able to name one application individuals with TBI may use to compensate for executive functioning (planning) deficits.

Objective 3: After reading the "Apps" tab of the website, caregivers will be able to name one task or activity a TBI survivor may use Apple iOS to compensate for, considering deficits commonly experienced by individuals with TBI.

Goal 2: By utilizing TBI-Apps.com, caregivers will be educated on the effects of TBI.

Objective 1: After reading the "Effects of TBI" tab of the website, caregivers will be able to identify one cognitive deficit individuals with TBI commonly experience.

Objective 2: After reading the "Effects of TBI" tab of the website, caregivers will be able to identify one behavioral deficit individuals with TBI commonly experience.

Objective 3: After reading the "Effects of TBI" tab of the website, caregivers will be able to identify one physical deficit individuals with TBI commonly experience.

Objective 4: After reading the "Effects of TBI" tab of the website, caregivers will be able to identify one common cause of TBI.

Goal 3: By utilizing TBI-Apps.com, caregivers will be educated on adaptive equipment and accessibility options available for Apple iOS users with TBI.

Objective 1: After reading the "Accessibility" tab of the website, caregivers will be able to identify one piece of equipment that can aid individuals with TBI who experience upper extremity motor impairments access and utilize mobile technology.

Objective 2: After reading the "Accessibility" tab of the website, caregivers will be able to identify one accessibility option that can aid individuals with TBI who experience vision impairments access and utilize mobile technology.

Objective 3: After reading the "Accessibility" tab of the website, caregivers will be able to identify one accessibility feature that can aid individuals with TBI who experience hearing impairments access and utilize mobile technology.

Goal 4: By utilizing TBI-Apps.com, caregivers will be educated on how to instruct individuals with TBI experiencing cognitive deficits in order to facilitate learning, maintenance, and generalization of knowledge.

Objective 1: After reading the "Teaching Tips" tab of the website, caregivers will identify one teaching method to facilitate learning for an individual with TBI experiencing cognitive deficits.

Objective 2: After reading the "Teaching Tips" tab of the website, caregivers will identify one teaching method to NOT DO when facilitating learning for an individual with TBI experiencing cognitive deficits.

Piloting of TBI-Apps.com to assess goal achievement occurred on April 27, 2015 to May 1, 2015. Five individuals participated in the pilot: two caregivers of individuals with TBI, and three occupational therapists and University of Puget Sound clinical instructors who have experience working with TBI survivors. To implement the pilot, the project team emailed participants an explanation of the project and asked them to browse the website for 20 minutes and then complete a quiz. The quiz contained seven scored questions relating to each project objective, and two open-ended questions asking for general feedback (see Appendix B).

The project team reviewed participant answers. The scored answers reflected that project Goals 1, 2, and 3 and their associated objectives were met. It is unclear whether Goal 4 and its objectives were met due to question design and/or the wording of information in the “Teaching Tips” tab of the website. The question pertaining to Goal 4 required that participants identify three teaching tips, whereas Goal 4, Objective 1 (above) only required identification of one teaching tip. Additionally, the “Teaching Tips” tab of the website included disclaimers that indicated some tips would likely be unsuccessful for people with severe TBI impairments. These

disclaimers may have confused quiz respondents when answering this question. A more clearly written question may have resulted in a 100% correct response rate that would have indicated Goal 4 was met.

Review of the unscored answers revealed that 4/5 pilot participants found TBI-Apps.com helpful due to easy website navigation, clear and informative content, and appropriateness of applications selected for TBI survivors' needs. One participant commented that the website would have been more useful for them if it included Android applications. Other participant suggestions included making minor formatting changes for readability, addressing additional mobile technologies, adding tutorials for memory remediation applications, and including tips for video modeling. Overall, pilot participant feedback indicated the target audience of caregivers of individuals with TBI would likely find TBI-Apps.com educational and useful.

Implications for Occupational Therapy

We used the Person-Environment-Occupation (PEO) model to guide in the selection and promotion of information on the website. This model required extensive consideration of how tasks and environment can be adapted or modified for increased participation. The PEO model addresses limitations in occupational performance by trying to improve the match between a person's abilities, the environment, and occupational demands (Brown, 2014). The term "task" refers to purposeful activities, and "occupations" are self-directed tasks that occur over the lifespan (Brown, 2014). Adaptation of the task addresses the component parts of an occupation. For example, using a medication reminder app to adapt for decreased memory will better allow an individual to complete his or her medication management, an Activity of Daily Living (ADL), independently by changing the task demands to better meet the person's abilities with memory. Environment in the PEO model includes physical features such as buildings, terrain, objects, and

tools. It also includes nonphysical aspects such social and virtual environments. Modifying the environment can be accomplished for individuals with low vision, for example, by using phone settings to increase contrast. For people with impaired upper extremity functioning, phone operations can be adapted for deficits in fine motor coordination, for example, by slowing key response. Finally, for individuals with cognitive limitations, the speech recognition and reading programs can offer intuitive techniques to navigate and assist in device operation.

A major consideration of the PEO model is that treatment should be client-centered and collaborative, based on the wants and needs of the client (Brown, 2014). Attending and organizing are performance skills that are needed to meet many occupational demands (American Occupational Therapy Association [AOTA], 2014b); their absence can disrupt performance patterns and ultimately compromise an individual's ability to engage in occupations (AOTA, 2014b). The aim of this project is to compensate for deficits in these performance skills through the use of mobile technology.

Mobile technology is fast becoming an integral aspect of how people interact with each other and perform routine tasks. The role technology, and ability for individuals to access and utilize technology, therefore, is well within the scope of occupational therapy's domain (AOTA, 2014b). AOTA advocates using technology to promote, maintain and improve function in ADL, work, education, leisure, play, social interaction, and sleep (AOTA, 2010).

Treatments and rehabilitation for those with brain injury have begun to increasingly use external memory aids, such as handheld computers and personal electronic devices to compensate for losses in memory and executive function (Costa, Campbell, Yarvi, & Cardell, 2014). We can assist individuals with TBI to compensate for critical cognitive performance skills by teaching their caregivers evidence-based methods of instruction to assist them in learning and

using technology. The website's aim, therefore, is to help individuals function within their chosen occupations by preventing a mismatch between person, environment, and occupation.

Limitations

A limitation of this project is that due to the variety of severity and symptoms of TBI, the website will possibly not be helpful for all caregivers of individuals with TBI. It likely will not benefit caregivers of individuals with severe cognitive, physical, and/or behavioral impairments due to TBI. It is most likely to benefit TBI survivors with awareness of their cognitive deficits and sufficient motivation to practice using compensatory aids.

Another limitation of this project was its piloting, which was only partially done with participants representing the website's intended audience out of convenience and due to a limited timeframe to access these participants. Some participants were not caregivers, but clinicians who had experience working with TBI. Ideally, the project team would have piloted the website with caregivers of individuals with mild TBI over a several week period, allowing them time to download, program, and implement one of the recommended mobile applications as instructed, and report back. This would have given valuable information for the website's usefulness, not only in its presentation of information but in its implementation as well.

For practical reasons, the project team chose to focus on Apple iOS devices and related software to highlight on the website. This limits the website's audience to owners or prospective buyers of Apple products. Many people fitting the project's target demographic may lack access to this technology due to cost. It would have been preferable to provide tutorials for a variety of devices, both low- and high-tech, but the project team decided it would be most beneficial to focus on Apple products due to their widespread use and accessibility features. By narrowly

focusing on these products, the project team was able to create detailed instructions on their use that would not have been achievable using a broader approach, due to project time constrictions.

Future Steps/Sustainability

Sustainability of TBI-Apps.com will require upkeep of web-hosting costs, monitoring for updates in Apple iOS and applications that might impact accuracy of existing tutorials, modifying tutorials in response to updates, and frequent testing of links to external resources to verify their working status. This upkeep will be performed every two months by one of the website creators, Ana Wright.

Future steps to improve TBI-Apps.com include: creation of additional application tutorials for a variety of mobile devices; tutorials on low-tech options; a way for visitors to recommend applications and share success stories via forum or comments section; and hardware reviews detailing pros and cons of different types/sizes of mobile devices with TBI survivors in mind, which may be carried out through future University of Puget Sound occupational therapy student projects or by the website creators themselves in the next year.

Conclusion

Three occupational therapy masters students created TBI-Apps.com to help caregivers and family members learn to effectively use mobile devices as compensatory aids in order to improve daily functioning and occupational engagement in individuals with TBI. TBI-Apps.com features step-by-step Apple iOS tutorials created specifically to compensate for long-term memory and executive functioning deficits commonly experienced by individuals with TBI. Mobile applications were selected based on ease of use and their similarity to technologies supported in research as effective with TBI. TBI-Apps.com also provides caregivers tips on how

to teach a TBI survivor to use the apps based upon occupational therapy cognitive rehabilitation approaches to facilitate learning.

Smartphone and tablet devices are widely used today and are predicted to be even more prevalent in the future. The authors' hope that the information provided by TBI-Apps.com allows for therapeutic treatment to continue in the hands of caregivers when individuals with TBI experience unmet cognitive needs due to limited time in rehabilitative care.

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Appendix A

Website Screenshots

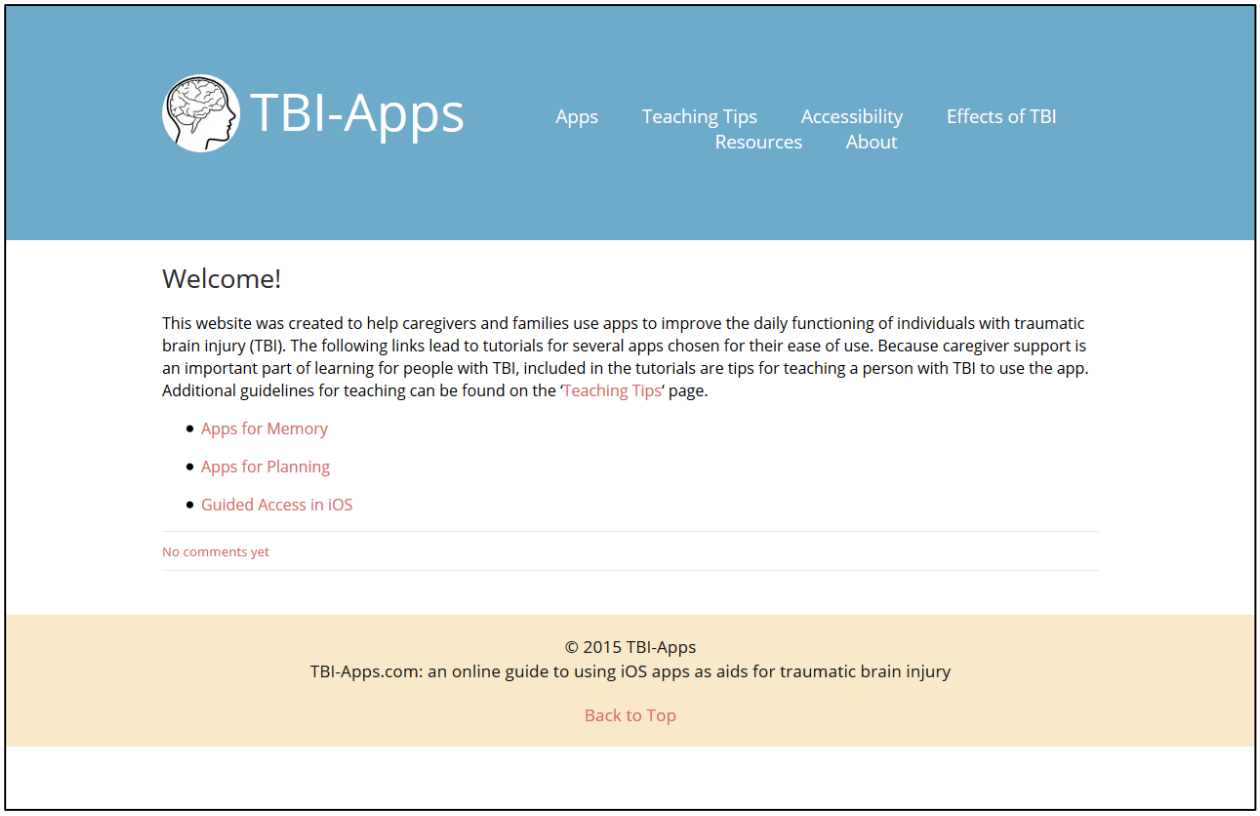

Figure 1. Screen shot of TBI-Apps.com "Apps" page. This figure shows the "Apps" page, which also serves as the welcome page of TBI-Apps.com. This page contains general website information and links to "Teaching Tips," "Apps for Memory," "Apps for Planning," and "Guided Access in iOS" pages. This figure and the following figures (Figures 2-6) also show the website logo, name, navigation menu, copyright, and footer that appears on each page of TBI-Apps.com.

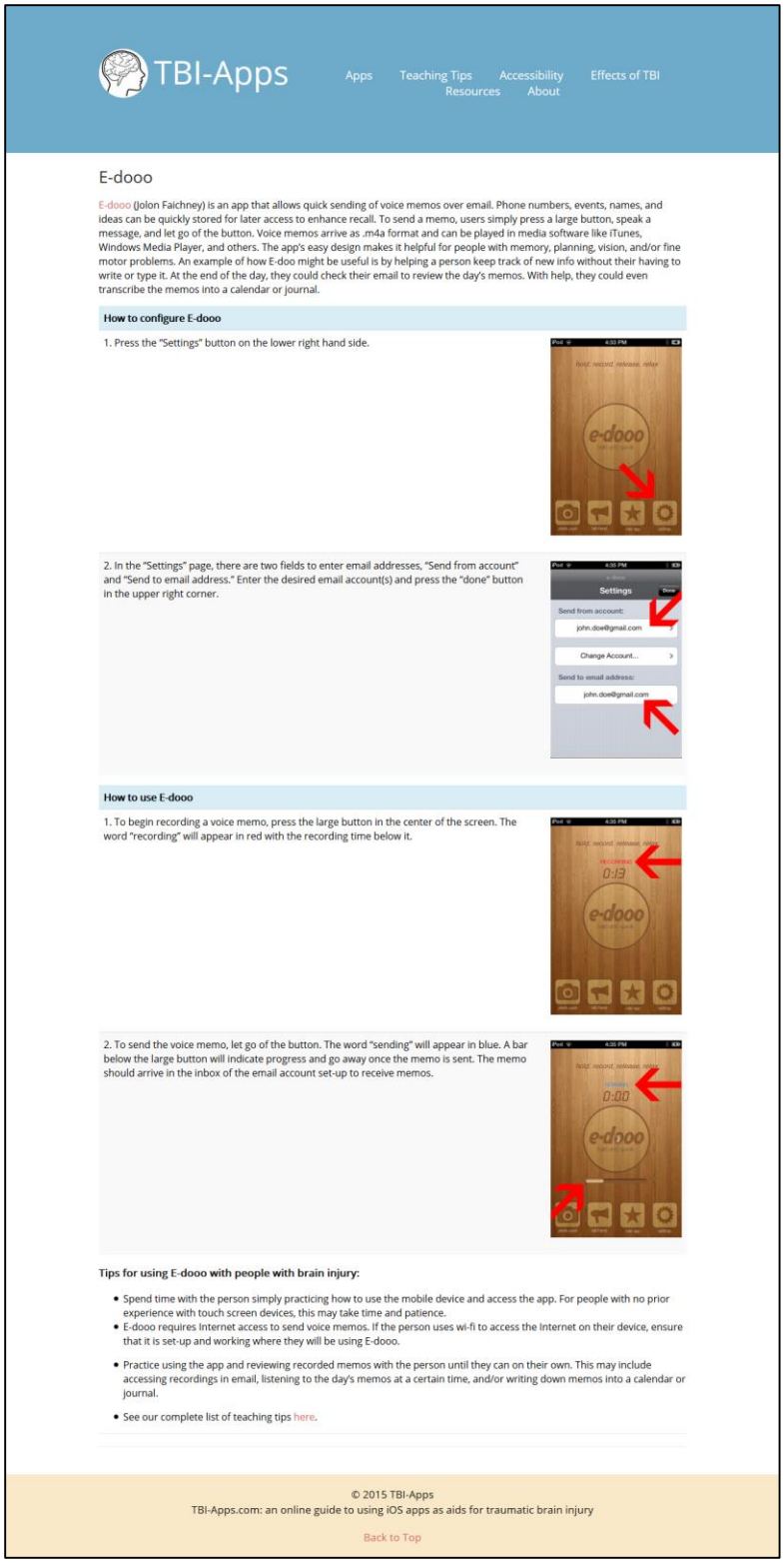

Figure 2. Screen shot of E-dooo tutorial. This figure shows an example of an Apple iOS tutorial on TBI-Apps.com.

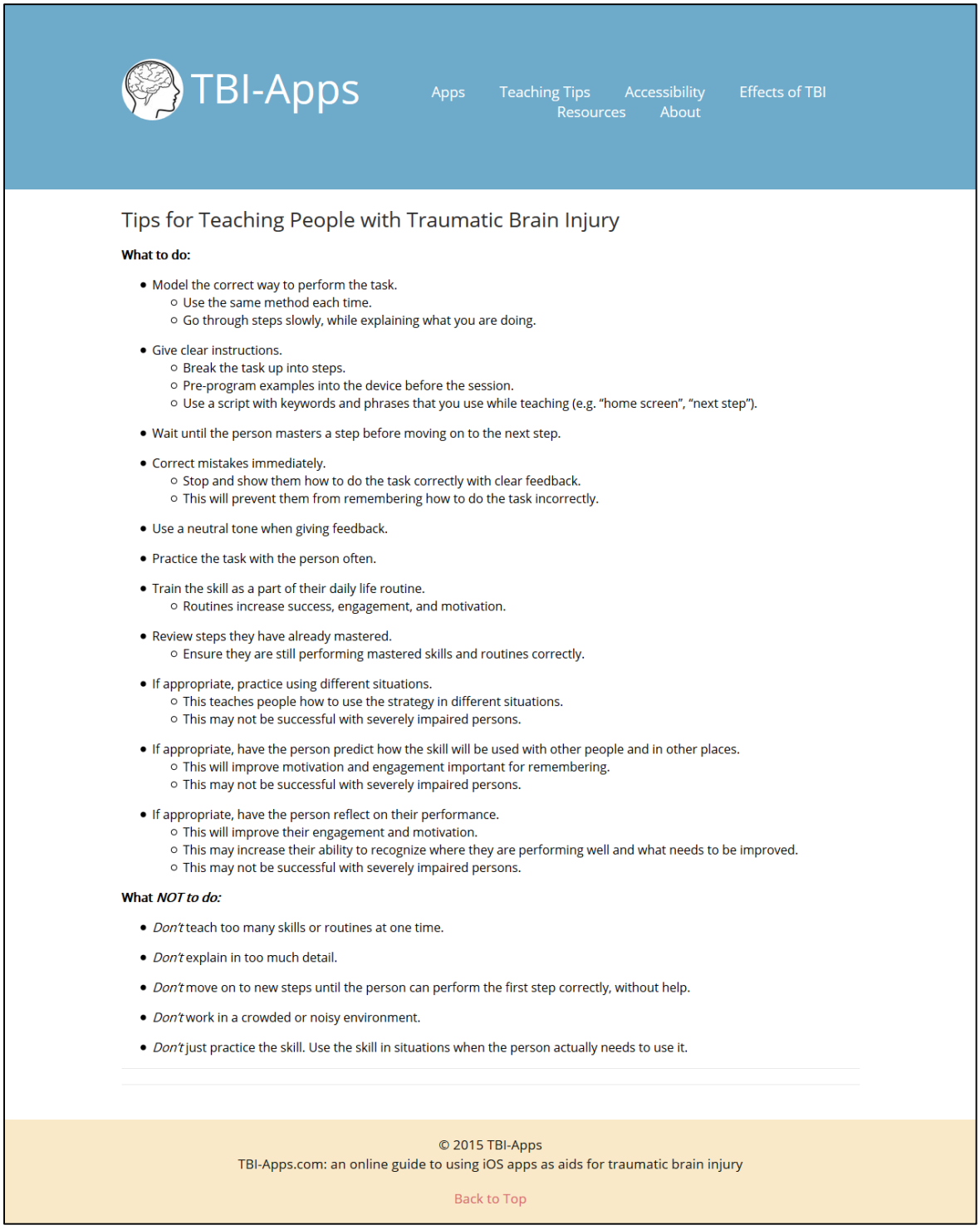

Figure 3. Screen shot of "Teaching Tips" page. This figure shows the page on TBI-Apps.com containing a list of tips for teaching people with traumatic brain injury.

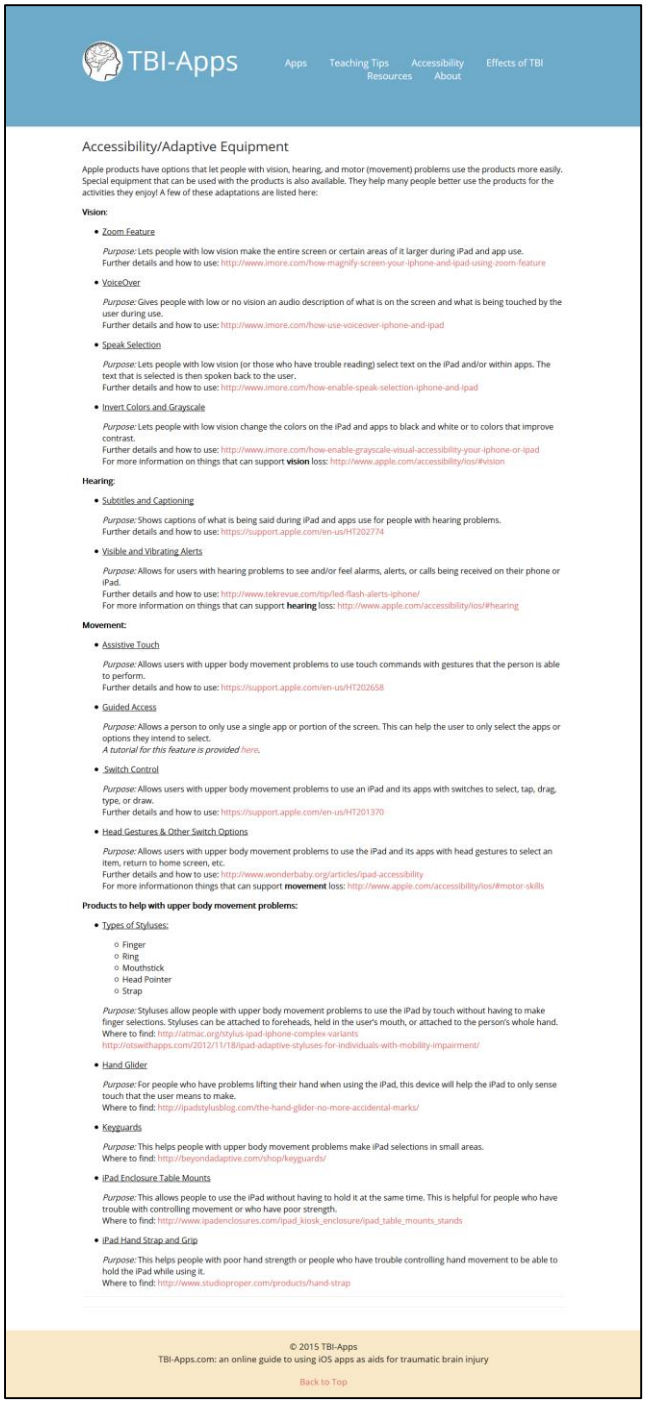

Figure 4. Screen shot of "Accessibility" page. This figure shows the page of TBI-Apps.com that describes Apple iOS accessibility features and additional products that may help individuals with deficits in vision, hearing, or movement, or upper body movement problems, use Apple products more easily.

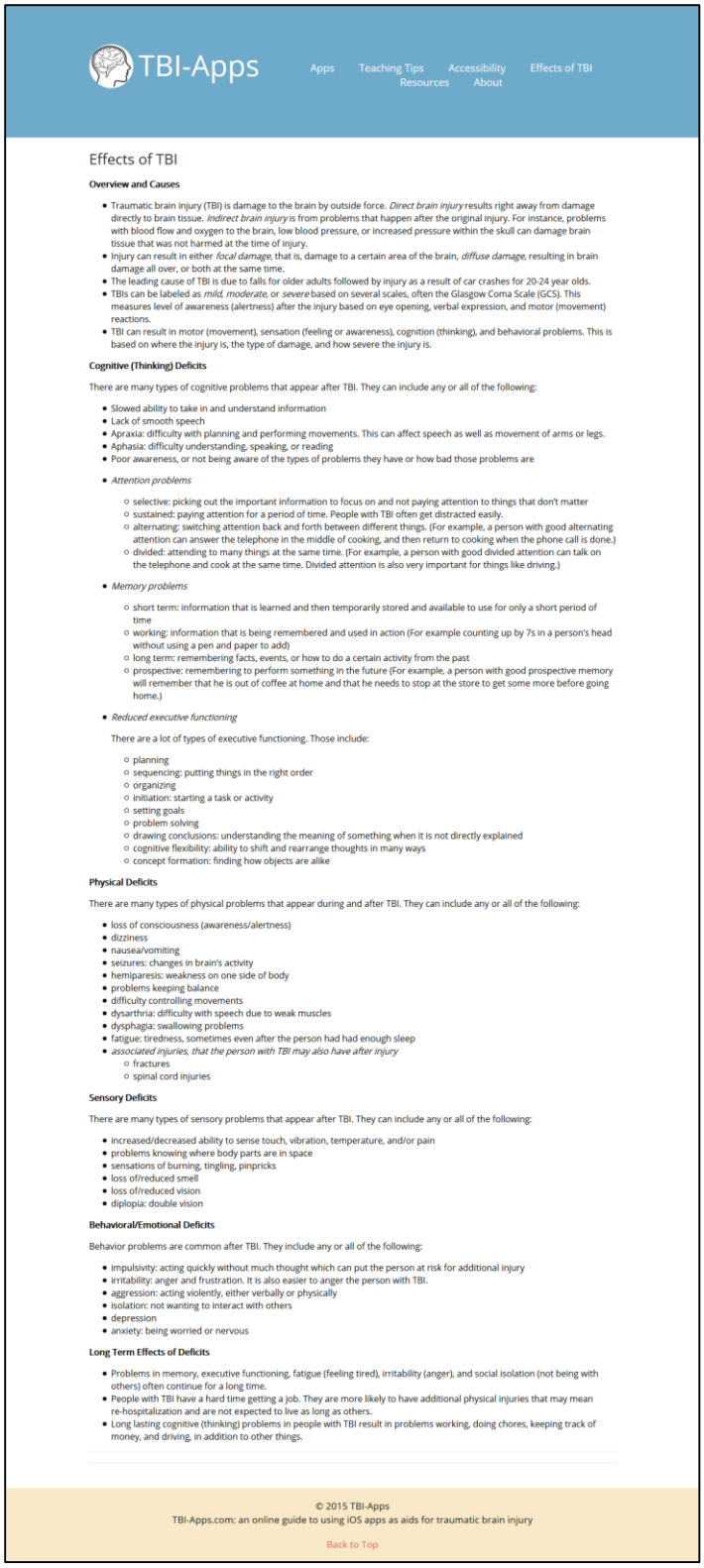

Figure 5. Screen shot of "Effects of TBI" page. This figure shows the page on TBI-Apps.com that displays information about TBI causes and deficits that may result from TBI.

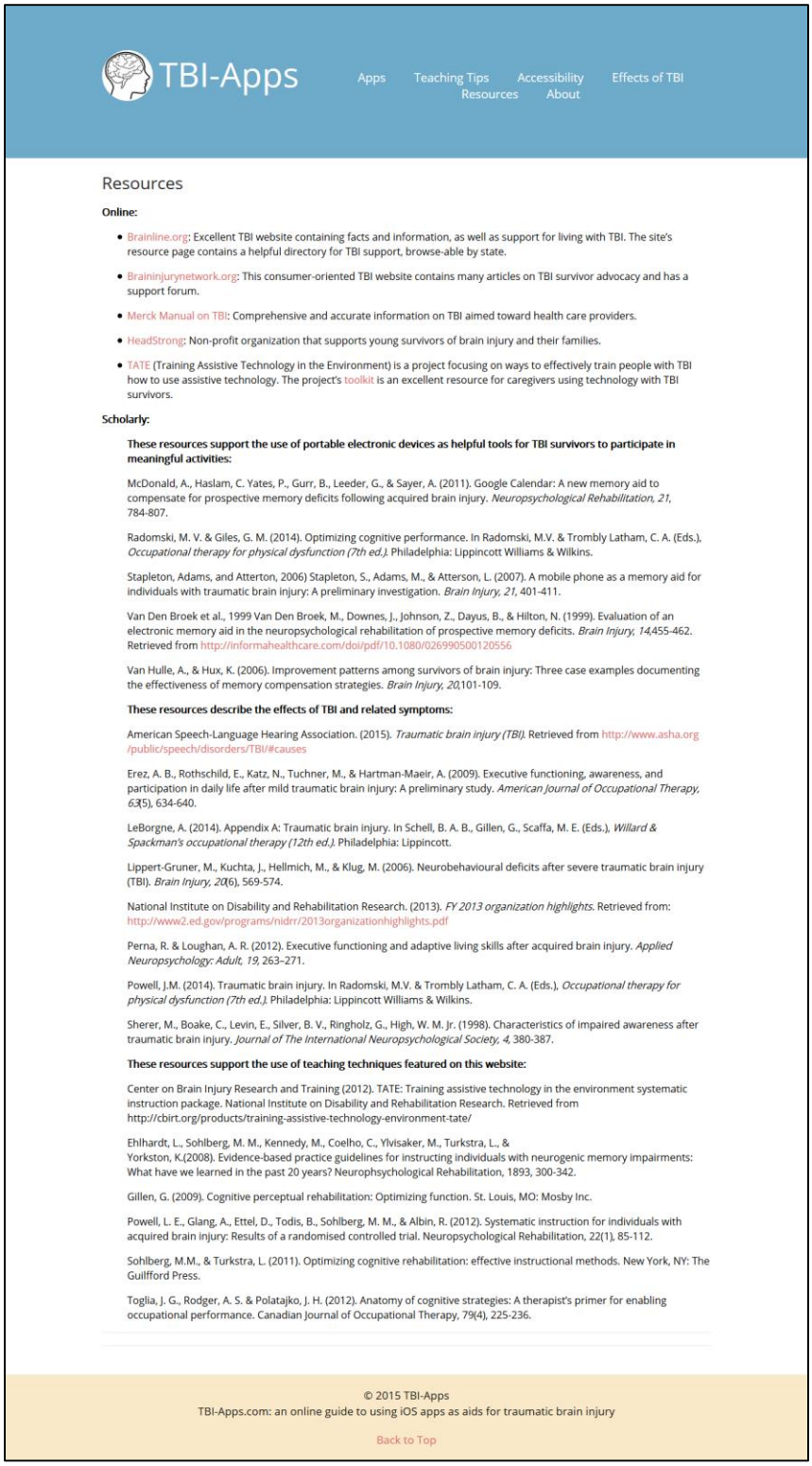

Figure 6. Screen shot of "Resources" page. This figure shows the page on TBI-Apps.com that lists online and scholarly resources a caregiver may use to learn more about TBI.

Appendix B

TBI-Apps.com Pilot Participant Quiz

Thank you for your participation!

Please take about 20 minutes to browse all the tabs on the website accessed at this address: www.tbi-apps.com Then please take about 10 minutes to answer some questions about the website content and to give your opinion on the website's usefulness. Those questions can be found in the attached document. Finally, please email your answers back to the following address: _____ by Friday May 1st so that we can make improvements on this website. Thank you!

1. List 1 application that would help an individual with memory problems and 1 application that would help an individual with difficulties planning. (type in your answer please)
   A. Memory Problems: _____
   B. Difficulties Planning:_____

2. Each of the following is a tip for facilitating learning for individuals with people with TBI experiencing cognitive deficits EXCEPT: (bold the correct answer please)

a. Immediately stop and correct mistakes.

b. Use different tasks or examples to generalize use of the app into everyday life.

c. Never ask them how they think they are performing.

d. Train in other places and with other people.

3. List 1 task or activity that you think would be more easily performed with one of the apps suggested for people with TBI experiencing memory and/or planning difficulties.

_____

4. All of the following are problems that people with TBI may experience EXCEPT:

a. Attention problems

b. Difficulty controlling movements

c. Aggression

d. Reduced taste

5. All the following are common causes of TBI EXCEPT:

a. Car accidents

b. Illness

c. Falls

6. Each of the following is a product or accessibility feature that can help people with upper body movement problems, vision problems, or hearing problems use tablets/smartphones EXCEPT:

a. VoiceOver

b. iCloud

c. Visible and Vibrating alerts

d. Hand Glider

8. If you were caring for a person with TBI would you find this website useful? Yes/No.

Why or why not?

9. Do you have any suggestions of things to change or include?