

Chapter 2

Assistive Technology for People with Acquired Brain Injury

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Introduction

Acquired brain injury (ABI) is the leading cause of death and disability worldwide (U.S. Department of Health and Human Services, National Institutes of Health [NIH] 2013). It has been reported that over 10 million people incur an ABI yearly across the globe (Bragge et al. 2012) and can cost the United States up to \$60 billion annually (Finkelstein et al. 2006). According to the NIH (2013), there are over 5 million people living with ABI in the United States today who require continuous support and assistance in completing daily tasks, particularly in the areas of cognition, physical mobility, adaptive behaviors, and engagement in socially appropriate behavior (Flanagan et al. 2008). These deficits can negatively impact the individual's social relationships, educational gains, employability, and community life (Ross et al. 2011).

ABI refers to damage to the brain after birth resulting in impairments in typical functioning (Fletcher et al. 1990). Causes of ABI can include infection, substance abuse, or loss of oxygen to the brain, as in the case of a stroke (US Department of Health and Human Services, Center for Disease Control [CDC] 2010). Traumatic brain injury (TBI) is the most common cause of acquired brain injury. TBI refers to an external injury to the brain and can be classified into two subgroups: closed head injury and penetrating head injury. A closed head injury occurs when an object suddenly and forcefully comes into contact with the

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individual's head. A penetrating head injury occurs when an object enters the individual's brain tissue. TBI is most often a result of falls, motor vehicle accidents, being struck by an object, sports accidents, or physical assaults. According to the NIH (2013), individuals between the ages of 15 and 24 years, those over 75 years, and those younger than 5 years are at the highest risk of sustaining a TBI.

The second major cause of ABI results from internal injury to the brain. A cerebrovascular accident (CVA), or stroke, is the most common type of internal brain injury in which blood supply to the brain is disrupted. This loss of access to blood can cause brain cells to die, leading to brain injury. Because CVA can impact a variety of areas of the brain, the resulting damage and deficits vary across individuals. Unlike TBI, which tends to have the highest incidence in people between the ages of 15 and 24, CVA is most likely to affect individuals over the age of 65 years (U.S. Department of Health and Human Services [CDC] 2012). While anyone is vulnerable to having a CVA, additional risk factors include poor diet, smoking, lack of exercise, excessive consumption of alcohol, and hypertension (CDC 2012).

Effects of Acquired Brain Injury

ABI can be classified as mild, moderate, or severe. Mild ABI is associated with a loss of consciousness for less than 30 min and temporary post-traumatic amnesia, in which the individual has difficulty recalling events surrounding the incident in which the damage was incurred. Moderate ABI is often caused by loss of consciousness for more than 30 min, but less than 24 h, and post-traumatic amnesia that persists for more than 24 h. Severe brain injury consists of loss of consciousness for over 24 h and post-traumatic amnesia persisting for 7 days or longer (Corrigan et al. 2010).

The impact of ABI on the individual's functioning can be temporary or permanent. For those individuals who sustain moderate to severe ABI, many may never fully recover and often require continued support (Maas et al. 2008). ABI may result in changes in personality as well as loss of cognitive skills such as memory or decision making, loss of communication skills, decreased mobility, loss of adaptive and leisure skills, and vocational skills (U.S. Department of Health and Human Services [NIH] 1999). In order to address these specific deficits and needs, effective rehabilitation treatments are needed throughout the lifespan.

Recovery and Treatment

Treatment goals for persons with ABI may be restorative in nature; that is, the goal may be to restore or improve the individual's functioning. For example,

participating in a virtual reality simulation may facilitate the re-emergence of a previously mastered behavior. An individual who was able to drive a car independently prior to sustaining an ABI may be able to regain that skill by learning to drive using a virtual reality program. Other goals may be compensatory in nature by assisting the person in adapting to their skill loss in order to interact with the environment. For example, an individual who has lost the ability to speak may make use of a speech-generating device in order to communicate their needs and wants. In some cases, compensatory goals may also produce restorative benefits. For example, an individual whose memory has been compromised due to ABI may have a compensatory goal of using an electronic device to remind him or her of appointments or tasks. The frequent use of this compensatory device may result in improved memory (de Jooode et al. 2010). All of these examples illustrate the use of assistive technology (AT) in both restorative and compensatory treatment for persons with ABI.

The developmental and refinement of assistive technologies has greatly improved treatment outcomes for individuals with ABI (Wallace and Bradshaw 2011). AT provides a means by which individuals with ABI can regain some of the independence, self-determination, and autonomy that was lost due to their brain injury (Dry et al. 2006). AT is defined as any item or equipment that is used to improve or maintain an individual's independence and/or functioning (Assistive Technology Act of 1998, 2004).

AT may range in complexity from low-tech to hi-tech. Low-tech AT refers to items or equipment that are readily available to those with and without disabilities, such as a pocket calendar intended to assist in planning and remembering tasks and activities. Low-tech AT is a frequently used, effective, and low cost option for supporting individuals with ABI across a range of skill domains (Evans et al. 2003). Hi-tech AT may include, but are not limited to, portable electronic devices to assist in memory (Sohlberg et al. 2007b), microswitches to allow the individual to interact with their environment (Lancioni et al. 2011d), or speech-generating devices to provide opportunities for communication and social interaction (Johnson et al. 2008).

The purpose of this chapter is to provide a review of the research supporting the use of low-tech and hi-tech AT with persons who have ABI as well as clinical and academic implications. The chapter is organized into skill domain areas in which AT has been applied to assist in the rehabilitation of persons with ABI. These skill domains include: (a) cognition, (b) communication, (c) leisure skills, and (d) vocational skills.

Cognition

ABI can have acute and lasting effects on cognitive functioning and may result in lifelong disability (Bergquist et al. 2009). One of the primary cognitive areas impacted by ABI is memory and executive functioning (Dry et al. 2006). Though

the severity of memory and executive functioning deficits varies across individuals with ABI, most experience some level of difficulty in storing and retrieving relevant information about themselves, other people, and events. Individuals with ABI may have difficulty completing simple tasks, such as remembering to take medication (Wilson et al. 2001), as well as more complex, organizational tasks such as scheduling and keeping appointments and recalling relevant information needed to complete tasks at home or at work (de Joode et al. 2010). Such cognitive deficits can further impact an individual's daily life by creating dependence on others for organizing and managing daily tasks and activities (De Pompei et al. 2008).

Research has yet to identify a treatment with restorative benefits for cognitive skills in persons with ABI. For this reason, most cognitive treatments are compensatory. The use of AT to compensate for memory and executive functioning deficits is considered to be the most effective treatment for memory impairments in persons with ABI (Sohlberg et al. 2007b). AT can be used to reduce the difficulty level of a given task or to reduce an individual's need to rely on cognitive skills in order to complete a task. For example, Van Hulle and Hux (2006) taught three individuals with TBI to wear a wristwatch with an alarm to remind them to take medication so that they did not have to rely on memory. Results of the study showed that two of the three participants made substantial gains in taking medication without the need for support staff reminders.

Although AT exist to improve functioning for individuals with ABI, there are numerous barriers to the use of AT by consumers (Gartland 2004; Lemoncello et al. 2011). Research indicates that few people are using electronic memory aids and instead rely on low-tech memory aids (Evans et al. 2003). The most commonly used types of external aid to cognition for persons with ABI are low-tech paper-based products such as calendars, "to do" lists, sticky notes and daily planners (De Pompei et al. 2008), or memory notebooks. Memory notebooks typically consist of daily planners and calendars, such as a weekly calendar, a "to-do" list, and a section to record the events of the day (McKerracher et al. 2005) (Fig. 2.1).

McKerracher et al. (2005) compared two memory notebook formats with a 46-year-old man with TBI. The first memory notebook was described as "standard" and contained two sections, a weekly calendar and a weekly to-do list, separated by a plastic divider. The second notebook was modified in that a daily schedule and a daily to-do list were placed on adjacent pages. The participant was taught to use each diary via systematic verbal prompting and feedback. Training was provided during the last 10 min of his scheduled rehabilitation sessions. Data were collected on the participant's performance on five tasks that involved memory, such as telephoning his case manager and bringing paperwork to his therapy appointments. Results showed that use of the modified memory notebook was associated with a higher number of tasks completed independently for the week than the standard memory notebook. These findings suggest that tailoring the design of memory

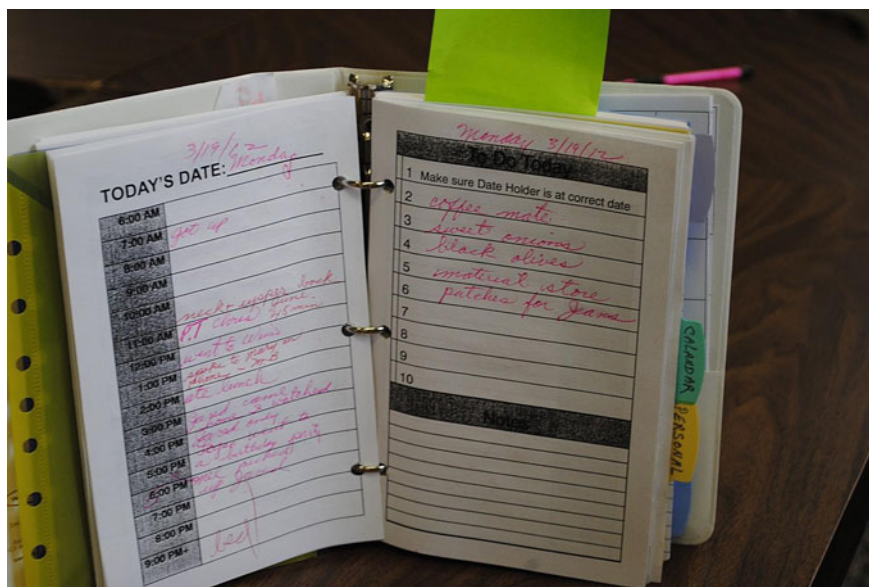


Fig. 2.1 Low-tech memory notebook. A low-tech memory notebook allows users to record appointments, create “to-do” lists, and record notes from the day. Retrieved from <http://news.wsu.edu/Pages/Publications.asp?Action=Detail&PublicationID=30980>

notebooks to patient characteristics and preferences may be beneficial in producing positive outcomes.

Sandler and Harris (1992) present a case study of a young adult male who sustained TBI at 18-years old and had significant memory deficits as a result. The patient lived in a long-term residential treatment facility for persons with TBI. The purpose of the case study was to evaluate the patient’s use of a memory notebook. The memory notebook consisted of a file folder, which contained a monthly calendar, a schedule of group meetings, and weekly therapy appointments. The researchers reported that during the first 3 months after the patient was provided the memory notebook, the patient misplaced the notebook regularly and did not bring it to therapy sessions or take it with him following the conclusion of the therapy session.

The staff made modifications to the memory notebook including (a) using a large three ring binder rather than a file folder to help differentiate it from other stimuli in the patient’s environment, and (b) adding a daily schedule to the notebook each morning. Instructional modifications were also made to enhance the patient’s use of the notebook. Prior to each therapy session or group meeting, the staff verbally prompted the patient to return to his room to retrieve the notebook. In addition, a visual task analysis was posted on the patient’s bathroom door prompting him to get the notebook, open to the calendar, and complete steps involved in determining the current day and appointments.

Ten months after these modifications were put in place, the authors reported the patient's use of the memory notebook improved and that he consistently brought the memory notebook with him to all appointments without verbal prompts. Though this is a case study, and experimental control was not demonstrated, the report does suggest that perhaps simply presenting individuals with a memory notebook may not be sufficient in improving outcomes without explicit instructions and other environmental cues.

In recent years, the use of hi-tech devices and technology has been the focus of research on AT to address cognitive needs of persons with ABI. Some drawbacks of hi-tech AT include the need for the patient to learn to use the device, which may require the use of cognitive skills, and the social stigma that may arise from interacting with the AT device or software (Wade and Troy 2001). However, the increased popularity, portability, and acceptability of technology in the daily lives of individuals without disabilities may help ameliorate the social stigmatization of reliance on AT. In contrast to low-tech AT, hi-tech AT provides "active reminders" to users by alerting them to the device or to the task to be completed (McDonald et al. 2011). Hi-tech AT for persons with ABI may include electronic devices that are widely used by individuals without brain injury such as pagers, cell phones, PDAs, electronic diaries, instant messaging programs, and Internet calendars (Bergquist et al. 2009; McDonald et al. 2011).

Electronic memory aids. Electronic memory aids have been used to support individuals with ABI in their daily lives by assisting them with driving (Anshutz et al. 2010; Klarborg et al. 2012; Lane and Benoitb 2011), dealing with getting lost (Lemoncello et al. 2010; Sohlberg et al. 2007b) and cooking (Zhang et al. 2001). Electronic memory aids may be used to assist individuals with tasks requiring higher-level cognitive skills, such as budgeting (Bergman 2002) and planning out daily routines (Boman et al. 2007; Fish et al. 2008; Gorman et al. 2003).

Boman et al. (2007) equipped two apartments with electronic aids for daily living (EADL) to assess if eight adult participants with moderate ABI would be able to utilize the AT to improve their ability to perform daily tasks (e.g., planning and preparing meals, remembering to lock doors, engaging in recreation and leisure activities). The EADL included AT such as (a) a stove guard that shuts off power when something is burning, (b) an alarm to signal that the refrigerator door has been left open or that there is a leak, and (c) a remote control placed next to each participant's bed that will turn off all lighting, power to stove, and will alert the participant if the front door is unlocked. Results showed that it took participants a median of 4 weeks to learn how to use these EADL with a range from 2 to 24 weeks. Most participants also rated themselves as having less difficulty engaging in daily living activities as a result of the EADL. Despite these promising results, research in the use of AT embedded into home environments is an emerging area where continued research is needed.

Handheld electronic devices. Smartphones, and other handheld electronic devices such as pagers, personal data assistants (PDAs), electronic diaries, and pocket computers may be used to compensate for cognitive impairments in persons with ABI. Software that generates reminder messages can be linked to a variety of



Fig. 2.2 Tablet calendar application. The visual schedule planner is an audio-visual tablet application which allows users to create and manage daily, weekly, and monthly schedules. The visual schedule planner is produced by Good Karma Applications, Inc., San Diego, CA

small portable devices in order to cue, or remind the user to complete specific tasks or attend appointments (Thone-Otto and Walther 2003). Such handheld devices can then deliver reminder messages using a variety of outputs such as voicemail, beeps, alarms, text messages, or visual cues. While the portability and lack of social stigma are benefits of handheld electronic devices, practitioners may find it necessary to program the device with a reminder message in the morning to alert the individual to utilize the device during their day (De Pompei et al. 2008) (Fig. 2.2).

Smartphones and cellular phones represent one means of providing individualized support to persons with ABI without drawing attention to their disability. These mobile phones have been shown to assist in compensating for memory impairments by assisting with planning and organization for persons with ABI. Wade and Troy (2001) investigated the effectiveness of cellular phones as AT for persons with memory impairments by providing a specially programmed cellular phone to five individuals with ABI resulting from stroke or TBI. The purpose of the phone was to assist the user to remember to engage in specific daily tasks. Tasks included taking medication, going to lunch groups, taking a walk, preparing a meal, and heading for the bus stop. Each participant's cellular phone was loaded with individualized, pre-recorded messages. Participants were provided with the

phones and were given verbal instructions about how to answer the phone to hear the pre-recorded messages. Data were taken on the number of daily tasks the participant completed independently before and after each was provided a cellular phone. Results for all participants showed the use of the cellular phone as a memory aid increased independent engagement in daily tasks.

Similar to smartphones, handheld electronic devices have been used to remind adults and children with ABI to complete daily tasks in rehabilitation and community settings (De Pompei et al. 2008). PDAs and other handheld computers allow the user to receive messages in a variety of settings away from a desktop computer. PDAs have also been used to compensate for cognitive skills required during navigation. For example, Kirsch et al. (2004) taught a 19-year-old male with TBI to use a PDA to help him navigate from one therapy room to another at a rehabilitation treatment facility. The PDA was programed to display a screen with a landmark image in the center and instructional text telling the individual what landmark to attend to and to tap the screen when he arrived at that landmark. The PDA also delivered these written instructions using speech-generating technology. Data were collected on the number of errors made en route during each transition from one therapy room to the next. Results showed that the participant made fewer errors when the PDA delivered navigational cues (e.g., "Turn right here") compared to when it did not.

Sohlberg et al. (2007a) compared the efficacy of four modes of prompting for route finding provided via a wrist-worn electronic device (i.e., Hewlett-Packard iPaq pocket PC) on the navigation of 20 individuals with severe cognitive disabilities due to ABI. These four types of prompts included (a) aerial map image, (b) point of view map image, (c) text only instructions, and (d) audio only instructions. The effects of the four types of prompts on participant's pedestrian route finding skills were evaluated. Results showed that participants' performance was better when provided audio only instructions and they also preferred this type of prompt to the others assessed. These findings suggest that future research should focus on determining the most effective type of prompting to use when using hi-tech devices. Hi-tech devices often enable researchers and clinicians to utilize a number of different types of prompts and some may be more appropriate for some tasks and/or rated as more highly preferred by individuals with ABI.

Internet resources. Online calendar programs have been shown to support the cognitive needs of persons with ABI. Online calendars have the benefit of being accessible on a desktop computer as well as on handheld devices such as tablet computers, PDAs, and smartphones. One online calendar is Google Calendar, a free Internet-based calendar that allows users to schedule one-time and recurring appointments and store relevant information for each appointment, such as location and phone number. Google Calendar can also be synced to smartphones, tablet, and desktop computers in order to allow the user to enter appointments from a variety of locations. Google Calendar will also notify the user, via the synced devices, of upcoming appointments.

McDonald et al. (2011) compared the use of Google Calendar to a standard paper diary on daily memory tasks with 12 adults with ABI. Data were collected

on the number of events successfully recalled each week and the percentage of appointments/tasks completed correctly. Results showed that Google Calendar was more effective in improving performance on planning and organizational skills than the paper diary. Nine of the 12 participants indicated they preferred Google Calendar to the standard diary and anticipated continuing to use it. All participants stated they would recommend the Google Calendar to others.

De Jooode et al. (2012a) successfully taught 15 adults with ABI to manage daily appointments and events using Microsoft Outlook© 2003. Microsoft Outlook© is another example of an electronic calendar. However, participants with ABI tended to exhibit increased frustration with the software and increased cognitive fatigue as compared to individuals without ABI. As such, for individuals who have difficulty navigating through a standard Internet program, it may be beneficial to explore software and devices designed specifically for persons with ABI.

ABI-specific. Some of the technology frequently used by individuals without disabilities may be too complex for individuals with cognitive impairments resulting from ABI (Sohlberg et al. 2007b). To better fit this population's needs, devices and software specially designed for persons with ABI are available. These devices and software are adapted to meet the needs of persons with ABI by being simple to use and free of distractions. ABI-specific AT may include specialized calendar and diary software, specialized pocket computers, and voice prompting systems (Thone-Otto and Walther 2003; Wright et al. 2001).

One type of ABI-specific memory aid for persons is an alphanumeric pager prompting system in which pagers can be programmed to deliver short text prompts at specific times. The NeuroPage™ (Hersh and Treadgold 1994) is an example of a pager designed for individuals with ABI. NeuroPage is a portable pager that can be attached to a belt and contains a screen and one large button, making it easier to use for persons with motor difficulties. Messages and reminders are entered into a computer, sent to the paging company, and then displayed on the NeuroPage™ at predetermined times.

Fish et al. (2008) compared the effects of a self-monitoring checklist to the use of the NeuroPage™ on task engagement for a woman with ABI. The pager provided 14 daily reminders to engage in specific activities (i.e., orientation/alarm clock, complete morning hygiene and dressing routine, complete activity for the day, meal preparation, take medication, complete evening hygiene and dressing routine). The written self-monitoring checklist aimed to decrease perseverative behavior (i.e., morning routine took 5 h due to compulsive and repetitive behaviors). As she completed each discrete step of her morning routine she was to check off the box next to the step and record the total amount of time her routine took. An alternating treatments design was used to evaluate the two interventions with the final experimental phase consisting of both the pager and checklist.

Results indicated that the pager was associated with shorter tasks duration and higher number of tasks completed (i.e., morning and evening routine and take medication) than the checklist. The results of this study indicate the potential positive outcomes of using a device such as a pager that delivers a tactile prompt followed by a message to change the behavior of individuals with persistent

difficulties remembering to engage in daily activities. Additional reminder prompts may be especially useful for individuals who engage in maladaptive behaviors (e.g., obsessive compulsive behaviors) that may prevent them from successfully using memory aids that require them to remember to shift their attention to the cue.

Similar to the alphanumeric pagers, voice prompting systems have also shown benefit to individuals with ABI. Voice prompting systems can record the user's voice and then use the recorded messages to deliver auditory prompts to the users at the necessary times. For example, Hart et al. (2002) taught five adults with ABI to use a voice prompting system in order to record and review their therapy goals. They found that when the participants recorded their goals and then replayed their recording three times daily using the voice prompting system, they were better able to recall and follow through with their goals than those participants in the control group who did not use a voice prompting system. Examples of voice prompting system devices include VoiceCraftTM and Voice Organizer. The VoiceCraftTM is a handheld alarm that beeps and presents a voice output message to prompt the individual to engage in a specific behavior (Van Hulle and Hux 2006).

The Voice Organizer is a handheld device that can be programmed to recognize specific speech patterns and is able to record an individual's voice and then play back those recorded messages at specific times. Van den Broek et al. (2000) evaluated the effects of using the Voice Organizer on completion of daily routines for five adults, ages 25–56 years, with ABI. The effect of the Voice Organizer on completion of daily tasks was compared to use of a paper and pencil to-do list. In the paper and pencil condition, the participants were told they could write down tasks they needed to complete, but they were not to use any other form of memory aid. In the Voice Organizer condition, participants were taught how to record messages and program messages to be played at specific times in order to remind them to complete daily tasks such as vacuuming and cleaning tables. However, the authors did not provide detail on teaching procedures utilized to train participants to use the Voice Organizer. Results suggest that for four of the five participants, performance scores on completion of daily tasks were higher when participants used the Voice Organizer than when participants used paper and pencil to-do lists. Though preliminary, these findings suggest that use of the Voice Organizer may be beneficial for individuals with ABI who have difficulty remembering to complete specific tasks. It is unknown, however, if the Voice Organizer as a product is more beneficial than other handheld voice prompting systems.

Prompting systems may also make use of other technology, such as wrist-watches (Van Hulle and Hux 2006) or televisions. The Television Assistance Prompting (TAP) system is a device that contains a small computer that is affixed to a television. The system is designed to provide users with familiar interface and tools (i.e., TV screen and a remote control). The TAP system automatically turns the television on and off in order to deliver messages to the user at pre-specified times using text, visual images, or audio output. These messages are composed using a computer with Internet access and are stored on a secure Internet server (Lemoncello et al. 2011).

Lemoncello et al. (2011) conducted a randomized controlled crossover trial study in order to evaluate the use of the TAP system on the completion of daily cognitive tasks. The authors sought to determine if adults with ABI were able to complete more tasks when the TAP system was installed in their home as compared to their usual memory aids. Twenty-two adults with ABI participated in the study and were randomly assigned to the TAP or control group. Each group experienced both treatment conditions twice by moving to the other condition every 2 weeks. In the control condition, participants were permitted to use the memory supports they typically used, such as adult prompting, calendars, or notes. In the TAP condition, reminders to complete tasks were delivered using the TAP system, which was installed in each participant's home. Care providers were asked not to provide any additional prompts or reinforcement during the 2-week TAP condition.

In each of the two conditions participants were asked to complete six tasks including two preferred tasks, two non-preferred tasks, and two tasks assigned by the researchers. Tasks included such activities as taking medication, completing chores, following up on therapy tasks, going out to eat, and engaging in hobbies. Data were collected on the percentage of tasks independently completed during each condition. Data were also gathered via semi-structured interviews on the participants' satisfaction with the supports provided in each condition. Results for task completion showed that task completion was higher in the TAP condition for both groups than in the control condition with a medium-to-large effect size. Participants reported that the TAP system was easy to use and helpful. The results of this study show that the TAP system is a promising means of incorporating AT into the daily lives of individuals with ABI. However, this is a new technology and replication of these findings is warranted. At the time of the writing of this chapter, the TAP system was not commercially available. Future research is needed to make the TAP system affordable and available to consumers.

Summary. The use of both low-tech and hi-tech AT to compensate for cognitive impairments in individuals with ABI is supported in the literature. Decisions about what type of device to use and whether/how to customize the AT require knowledge of the individual's skills, preferences, and needs. The demands and characteristics of the environment in which the AT is to be used should also be considered. For example, if one is considering a voice prompting system, they will want to consider the noise level of the environment in which the system is to be used to ensure the patient will be able to attend to the prompts. Finally, sustained use of the AT system depends in part on the acceptability, feasibility, and suitability of the AT system to the patient with ABI and his or her support staff (De Pompei et al. 2008).

Communication

The ability to express one's wants, needs, and opinions is an everyday skill that many of us take for granted. For a person who sustains an ABI, this ability to communicate can change suddenly and profoundly. An individual who possesses a functional communication system often has frequent social interactions, has the ability to communicate his or her wants and needs, can voice choices and decisions, and tends to have a greater sense of self-determination than those individuals who lack functional communication (Fox and Sohlberg 2000). Sustaining an ABI can greatly impact this functional communication system.

The change in communication resulting from an ABI varies widely across individuals in terms of severity and duration of impact. Some individuals may have poorly organized speech, making it difficult for a listener to follow the conversation. Others may lose the ability to speak altogether. These communication impairments may be temporary or may persist throughout the persons' life. Common communication impairments following ABI include aphasia (i.e., difficulty speaking or understanding language), apraxia (i.e., poorly coordinated oral motor movements needed to produce clear speech sounds), slow or hesitant speech, deficits in pragmatics (i.e., maintaining a socially appropriate conversation), disorganized speech, or total loss of speech. The impact of the ABI on communication may be exacerbated by cognitive deficits and motor skills resulting from the ABI. These deficits may make it difficult for individuals with ABI to acquire and successfully use new communication strategies (Wallace and Bradshaw 2011).

AT for communication typically involves the use of aided Augmentative and Alternative Communication (AAC; see Chap. 4). Aided AAC involves the use of external materials, such as pictures, electronic devices, books, or boards with text, to assist the person in expressing his or her wants, needs, and opinions. Aided AAC may be used to augment communication by supplementing the individual's existing speech in order to aid clarity and structure. For example, for an individual who has difficulty organizing his speech, a list of key phrases may be written on a card to help cue him to sequence their conversation in a logical manner.

Aided AAC may also be used as an alternative to speech in cases in which speech is no longer present or is minimal or unintelligible (Garrett et al. 1989). Persons with ABI who have total loss of communication may use an alternative communication system in which they point to symbols or pictures representing their wants, needs, and opinions (Johannsen-Horbach et al. 1985). AAC may help compensate for loss of communication skills, thereby allowing the individual to more clearly and effectively communicate. In some cases, the use of AAC has resulted in restorative communication, particularly with young children (Bodine and Beukelman 1991).

AAC has been used to address (a) receptive language skills that involve understanding what is heard or read; (b) expressive language skills, such as labeling, requesting, or commenting; and (c) pragmatic skills needed in social interactions and conversations. Pragmatic skills are one of the hallmark communication

impairments of individuals with ABI (Bellon and Rees 2006). For example, persons with ABI may have difficulty initiating a conversation, and attending to and adjusting the conversation based on listener cues. These deficits in pragmatics can result in fewer opportunities to interact socially and can lead to social isolation and withdrawal (Bellon and Rees 2006; McDonald 1993).

Low-tech AT is the most common form of AT to address communication deficits in persons with ABI (Fried-Oken et al. 2012). Low-tech AT tends to be inexpensive, easily transportable, and often can be created using readily available materials (Wallace and Bradshaw 2011). Examples of low-tech AT for communication include paper and pencil, written symbols, photographs, letter boards, visual scene displays, and thematic dictionaries (Garrett et al. 1989). Low-tech AT is often used to cue a person to talk about a certain topic, to organize their conversational speech, and to assist in recalling names of specific people or places or details of events. For example, looking at photos from a specific event may assist the person in describing details of the event, including people in attendance or activities that took place (Wallace and Bradshaw 2011). Specific types of low-tech AT for communication include iconic symbols and visual scene displays.

Iconic symbols. Iconic symbols refer to visual representations including pictures, drawings, or symbols of concrete (rather than abstract) nouns, such as people, places, and objects. Research has shown that individuals with ABI are more likely to remember and generalize use of iconic symbols rather than abstract symbols when attempting to communicate (Beck and Fritz 1998). Iconic symbols can be used to facilitate expressive communication by prompting the person to recall and talk about a certain person, place, or event.

These iconic symbols are frequently stored in a communication book. A communication book usually consists of a few pages that have symbols depicting information pertaining to the person with ABI. For example, there might be a page with a photograph of a flower and text at the bottom of the page that reads, "I like to spend time in my garden." Information relating to past or future events as well as hobbies, family, and important people in the individual's life may also be stored in the communication book. In some cases, remnant materials, such as souvenirs or objects like a ticket stub, relating to specific events may be adhered to the book page rather than photographs or drawings. The communication book can be used to prompt the individual to share information with others in conversation. Communication books are typically used with individuals who have difficulty retrieving information when speaking (see Chap. 8) or who have poor receptive language skills (Wallace and Bradshaw 2011).

Ho et al. (2005) examined the effects of a communication book and the stimuli presented within the communication book on social initiation and maintenance of conversations. Two adults with ABI resulting from a stroke (CVA) participated in this study. Both participants had aphasia (i.e., difficulty speaking or understanding language) and had either no verbal communication skills or spoke in fragmented phrases as a result of their ABI. Participants were exposed to three conditions: (a) no communication book, (b) communication book with iconic symbols (computer-generated drawings generated from Boardmaker[®] software), and (c) communication book with

remnants (e.g. maps, photos of family members, tickets). Each page of the communication book contained a simple sentence and a corresponding remnant or image.

Using an ABA design with an embedded alternating treatment design, participants were exposed to the three conditions once daily for 5 days. In each 5-min session, the participant was seated with a conversational partner who was instructed to ask a few open-ended questions to the participant. During the conditions in which the communication book was present, the conversational partner opened the communication book and turned to a page in order to prompt the participant to initiate a comment/conversation. Results showed that both participants initiated more conversations and had fewer communicative breakdowns when the communication book consisting of pictures or consisting of remnant materials were used as compared to when the books were absent. Participants responded more to social initiations during the communication book with remnants condition as compared to the communication book with iconic symbols. There was considerable overlap on social initiation and maintenance of conversation across the communication book with remnants versus with iconic symbols conditions for both participants suggesting that both sets of stimuli may be effective for persons with ABI.

Determining what types of images or pictures to include in a communication book for persons with ABI may present a challenge to clinicians. McKelvey et al. (2010) examined participant preference and accurate use of three types of visual stimuli often included in communication books. These three types of visual stimuli included: (a) personally relevant, contextualized images (photographs in which familiar people, objects, and/or places are depicted within a scene), (b) contextualized images without personally relevant features (commercially available photographs of scenes which include people, objects, or places unfamiliar to the individual), and iconic images (computer-generated drawings generated from Boardmaker[®] software). Participants included eight adults who had sustained a stroke and who were between the ages of 25–86 years with a mean age of 61 years. The first phase of the study was to assess the participants' preference for each type of visual stimuli. The researcher presented the participants with three images, one from each visual stimulus category, representing a single word. The participants were asked to select the picture they preferred. This procedure was repeated across 45 target words with the position of each visual stimulus counterbalanced across trials. Results showed that for 79 % of trials participants preferred the personally relevant, contextualized stimuli over the contextualized stimuli and the iconic images.

In the second phase of the study, the researchers examined the accuracy with which participants could match a target word to the corresponding image across visual stimuli groups. The researcher verbally stated a target word and asked the participants to identify the corresponding picture out of an array of three pictures, one from each visual stimulus category. Only one picture matched the target word. Results showed that, overall, participants were most accurate when matching words to personally relevant, contextualized photos rather than to iconic images or noncontextualized photos. The findings from this study suggest that individuals with ABI may prefer certain forms of visual representations for communication and that these preferences can be assessed within a trial-based format.

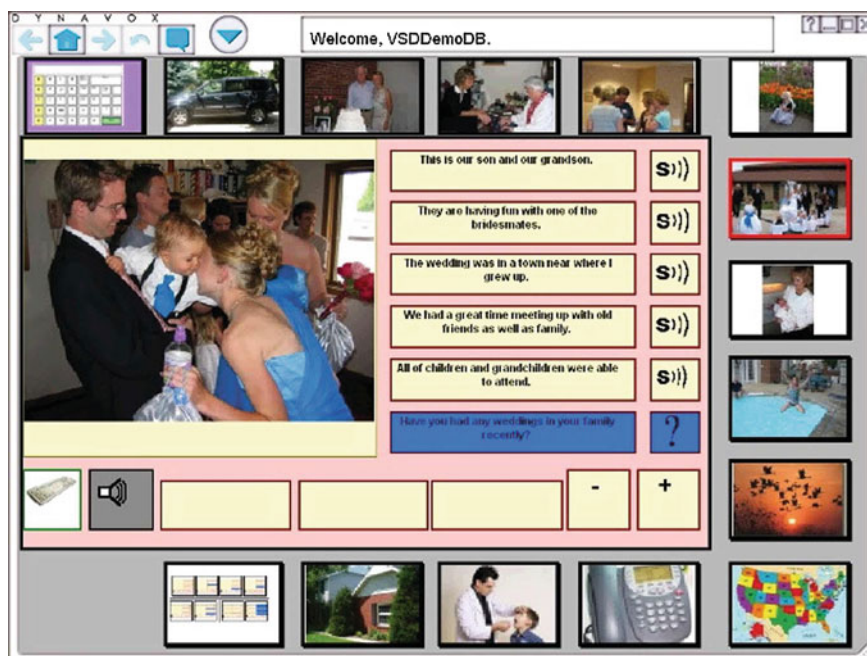


Fig. 2.3 Visual scene display. A hi-tech visual scene display provides contextualized images, written cues along with speech-generating technology to support communication. Adapted from Fried-Oken et al. (2012)

Additionally, the use of personally relevant, contextualized images may promote more accurate communication for individuals with ABI. This finding might be expected given that one of the communication deficits associated with an ABI is difficulty linking abstract images with meaning (Fox et al. 2001). By making these images more concrete and relevant to the individual's life, individuals may be more likely to connect those images with the corresponding words and descriptions and generalize their use to communication exchanges.

Visual scene displays. Similar to personally relevant, contextualized images, visual scene displays place an individual's personal experiences, information, and interests into a concrete format. The goal of a visual scene display is to depict the relationships that exist between the individual and those people and events around him or her (Hux et al. 2010). For example, a visual scene display may include the person's family members gathered around a table eating dinner. At the bottom of the picture, there may be a brief sentence describing the event or the relationship among the people in the photo. Both the individual with ABI and their conversation partner are able to view and refer to the visual scene display in order to co-construct a conversation. Visual scene displays have been used to assist persons with ABI in retrieving and expressing relevant personal information. Visual scene displays can be used with low-tech or with hi-tech AT systems (Fig. 2.3).

Low-tech visual scene displays are typically static photos that can be part of a communication book or a separate document. For example, Hux et al. (2010) taught a 61-year-old male with ABI resulting from CVA to use a low-tech visual scene display. Two pages with visual scene displays were placed in a communication book. One scene depicted a photograph of the participant working on the engine of a classic Chevrolet—a car that was very important to the participant. The second depicted a classic car show. Below each picture were three to five brief phrases relating to the scene depicted on that page. Data were collected on the content and quality of conversations when the visual scene display was (a) present but only viewed by the participant, (b) present and viewed by the participant and the conversation partner, or (c) when the visual scene display was absent. Results showed that when the visual scene display was present and viewable by both the participant and the conversation partner the quality and detail of the content discussed was higher than in the other two conditions. These findings highlight the importance of using a visual scene display as a means for both conversation partners to co-create and guide the conversation.

Although less often used in clinical practice, research has shown hi-tech AT to be an effective means of promoting functional communication in individuals with ABI (Fried-Oken et al. 2012). Hi-tech AT for communication may include speech-generating devices, computer software and interfaces, as well as applications for tablet computers. Hi-tech AT can be similar in many respects to low-tech AT for communication. Many software programs utilize yes/no sections (Doherty et al. 2002), keyboards for spelling out messages (Lancioni et al. 2011a), and visual scene displays (McKelvey et al. 2007).

Speech-generating devices. AT devices may also be used to provide an alternative means for the person with ABI to communicate. Such devices for persons with ABI typically include a speech-generating device (SGD). An SGD is a portable device that produces a pre-recorded (digitized) or synthesized verbal message when activated. Simple SGDs may include a single button, or switch while more complex SGDs can contain dynamic displays that require the user to scan through visual menus in order to select the content of the message they wish to communicate (Wallace et al. 2010). Most SGDs usually involve touch screens that can be activated with hand touch, eye gaze tools, optical head pointers, or joysticks. In some cases, SGDs can be paired with microswitches to enable individuals with limited motor movements to activate the device and communicate their wants and needs (Lancioni et al. 2010a) (Fig. 2.4).

Lancioni et al. (2009b) paired a microswitch with an SGD in order to teach a 35-year-old man with severe TBI and minimally conscious state to request caregiver assistance or attention using an SGD. The participant was seated in a wheel chair and was able to activate the SGD by moving a small device located near his stomach. When activated, the microswitch triggered the SGD to produce a verbal request for a caregiver. The caregiver then responded by providing attention and physical proximity to the participant. Results showed that when use of the SGD led to social interaction with the caregiver, the participant's use of the SGD increased. The results of this preliminary study suggest that individuals with severe ABI may

Fig. 2.4 TouchTalk. The TouchTalk is a lightweight tablet-like speech-generating device with a dynamic display. The TouchTalk is produced by Lingraphica®, Princeton, NJ, USA



be able to initiate social interaction through the use of microswitches paired with SGDs. Research is still needed to determine how these social interactions might be maintained through the use of AT.

Speech-generating technology has recently been combined with hi-tech visual scene displays in order to promote effective functional communication for persons with ABI. This technology can be created using computer software to display a scene or an event from the individual's life onto a computer, SGD, or tablet screen. When an individual clicks on a certain location on the screen, called a hot spot, the computer utilizes speech-generating software to state a relevant word or phrase. For example, when the image of an airplane is selected the phrase, "I like to watch airplanes" may be generated. As in the low-tech counterpart, hi-tech visual scene displays are designed to facilitate and structure conversations.

McKelvey et al. (2007) evaluated the use of a visual scene display on a portable speech-generating device on behaviors associated with communication breakdowns. The participant was a 61-year-old man who had sustained a stroke and had aphasia and apraxia of speech. The visual scene display software presented a single page that contained personally relevant, contextually rich photographs, text boxes describing the photos, and speech buttons. When the participant touched the speech box, a digitized speech message of the text in the text box was produced. The participant engaged in conversations with unfamiliar partners in the presence and in the absence of the visual scene display software. Data were collected on the frequency of specific communication breakdown behaviors including self-talk, discussion of his disability and difficulty communicating, and inappropriate questions/responses. Results suggest that when the visual scene display software was in use, fewer communication breakdowns occurred as compared to when the software was absent. These preliminary findings suggest that individuals with ABI may be able to improve the quality of their communication interactions through the use of visual scene displays. This is a cutting edge area of research, however, and more data are needed to make conclusive statements regarding the use of this technology.

Summary. Both low-tech and hi-tech AT has been shown to augment or provide an alternative means of communication for persons with ABI. When determining what type of AT to use to support the individual's communication skills, clinicians should consider the cognitive as well as motor skills of the individual with ABI. For example, clinicians should assess the patient's cognitive skills to determine if there is a match with the skills needed to navigating a dynamic display screen for a hi-tech speech-generating device. As many of the AT used to support communication require manual activation (SGD or letter boards) it is important to consider the patient's fine motor abilities to ensure that they will be able to independently utilize the AT to compensate for communication deficits. For persons with limited mobility, a microswitch that is activated by small movements may be appropriate (Lancioni et al. 2009b). The studies reviewed here also suggest that incorporating contextualized, personally relevant images may support effective communication in persons with ABI.

Leisure Skills

Individuals with ABI may experience difficulty in independently engaging in leisure activities for a variety of reasons. Persons with ABI may have memory or other cognitive deficits which make scheduling, planning, and carrying out leisure tasks at the correct time difficult (Hutchinson and Marquardt 1997). Individuals with more severe ABI may lack the ability to interact with stimuli in the everyday environment due to severe physical, communication, or cognitive deficits. Individuals with severe and persistent impairments are largely dependent on caregivers (Chua et al. 2007). For these individuals, interventions primarily rely on the use of high-tech AT (see Lancioni et al. 2010a for a recent review). Hi-tech AT to support leisure skills includes microswitches, virtual reality, prompting systems, and adapted household equipment. We provide a brief review of some of the research in each of these areas below.

Microswitches. Teaching individuals with ABI to use a microswitch to activate environmental stimulation may contribute to an increased awareness of the effects their own behaviors have on the environment and others, thus leading to improved consciousness and engagement (Canedo et al. 2002; Lancioni et al. 2009b; Naudé and Hughes 2005; Watson et al. 1999). Microswitch systems have been used with positive effects on engagement with environmental stimuli for children and adults with severe and multiple disabilities in a large number of studies (e.g., Lancioni et al. 2006, 2007, 2008, 2009a, c) and has more recently been shown to result in positive outcomes for individuals with severe ABI (Lancioni et al. 2010a, 2011a, b, 2012a, b, 2013).

Lancioni et al. (2011c) assessed whether a technology program consisting of a microswitch and a computer program would increase participants' access to preferred environmental stimulation. Three adults ages 53, 62, and 42 years who had severe TBI or ABI participated in this study. At the time of the study, all

participants had extensive cognitive and motor impairments and received treatment at a rehabilitation clinic. An assessment of responses for each participant was conducted and microswitches were designed to fit these responses. Responses included eyelid closure or double eyelid closures. Microswitches consisted of optic sensors directed toward the participants' eye. The microswitch was linked to a computer system in order to provide participants with 20 s of access to the stimulation they selected, and to deliver a prompt to participants reminding them that they could use the microswitch to contact environmental stimulation. The stimulation samples consisted of preferred (e.g., family members talking, clips of music or videos) and non-preferred (e.g., distorted sounds) audio and or visual stimuli. Results showed that all participants used the microswitch to access stimulation and that each participant requested more access to preferred, as compared to non-preferred, stimuli. These findings suggest the individuals with severe ABI may be able to use microswitches and computer programs to access preferred stimulation.

Individuals with ABI have also been taught to activate multiple microswitches using different movements in order to access a variety of stimulation. Lancioni et al. (2010b) taught two adults with severe ABI and minimal movement to use two microswitches using different motor responses. For the first participant, motor responses included moving her finger and slightly nodding her head. For the second participant, motor responses included eyelid movements and hand stroking/pushing. Each microswitch triggered 10–15 s of access to either preferred music or a preferred movie. Results showed that both participants were able to engage in two responses to activate microswitches to access preferred stimulation. The authors suggested microswitches which enable persons with severe ABI to access preferred stimulation and to have some control over their environment may be one means of increasing the individual's awareness of his/her surroundings and decreasing social isolation for this population (Lancioni et al. 2010b).

Virtual reality. Virtual reality (VR) is another emerging technology for assisting individuals with ABI. VR interventions use computer-generated environments that allow individuals to interact with a three-dimensional world in real time. Depending on the technology utilized, individuals may view themselves immersed in the virtual environment in a way that closely approximates real life (Broeren et al. 2008; Crosbie et al. 2007; Henderson et al. 2007). Because VR closely simulates experiences individuals might have in community settings (e.g., shopping, having a check-up at a doctor's office, or operating a vehicle) it may offer a safe, controlled means of helping the individual regain skills that have been impacted by ABI. To date, much of the work in this area has examined whether and how individuals with ABI can interact with VR simulations, rather than on the role of VR in achieving restorative goals (Kang et al. 2008; Lengenfelder et al. 2002; Schultheis et al. 2007; Wald et al. 2000; Wald and Liu 2001).

Fong et al. (2010) evaluated the use of a 3-week virtual reality intervention with 10 individuals with ABI using a pre-test post-test design that matched participants (on age, gender, education level, and baseline cognitive performance) to either computer-assisted instruction (CAI) or the VR program. The VR program used a

touch screen format and offered participants opportunities to manipulate all aspects and objects (card, receipt, and cash) involved in ATM transactions. The VR program allowed the researchers to assess the performance of participants on a task analysis checklist for withdrawing and transferring money using a real ATM. Data were also collected on the duration of completing the task, the percentage of errors on the task analysis, and the level of prompting required. Findings showed that the task duration of cash withdrawals was significantly shorter in the group who participated in the VR program than the CAI group. There was no significant difference between the two groups on reaction time or accuracy with money transfers. These findings suggest that VR program may be used to design instructional and practice opportunities for individuals with ABI that are at least as effective as other commonly utilized instructional strategies (e.g., CAI).

Cox et al. (2010) utilized VR to teach driving skills to military personnel with TBI. Eleven males with TBI participated in the study in either the control group or the VR group. The control group received residential rehabilitation including speech, occupational, and psychological therapy. Participants in the VR group received between four and six 60 to 90-min training sessions using a VR driving simulator. The VR simulator included 180° view, rear and side view mirror images, turn signal, brake and gas pedals, and a steering wheel. In the VR driving simulator, participants were exposed to various driving scenarios including rural roads, highway, and urban driving. Participants in the VR group received direct instruction and practice in several behaviors needed for successful driving such as maintaining center lane position, appropriate use of brakes, appropriate use of turn signal, and use of side/rear view mirrors. Participants from both groups were assessed pre and posttreatment on one driving scene of the VR driving simulator. A trained observer rated each participant's driving skills using a 5-point scale. Results showed that driving performance for the VR group significantly improved from pre-test to post-test. However, it is unclear if repeatedly practicing driving skills using VR program or the prompting/direct instruction piece led to improved driving skills as the control group did not receive any driving instruction. Notwithstanding this omission, this study does speak to the possible promise of VR in rehabilitating leisure skills for individuals with ABI.

Adapted household equipment. Lancioni et al. (2010c) taught a 46-year-old man with ABI to independently operate his television in order to view television programs. The researchers modified the television by connecting two microswitches and an amplified MP3 player to the TV. One microswitch allowed the participant to turn the TV on and off while the other microswitch enabled the participant to change the TV channels. By combining AT with the television the participant was able to change channels and turn the television on and off.

In addition to modifying televisions, microswitches have also been used to modify other household leisure items such as radios. Lancioni et al. (2012a) utilized a non-concurrent multiple-baseline design to examine the effects of teaching three post-coma adults to operate a modified radio device using a microswitch on participant responding. During baseline a conventional radio was available and the participants were told to tell the research assistant if they wanted to listen to

another station, but none of the participants asked to change the station. Intervention simply consisted of five sessions (each session 30 min maximum) when the participants were allowed to experience the various options of microswitch activation and the radio stations (e.g., love songs, talk shows). Following intervention, each participant learned to operate the radio device by starting, stopping, and changing stations. Every 3 minutes, a prerecorded message asked the participant if s/he wanted to continue listening to a particular station. Participants appeared to demonstrate preferences for some radio stations over others, because they stayed on some stations longer than others and ended some sessions before the maximum allotted time. These findings indicate that the use of microswitches may facilitate engagement in everyday leisure activities and allow such individuals to express choice of activities for post-coma participants with significant motor and communication deficits.

Due to the motor impairments associated with severe ABI, clinicians should assess the individual's repertoire of motor responses and carefully consider the type and position of AT, such as microswitches. Indeed, microswitches are sometimes custom designed especially for an individual for whom available microswitches are not easily activated (Holburn et al. 2004). For instance, Lancioni et al. (2010c) developed a novel microswitch for a woman with ABI and profound and multiple disabilities so that she could access preferred stimuli. This woman's trunk, head, and limbs were static, but her mouth remained semi-open and she would briefly open or close her mouth. The microswitch consisted of optic sensors (i.e., infrared light-emitting diode and mini infrared-light detection unit) attached to her chin in such a way as to detect changes in lip positions. To evaluate the effectiveness of the microswitch, an ABAB design was used where A was baseline (microswitch available, but activation did not produce contingent stimulation) and B was intervention (use of microswitch resulted in 10–15 s contingent access to music or family voices). Differences between baseline and intervention response frequencies were found to be statistically significant ($p < .01$). These results demonstrate the effectiveness of an individualized microswitch intervention for individuals with few or singular bodily movements.

Summary. AT has been successfully used to support leisure skills with individuals with ABI. The use of assistive technology to enable individuals with ABI who have severe and persistent motor and communication impairments to access sensory stimulation is a promising intervention to improve arousal and engagement with environmental stimuli, and decrease withdrawal. This type of intervention is notably the first to allow such individuals, who are generally dependent on caregivers, to exert control over their environments in ways that improve their quality of life through access to activities that are enjoyable. Small improvements in a person's ability to independently interact with the environment and exert choice may prove to be pivotal in rehabilitation efforts for this population. However, future research is needed to further document the effects and limits of assistive technology for individuals who are minimally conscious or emerging from a minimally conscious state. For persons with mild to moderate ABI, the use of virtual reality is promising. VR may afford individuals with ABI a safe, yet

realistic environment to practice and acquire leisure skills and skills needed for daily living (e.g. Fong et al. 2010). Future research is needed to explore additional uses of AT to support leisure skills in persons with ABI.

Vocational Skills

ABI impacts cognitive, physical, and emotional functioning, and as a result may dramatically affect one's ability to gain and maintain employment. In 2005, 42 % of individuals with ABI were unemployed as compared to a 9 % unemployment rate in the general population (Doctor et al. 2005). This high unemployment rate is likely due to the barriers individuals with ABI face in returning to and maintaining work (van Velzen et al. 2011). For example, individuals often experience greater post-injury fatigue that may impact their ability to work for successive hours (van Velzen et al. 2011). In addition, coordination, balance, and mobility may be compromised, prohibiting an individual from performing physical tasks in an employment setting while memory deficits may impede one's ability to remember what tasks need to be completed and how to complete them. Of those individuals who do obtain paid or supported employment, supports may be necessary to compensate for their skill deficits. In fact, it is estimated that 75 % of individuals with ABI who obtain employment or return to employment post injury will lose their job within 90 days unless they are provided with accommodations and supports, including AT (National Association of State Head Injury Administrators 2006). However, a records review of a sample of individuals with TBI enrolled in public rehabilitation services showed that of those persons who were provided AT in their workplace, 73 % were employed as compared to only 49 % of individuals with TBI who were not provided AT (Gamble and Satcher 2002). Below we provide descriptions of research evaluating the use of low-tech and hi-tech AT to support vocational outcomes.

Much of the AT supports for vocational skills are designed to compensate for cognitive skill deficits. This is likely due to the fact that vocational behaviors rely on memory. For individuals with mild to moderate ABI, memory notebooks, calendars, and alarms can be used to assist employees with ABI to complete job tasks. Because low-tech AT often consists of everyday materials, such as check-lists or visual cues, their use may have a more natural fit within the work environment.

For persons with ABI who have resulting physical or sensory disabilities or limited mobility, adapted or modified equipment may enhance their ability to perform job-related tasks. For example, enlarged keyboards or enlarged computer monitors may support an individual who has difficulty with fine motor movements or vision. In addition, AT to augment communication skills, such a voice amplification devices may be beneficial in a work environment when interacting with fellow employees, supervisors, or customers. Other AT, such as mouthsticks or

headpointers, may allow individuals with limited mobility to complete tasks such as answering the phone or typing on the computer (Inge et al. 2000).

Lund et al. (2011) conducted a qualitative, multiple case study with 10 adults with ABI and their significant other or family member. Participants (6 men, 4 women) were registered with a brain injury rehabilitation center in Sweden. Participants were between the ages of 33 and 59 years. Three participants were employed at the time of the study, and the other seven had temporary or permanent disability pension. All participants had received occupational therapy with a focus on the use of low-tech AT to support daily living and/or vocational goals. Vocational goals included such behaviors as arriving to work on time and completing job-related tasks without the help of another adult. Participants were interviewed for one hour regarding the type of AT they have used and the impact the AT had on their lives and the lives of their significant other/family member.

All participants with ABI reported that when they were taught to use low-tech AT, they were more independent and could complete tasks that they otherwise could not. Significant others/family members reported that they had reduced responsibility and stress when their family member was using AT. All participants reported an increased quality of life as a result of the use of AT to support daily living and vocational behaviors. Although these findings are qualitative, they suggest that AT may impact other areas of life, such as independence and happiness. Future quantitative research is needed to systematically examine the impact of AT on quality of life and employment for persons with ABI.

With the increased availability and use of technology, such as Smartphones or paging systems, individuals with ABI may be able to successfully complete vocational skills. Access to cognitive supports in community settings has been shown to improve performance in workplace settings, and increase in self-reported quality of life (Gentry et al. 2008). Hi-tech AT may help individuals with ABI to complete tasks such as attending meetings on time, taking notes during meetings and recalling tasks and appointments (Linden et al. 2011).

Hartmann (2010) presented a case study on the effects of AT on vocational skills with a 32-year-old man with mild TBI. Prior to the brain injury incident, the participant was a college graduate and employed full time as a paralegal. He sustained a head injury during a racquetball game that resulted in brief loss of consciousness. Following the incident, the participant experienced difficulties reading, staying on task, and interacting appropriately with other workers at his place of employment. In an attempt to improve the participant's performance at work, a variety of AT tools were presented to the participant. The participant selected four AT tools including text-to-speech software, a digital pen and specialized paper that allowed handwritten notes to be converted into a word processing document, the use of Microsoft PowerPoint to organize information, and a portable handheld dictation device. The participant was reported to successfully use these AT tools in his employment. The author reported that with the use of AT, the participant's work production returned to pre-injury levels. However, given the limited amount of research studies examining AT in support of vocational outcomes for persons with ABI, more rigorous empirical research is needed.

Handheld electronic devices. PDAs are one example of an unobtrusive handheld electronic device that can be used in employment settings. Gentry et al. (2008) provided PDAs and training to 23 adults with TBI who had difficulty performing tasks at work due to cognitive deficits. Participants were taught how to enter appointments into their PDA, how to enter and manage the calendar and alarm settings, and how to update the address book and the “to do” list feature of the PDA. Participants were taught to use the PDA over the course of three to six 90-min home visit sessions. Following this training, participants were to use their PDA for 8 weeks. Prior to and following the PDA training, participants and their caregivers rated participant performance at work and their satisfaction with their performance at work. Results showed statistically significant improvements in ratings on these measures 8 weeks following the PDA training. However, observational data on work performance pre-and post PDA training were not obtained. So, while PDAs appeared to have high social validity among participants in this study, more research is needed to evaluate the impact of PDAs on vocational behaviors for individuals with ABI.

Summary. Although there are a number of barriers to employment for individuals with ABI, returning to work is one of the most common goals for individuals with ABI (Velzen et al. 2011). Studies have shown that individuals with severe ABI can return to work when given proper supports (Inge et al. 2000). There is research to suggest that incorporating AT into employment is associated with an increased sense of satisfaction and quality of life for persons with ABI (e.g., Gentry et al. 2008). However, rigorous, experimental research is needed to evaluate the impact of AT on job performance, job attainment, and the maintenance of employment.

Implications for Practice

Empirical research has shown that AT is a very effective method for addressing compensatory goals for individuals who have ABI. Yet, AT, particularly hi-tech AT, is not often used in practice (Sohlberg and Mateer 1989). There are numerous barriers to the use of AT by consumers (Gartland 2004; Lemoncello et al. 2011) and research indicates that few people are using electronic memory aids and instead rely on low-tech memory aids (Evans et al. 2003). Barriers may include the complexity of using the AT device and the availability and cost of the device. In addition, use of the device may require additional resources such as batteries, technical support, and/or extensive training (e.g., Lemoncello et al. 2011).

The adoption of AT by clinicians and consumers requires considerable clinician expertise to (a) conduct assessment to match and adapt technology to user’s cognitive, communication, physical, sensory and motivational profile (LoPresti et al. 2004; Sherer et al. 2005) and (b) to design and implement systematic instruction so that the consumer and caregivers can effectively learn to use device (Kapur et al. 2002; McBain and Renton 1997; Powell et al. 2012; Singh 2000),

especially for consumers who lack experience with technology (Vaccaro et al. 2007), or experience frustration when the AT responds in an unanticipated manner (de Jooode et al. 2012b).

Assessment before selecting a device and periodic assessments after the device is in place may assist in determining if the AT is functioning as intended, being used regularly, or if changes/adaptations, reassessment need to occur. Assessing good fit between an electronic aid and a user is difficult as there are few available assessment tools that assess cognitive abilities in relation to AT use (Gillette and De Pompei 2004). Depending on the technology being used, some individuals with ABI may also require additional skill instruction to acquire prerequisite skills, such as literacy skills to utilize reminders via a smartphone. This is sometimes complicated by clinician's sometimes lack of knowledge, experience and training with AT devices (Gartland 2004; Hart et al. 2003), the high cost of technologies and lack of routes to reimbursement (Gartland 2004; LoPresti et al. 2004) and the usability, feasibility, portability of devices, and availability of ongoing technical support (Hart et al. 2004). However, these barriers may be shifting due to the increasing availability of electronic technologies such as computers, PDAs, and smartphones to the general public and their use by individuals with and without disability (Bryen et al. 2007). The use of generic, readily available technologies such as smartphones may result in decreased cost and improved use by individuals with ABI because such AT is socially valid and their caregivers and clinicians may have more experience with such devices (LoPresti et al. 2004).

Implications for Research

Although the research exploring the use of AT to support individuals with ABI is extensive and generally reports positive outcomes, these findings should be interpreted with caution. Many studies in this area utilize case studies that lack experimental control (e.g., McDonald et al. 2011). A recent review of AT across disability categories associated with cognitive deficits demonstrated that the certainty of evidence of these studies is lacking according to widely held guidelines regarding quality and rigor of experimental design (Gillespie et al. 2012). In order to provide more conclusive demonstrations of the impact of AT on the skills of individuals with ABI, more rigorously designed studies are needed. The use of strong single-subject research designs, such as alternating treatments or reversal designs, lends itself to the individualized nature of providing treatment of persons with ABI while also demonstrating experimental control (e.g., Lancioni et al. 2010c). Researchers have called for improvements to the quality of single-subject research on AT by including multiple data points across experimental phases, using standardized outcome measures, inter-rater reliability and the use of blind raters, and using statistical analysis in addition to visual analysis (Gillespie et al. 2012).

The extant research on AT with individuals who have ABI has addressed compensatory goals. Future research is needed to determine if and how AT can be used to restore skills and behaviors previously within the repertoire of individuals with ABI. Technology systems, such as virtual reality, are rapidly expanding and may lend themselves to such endeavors.

Research is also needed to examine issues related to the maintenance of AT use over time. Currently, most studies have taken place in highly controlled environments, such as hospitals or rehabilitation centers. Empirical data on the use of AT in more natural environments, such as homes, community, or vocational settings is needed in order to better understand the feasibility and suitability of these technological supports. In addition, much of the research to date has evaluated immediate or short-term use of AT and studies evaluating the long-term use of AT by persons with ABI are needed. Future research should also examine whether, and under what conditions, persons with ABI use AT to compensate for skill deficits.

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