This rapid response research report summarizes existing research on recent assistive technology devices across diverse disabilities. The goal is to provide a summary brief and an associated reference document with research descriptions and appropriate references.

Assistive Technology

Recent developments and advancements for individuals with disabilities

Produced for the Rocky Mountain ADA Center

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Recent Developments in Assistive Technology
Three Page Summary Brief

Introduction: This report is the product of a rapid response research activity designed to research and summarize recent advancements in and efficacy evidence for assistive technologies (AT) for people with disabilities. The full report includes a discussion of the review process, limitations and cautions, a brief discussion of research supported AT, a brief discussion of barriers to AT adoption, links to further information on AT product information, and summaries of reviews of research and studies organized under the following functional categories: sensory, physical, intellectual/cognitive (including autism spectrum disorder), and communication.

AT efficacy evidence is limited. The consensus by researchers is that AT, particularly computer and mobile technology, is evolving at a rapid pace and holds great promise for benefit, though they caution that there remains a shortage of high quality research evidence on the efficacy and usefulness of these devices (Brandt & Alwin, 2012). The same is true of up-to-date AT usage statistics.

The following summarizes recent literature on the use and efficacy of AT. Please refer to the larger report for more detailed information and complete citations and references:

Sensory:

- Assistive listening devices, such as sound field systems and FM systems (loop systems), appear beneficial in supporting student learning and hearing when the volume is insufficient, there is ambient noise, or there is reverberation (efficacy research is limited).
- Mobile applications, texting, and email systems have been shown to be used frequently by people who are deaf, though evidence of efficacy in supporting functioning is still lacking.
- White canes remain the most popular travel support AT for people with vision related disabilities, though there are rapid advancements in electronic mobility/travel aids, electronic orientation supports, and location systems using GPS. Researchers have surmised that no system currently contains all necessary features and reliability for general wide scope use.
- Electronic mobility/travel aids, such as obstacle detection devices or environmental imaging devices, have shown promise for supporting navigation and travel for people who are blind or deaf/blind (efficacy research is limited). Examples include the SmartCane, GuideCane, and EyeCane.
- Current research supports the use of screen reading software by people with visual impairments for reading electronic text and navigating webpages, though these appear to require significant training, support, and have frequent problems reported. Commonly used options are JAWS, NVDA, and VoiceOver, Window-Eyes, and ZoomText for desktop computers; VoiceOver, TalkBack, and Nuance Talks for mobile options; and Apple IPad/IPhone/IPod touch as the most popular mobile platform.
- Voice recognition software is among the most prevalent AT used in post-secondary education and allows users to operate computers by converting speech to text through voice commands. Dragon products are among the most popular with versions for desktop and mobile use.
- Haptic feedback devices that provide touch or vibration feedback via computers, smartphone, or wearable devices have shown to improve functioning in prosthetic use, vestibular impairment,

osteoarthritis, vision loss, and hearing loss, though there are significant limitations in understanding and efficacy research evidence.

Cognitive/Intellectual or Psychological:

- Systematic reviews of research have shown that AT has been used effectively to support cognitive functions related to attention, calculation, emotion, experience of self, planning and time management, and memory (Gillespie, Best & O'Neill, 2012). Researchers report there is convincing evidence for the benefit of AT for memory and reminder functions.
- There is research support for the use of personal digital assistants (PDAs; and like portable smart technologies) to support cognition for people with brain injuries, multiple sclerosis, intellectual disabilities, Alzheimer's disease and mental illness, in functional areas such as in memory prompting, schedule management, instruction, navigation, social interaction training, various daily living skills, and work supports.
- Microswitches have been used successfully to assist individuals with limited consciousness or minimal motor movements in basic communication or in operating things in their environments.
- A systematic review of research of AT for people with brain injuries showed a variety of AT options (computer software, email interfaces, smartphones, pagers, PDAs, text to speech software/devices, portable prompting devices, personal cameras), which were able to enhance independent functioning, with more specific improvements to reading speed, work productivity, memory of events and tasks, social engagement, initiating behaviors, and remembering medications (Lourie, Petras, & Elias, 2015). PDAs were the most commonly used AT devices in this study.

Autism Spectrum Disorder (ASD):

- In general, there is evidence for the benefit of AT devices for assisting people with ASD in communication, social/emotional functioning, and daily living. Research suggests that people with ASD will often need intensive training and on-going supports, particularly when the AT is complex.
- Speech generating devices (SGDs) have been shown to benefit communication and in some cases, challenging behaviors for people with autism. These devices produce substitute synthesized or prerecorded speech output from a variety of accessible interface options for those with limited language functioning. Modern examples include mobile platforms, such as the Proloquo2Go app loaded on an IPad.
- Picture Exchange Communication System (PECS) is a picture card based communication system that helps non-verbal clients communicate through choosing cards. More recent systematic reviews of research have found that PECS is very effective but is more effective when started at a younger age, with more extensive training, and in those with autism over other disabilities (Ganz et al., 2012 as cited in Lang et al., 2014).
- Computer based instruction and teaching social skills through computer and video means has been shown through research to be useful in supporting communication, social skills, and daily living skills enhancement, though there are cautions related to research limitations.
- A recent randomized clinical trial by Gentry et al. (2015) found that using the IPod touch PDA (apps were not standardized but based on individual needs) helped reduce the need for job coaching supports for adults with ASD in work settings.

Physical/Mobility/Motor:

- Microswitches are switches operated through micro-movements of the body. They have been used successfully to assist individuals with limited consciousness or minimal motor movements to operate other AT devices (e.g. communication AT) or appliances in their environments.
- Haptic feedback devices have shown benefit for prosthetic use such as improving sense of touch and grip force in upper limb prosthetics.
- Robotics AT for mobility (e.g. smartwalkers or robotic exoskeletons) to support motor impairments (e.g. robotic arms) have had great advancements over the past two decades, but there is very limited research on the efficacy of these devices, particularly in efficacy for use in activities of daily living.
- Electrical stimulation, functional electrical stimulation systems, electromyography, and neuroprosthesis (implanted device to stimulate muscles in the target area) have been used to help exercise and to improve motor control and functioning (Bryden, Ancans, Mazurkiewics, McKnight, & Scholtens, 2012). More research evidence is needed to validate the efficacy of these devices.
- Modified wheelchairs are the most used and effective AT devices for athletic purposes for people with physical disabilities. Several other prostheses advancements including lower limb “cheetah” technology, snow ski prosthetics, snowboarding prosthetics, and swimming prosthetics have been developed, though efficacy research is lacking.
- Non-invasive movement controls used as control interfaces such as eye-movement, myoelectric-based, tongue control, head movement, speech command, and hand joystick are “suitable solutions” for controlling movement and mobility AT. However, new brain signal control options (e.g. EEG) still have significant limitations in speed, accuracy, and reliability (Lobo-Prat et al., 2014).

Communication:

- Both low-tech and hi-tech communication AT have shown promise in assisting people with communication disability express themselves more effectively. Low tech AAC AT are still the most common forms (e.g. photograph boards, notebooks, communication books), but more recently, hi-tech options are becoming more prevalent. A review of literature by Baxter, Pam, Philippa, and Simon (2012) surmised that there is good evidence that hi-tech augmentation and alternative communication devices (AAC) are beneficial for communication support across a variety of disabilities.
- Speech generation devices (SGDs) and IPad with SGDs loaded on the device have shown evidence for helping individuals with autism, intellectual disabilities, cerebral palsy, motor speech disorders, and multiple disabilities in supporting communication, social interactions and in some cases reducing negative behaviors.
- Voice recognition software has been shown to be useful AT for addressing communication disorders in those with aphasia. In some cases, voice recognition software can even be trained to recognize speech that is “highly unintelligible” (Sigafoos, 2014, p.96).

(See intellectual disabilities for more on communication disorders in autism.)

ADA Center Rapid Response Research Activity:

This report is the product of a rapid response research activity conducted by researcher partners affiliated with the Rocky Mountain ADA Center. These activities are designed to respond to ADA staff and stakeholder questions by assembling information from current research. These activities have a brief turnaround time and culminate in a brief report format.

Research Questions and Research Review Process:

The primary questions guiding this rapid response research activity were: **What are some of the recent and most important technological advancements for people with disabilities? What do we know about the impact of these tools and to what extent are they being used by people with disabilities?**

This rapid response research activity reviewed relevant literature on modern assistive technology (AT) from the year's 2012 to 2016 (in many cases, this literature includes research that was published prior to this time period). This should be considered a selective review of relevant literature as an exhaustive systematic review was not feasible due to the vast volume of materials related to assistive technology. Just to illustrate the scope of available research, an Academic Search Complete search using the search terms "assistive technology" or "assistive devices" for the years 2012 to 2016 yields a total of 1,736 journal articles. To reduce the amount of material and better synthesize findings across studies, the search was limited, in large part, to reviews of research across studies. Research reviews, overviews, and meta-analyses offer summaries of existing findings and present a more comprehensive and comparative view of the research landscape. It should be noted that reviews of literature often contain information on research studies that occur prior to the search dates.

This rapid response research focused on evidence informed materials primarily from peer-reviewed articles and textbook sources. In most cases, anecdotal information is omitted from the review, as these findings are unproven and conclusions may be incorrect or misleading. In certain cases, examples of technology and device options are included without research evidence for illustrative purposes; these are appropriately noted within the text. Practices and devices with known risks were not included in the report.

Major Research Sources:

Academic Search Complete (EBSCOhost) was utilized to search for reviews of research related to AT, with "assistive technology" and "review" or "overview" or "meta-analysis" used as search terms. The search from 2012-2017 yielded 198 articles. The article abstracts were then reviewed and selected for inclusion if they were available for review (in English) and were relevant to the goals of the research. To be included, the articles needed to be related to AT for one of four common functional areas (sensory, physical, intellectual/cognitive/mental, or communication) or autism; they had to be of an appropriate level of complexity to be interpretable by a general audience; they had to be related to the efficacy or usage levels of AT; and they had to be "recent technological advancements." Twenty-two review manuscripts were retained based on these criteria. In a few cases, more focused searches were completed to find information on technologies related to topics of targets of focus for this research activity (such as AT for autism spectrum disorders and AT usage levels).

The Lancioni and Singh (2014) text entitled "Assistive Technologies for People with Diverse Abilities" was also a primary source for this research activity. This text provided a rich review of recent research on AT for people with disabilities. It focused on nine groups, including people with brain injuries, college students' learning/cognitive disabilities, people with communication impairments, people with visual impairments and blindness, people with autism spectrum disorders, people with behavioral disorders, those with Alzheimer's disease, and people with profound intellectual disabilities or multiple disabilities.

Limitations and Cautions:

It is important to recognize the difficulties in identifying evidence based practices with regard to AT devices. Technology is advancing at such as rapid rate that the systematic evaluation of individual technological devices, programs, or strategies is problematic. Those devices that are currently on the market may become obsolete in the near future (Scherer, 2012), making it difficult for researchers to keep pace. Rigorous experimental studies are scarce due to issues with recruiting appropriate samples, difficulties in using experimental designs with clinical populations, the length of time it takes to conduct and publish research, and the impracticality of researching new devices due to the rapid turnover and updating of existing high tech devices and programs. Additionally, research on which devices, programs, or types of AT are most effective for which specific populations, under which specific conditions, and for what purpose, lags far behind the advancement (Gray, Silver-Pacuilla, Brann, Overton, & Reynolds, 2011). Furthermore, there is little standardization of measurement instruments (Brandt & Alwin, 2012), little standardization of procedure, little standardization of sample characteristics, and differences in technology/programs utilized which limits comparisons across studies and generalizability. As described by Sigafoos et al. (2014), research synthesis is problematic because studies differ "greatly in terms of participants' diagnoses, ages, type of assistive technology, skills targeted, experimental rigor, and intervention approaches" (p. 104).

In order for a practice or intervention to be considered evidence based, it must stand up to scrutiny in terms of rigor of research design, replication of findings, and peer review. The American Psychological Association (APA) defines this as an "integration of the best available research with clinical expertise in the context of patient characteristics, culture, and preferences." (APA, 2006, p.273). Within this definition, the APA specifies that the scientific evidence must be "sizable," endorsed from diverse research designs, show the practice is effective, and show that it is safe.

Sigafoos et al. (2014) argue that "clinicians should aim to use only empirically supported assessment and intervention approaches" (p.79) in selecting AT, but in most cases, evidence-based evidence is not available on specific devices or for specific circumstances. As an example, a review of the current state of research on AT for people with traumatic brain injury by Leopold, Lourie, Petras, and Elias (2015) found that a wealth of recent studies showed positive associations between the use of AT for cognition support, but that none of them were high level studies (level 1 standard of randomized clinical trials with strong methodological designs). This is very typical of the research evidence that is available for most AT at the current time. An overview manuscript by Anttila, Salminen, and Brandt (2012) summarizing the quality of evidence from all systematic reviews of outcome studies of AT for people with disabilities found that among the 44 systematic review studies included in the overview, only three had high quality of evidence according to their grading system. Only one of these studies found the benefits of a specific AT device: hearing aids were found to have clear benefit over no hearing aids for those with moderate to severe hearing loss.

The devices and information within this document may best be considered emerging practices that have in most cases been supported by empirical findings of varying degrees of quality. As mentioned, the nature of technology advancement and research limitations often precludes rigorous study of the efficacy of each emerging technology. Despite these limitations, there is clearly a consensus opinion in the AT research community that more research, with improved research methodology, is needed to better assess the efficacy of AT practices and devices, and to keep up with this quickly changing landscape.

Assistive Technology Definitions and Categorization:

Assistive Product Definition: According to the International Organization for Standardization an assistive product is "any product (including devices, equipment, instruments, technology and software) specially produced or generally available for preventing, compensating, monitoring, relieving or neutralizing impairments, activity limitations and participation restrictions" (Anttila, Samuelsson, Salminen, & Brandt, 2012, p. 9).

Assistive Technology Definition: The Assistive Technology Act of 2004, defines an assistive device as "any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to improve functional capabilities of individuals with disabilities (Assistive Technology Act, Public Law 108-364, Sec. 3(4))

Categorization: There is no recognized standard for the categorization of disability or for associated assistive devices. Medical models typically use diagnoses and may categorize conditions based on their etiology (as with cancers) or by the body system which is affected (as in neurological disorders), while categorization by functional limitations is commonly used in the field of rehabilitation (Szymanski & Parker, 2003) and may better reflect individuality in experience of disability. Scherer (2012) notes that the "International Organization for Standardization's ISO 9999: Assistive products for persons with disability classification and terminology" was adopted by the World Health Organization's Family of International Classifications in 2003. This ISO 9999 classifies AT by the functional area that it supports and has a series of classes, subclasses, and divisions.

This report will frame AT based on the functional category that the technology supports. In many cases, diagnoses will be specified as well, as this level of detail may be stated within the associated research, and results may have limited generalizability beyond this identified population. The results will be summarized according to the following four commonly cited functional areas: sensory, physical, intellectual/cognitive/mental, or communication. Additionally, there will be a supplemental section related to autism spectrum disorder (ASD), as this disability was requested as an emphasis area.

General AT Support Recommendations and Barriers to Adoption:

General Support Recommendations:

AT provision should include a process of investigating the utility to the individual's needs, as well as the evidence of benefits or potential harm. Within an evidence based model, the device should be evaluated on its potential benefit or harm, convenience, cost, in comparison to alternative strategies (or alternative devices), and should be based on the individual's values, experience, and needs (Antilla et al., 2012).

According to Sigafoos (20014, p. 105), personal preference is important to AT adoption. People must be exposed and trained in use, then have adequate maintenance support for technology for it to be worthwhile long term. The author recommends the following steps for assisting with the training and adoption of a new AT devices:

a. Participants receive initial training in the use of the device.
b. A trial period which they practice using the device in their daily lives
c. Evaluation of AT device satisfaction from the user, with improvements or modifications to address concerns
d. On-going support or maintenance to address changing AT needs or device issues

Leopold, Lourie, Petras and Elias (2015) note that usability of the AT is a highly important consideration for evaluating the effectiveness of AT because of the individual nature of needs and goals. They recommend:

a. AT be matched to the needs and goals of the individual
b. Comprehensive assessment before choosing an AT device for an individual
c. AT should be evaluated for usefulness in the setting that they will be used
d. Systematic training and practice be implemented for the AT
e. Individuals should be provided with long-term follow-up and support to determine whether the devices are useful over extended periods and to address any issues or needs.

Finally, Mulloy et al. (2014) suggest the following best practice considerations when supporting AT usage:

a. Matching AT to the person’s goals and needs
b. Providing on-going support for maintenance
c. Evaluation of AT usage outcomes
d. Being sensitive to cultural issues or preferences

Barriers to Adoption and Technology Abandonment:

The literature shows that unsuccessful outcomes in the use of AT by people with disabilities is often related to AT abandonment (Desideri, Roentgen, Hoogerwerf, & Witte, 2013). There appear to be very high rates of non-use of provided AT (Wessels, Dijcks, Soede, Gelderblom, & Witte, 2003) and abandonment in the use of AT (particularly high tech AT), meaning users use devices for a period of time, but then cease using them and go back to their old patterns (Phillips and Zhao, 1993). This dynamic is not fully understood but there is some evidence that privacy issues, cost, stigma, fear of dependence, ease of use, lack of training, and functionality of the device are all concerns (Yusif, Soar, & Hafeez-Baig, 2016).

Researchers have reported that people with disabilities utilize the Internet about half as much as those without disabilities (Jaeger, 2012 as cited in Gentry et al., 2015). Macdonald and Clayton (2013) report that the main obstacle for people with disabilities adopting new mobile and computer AT is due to expense, lack of training, and lack of skills to use them (Gentry et al., 2015). It is also a common issue that people do not have adequate technical support and maintenance supports to continue the use of these technologies over extended times, leading to abandonment issues. It is important to remember that high tech options may open up broad functionality, but they may also come with a host of potential problems, including increased training requirements, increased cost, greater chances of user errors, need for maintenance and updating, and the likelihood of more challenges and barriers to users because of their complexity.

Sources of Information on New AT Products:

AbleData: www.abledata.com

AbleData is funded through a federal grant by the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR) within the Department of Health and Human Services. According to their website, they are a "database for unbiased, comprehensive information on products, solutions and resources to improve productivity and ease life's tasks." They provide information on available products but do not sell or endorse any "non-government websites, companies, or applications." There are more than 40,000 AT products classified under 10 areas of functioning, with more specific categories listed under each area. The AbleData website contains links to devices, information, and vendors for the products.

The National Public Website on Assistive Technology: http://assistivetech.net/

A website managed by Georgia Tech's Center for Assistive Technology and Environmental Access (CATEA), funded by a grant from NIDILRR. The user can search products by function or activity, as well as buy, sell, or exchange AT devices.

Association of Assistive Technology Act Programs: https://www.ataporg.org/

A website which is the hub for the association of state AT Act programs. There are descriptions of the services that are offered at these programs including demonstration activities, AT device loan programs, AT reutilization activities, AT financing options with states, etc.

Center on Technology and Disability: http://www.ctdinstitute.org/

A center funded by the federal Office of Special Education Programs (OSEP). As described on their website, the center is meant to "increase the capacity of families and providers to advocate for, acquire, and implement effective assistive and instructional technology (AT/IT) practices, devices, and services." Their website includes information for leaders, teachers, researchers, service providers, and families/users. There is a library of resources and various learning activities.

Apple Accessibility Page: http://www.apple.com/accessibility/

This link is Apple's entry point for accessibility within their products lines. This includes Applewatch algorithms for wheelchair users, display settings, Switch Control, Live Listen, Voice Over, Speak Screen, and HomeKit-Enabled customization that can help the user control household tasks through the use of Siri (e.g. turning lights on and off or adjusting thermostats).

Microsoft Accessibility Page: https://www.microsoft.com/enable/at/types.aspx

A webpage devoted to assistive technology products that may be used with Microsoft products and operating systems. It includes links to use of AT with Windows 7,8,10 and various Office versions.

RehabTool.com: http://www.rehabtool.com/

A website for rehabilitation technology information started by a family who experienced a severe brain injury. This company develops and sells hardware and software for people with disabilities.

ACCESS IT: http://www.washington.edu/accessit/

A website from the National Center on Accessible Information on Technology in Education that provides IT accessibility guidance for creating documents, videos, and websites.

Sensory Disabilities

Haptics General Sensory Disability Use Research:

Haptics wearables (haptics or haptic feedback): Haptic feedback is the use of sense of touch feedback, often vibration feedback, which can be delivered via touch computers, smartphone or similar technologies. They interact with the skin or through clothing and can act as a sensory replacement for those who are blind, deaf, or have an amputation; or for sensory augmentation; or as a training device (Shull & Damina, 2015). A review by Shull & Damina (2015) found that wearable haptics have shown improvement of functioning for prosthetics, vestibular impairment, osteoarthritis, vision loss, and hearing loss. The authors caution that there are significant limitations in current understanding and need for further research.

Deaf and Hard of Hearing Disabilities:

Hearing aids for people with hearing loss: An overview of systematic reviews of outcome studies of AT by Anttila, Samuelsson, Salminen, and Brandt (2012) found that hearing aids supporting functioning of people with hearing loss was one of the only AT devices that has shown high quality research evidence of benefit within the literature base.

Learning AT for deaf and hard of hearing: Microphones and inductive loop systems, microphones combined with a FM system, and microphones connected to a sound field system are used regularly (Rekkedal, 2012). Rekkedal reports that research shows that those students with severe hearing loss who have cochlear implants or hearing aids early (before school age) are more satisfied with sound quality than those who use them later.

There is research that shows that sound field systems (microphone and amplified speakers) and personal FM systems (microphone, transmitter, and receiver worn by the user) have both been shown to improve speech recognition, and sound field systems have been shown to show improved listening and academic outcomes with children in primary grades (Nelson, Poole, and Munoz, 2013). The researchers found that approximately 27% of schools used personal FM systems with their 5-year-old students and that educators perceived these systems as improving students' attention, speech and language development, academic performance, and behavior.

Nelson, Poole and Munoz (2013) used surveys of 99 deaf preschool education programs in the U.S. and found that 58% of them used sound-field systems finding that teachers perceived that these systems increased student attention, improved language development, reduced strain on teachers' voices, improved academic performance, and improved student behavior.

Video relay services (VRS): This AT system is the use of a video sign language interpreter for distance telecommunication. The user communicates with a sign language interpreter through video who is connected with another person by phone. This has some benefit over text in that it allows closer to real time communication. Trials in Texas and Washington provided the basis for use today across the country. These are changing from videophone formats to Internet provided formats where the caller is sent to a sign-language interpreter who is visible over streamed video. (See the federal communications commission for more information: https://www.fcc.gov/consumers/guides/video-relay-services).

Assistive listening devices (ALDs): These are amplification AT devices to help support communication for those with hearing impairments by enhancing speech signals in cases when their personal hearing amplification is not adequate (Kim & Kim, 2014). Kim and Kim (2014) note that these devices help separate sounds such speech, from background noise, helping comprehension and communication. They most commonly use a microphone to pick up the speech and then some type of broadcasting system to the listener's ear, such as frequency modulation (FM) systems, infrared, or induction loop systems.

Digital wireless technologies: These may also be used to improve the signal to noise ratio, using sound processors to make speech easier to hear above other extraneous sounds in the environment. These AT devices take in the sound through some kind of microphone, process it and then send it to user. Examples of these devices are the ReSound Unite Mini Microphone (Kim & Kim, 2014; no efficacy research was reported).

Mobile applications "apps" for hearing health care: A review by Paglialonga, Tognola, and Pinciroli (2015) searched the leading mobile platforms to find apps that supported hearing health in four areas: screening and assessment, intervention and rehabilitation, education and information, and assistive tools. They found 203 apps that fit within these categories, though many covered more than one area. Only 7% of these were in the assistive tools category, though these covered a number of functional supports, including communication assistance, captioning, sign language supports, and alerts/alarms. The researchers noted that there are potential risks including "misuse, safety, privacy and the use of personal information, and reliability of information" (p. 297) and that research is "urgently" needed in this area. This paper provided very little research or information on efficacy or usage of these apps so any conclusions are tentative.

Travel and navigation for deaf: No available evidence was found.

Personal amplification systems: Units that can include personal amplification devices (besides hearing aids) that can be used to better understand one-on-one communication or group conversations (Scherer, 2012). Examples include Pockettalker Ultra System and Comfort Contego (Scherer, 2012; no research evidence reported).

Deaf and hard of hearing text and video communication: Common communication systems available in the general consumer market are texting, emailing, instant messaging, and captioned video. In a national survey by Bowe (2002), he found that even in 2002, most deaf and hard of hearing adults were using email and instant messaging "far more" than TTY or relay systems. A study in the U.K in 2008 by Pilling and Barrett found that email was the most used form of text communication for those that don't use telephones, but that messaging (text and instant messages) were preferred by younger users.

Mobile phones have been shown to be used frequently by people who are deaf, with the most common function being messaging service or texting for personal communication, with other functions such as video communication, Internet searchers, and email being regularly used (as cited in Liu, Chiu, Hsieh, & Li, 2010).

According to an online survey, the most common forms of AT for work accommodations for the deaf or hard of hearing were telephone aids and electronic communication options (Haynes & Linden, 2012).

Alerting devices and systems: Scherer describes that there are a variety of alerting devices and systems that can use flashing light and/or vibration to provide notification or signaling for telephone calls or guests at the door. Examples include the KA1000 Alerting System that can be integrated into clocks, lamps, telephones, beds, fire alarms, home security, and videophones (Scherer, 2012). The Door

Knocker 125 can be put above a door and notifies when someone is at the door with a bright flashing light (Scherer, 2012). These systems can use sound, light, or vibration alerts (Kim & Kim, 2014).

Telephone listening devices: Telecommunication devices for the deaf (TDD) or teletypewriters were used for many years for those who are deaf or have very little hearing, though these have been rapidly replaced by text, instant messaging, and email systems available through computer and cell phone technologies (Kim & Kim, 2014).

Deaf (haptics): A review by Shull and Damina (2015) describe that haptics and tactual aids have been shown to improve speech recognition as a supplement to lip reading. Research in this area is still limited and these technologies may be better considered as supplementary to existing compensatory strategies.

Apple watch has been used by a user who is deaf and registered blind, using its “taptic engine” which can give prompts, notifications, and directions through vibrations that feel like taps. The number of taps can relay information like turn right or left at the next corner. These can have associated Bluetooth connections that can provide audio information through amplified sound to the user as well (Griffin, 2015).

Haptic vests (VEST from Rice University) are being tested that provide vibration feedback to people who are deaf. These vests can vibrate in various patterns that represent words when attached to a smart phone (or similar technology) that processes the sound. Wearers learn to process the language of the vibrations and can then understand the spoken speech through vibration (Williams, 2015).

Cochlear implants using remote microphone systems: Cochlear implants may support very high sentence-recognition scores in quiet environments but have shown less success in noisy environments or those with echoing. A review by Wolfe (2014) noted studies that show that performance in these noisy environments may be improved through the use of remote microphones such as FM or RM (radiofrequency) systems.

Deaf-Blind AT:

Electronic mobility aid devices: A study of the use (single subject design, N=4) of electronic mobility aid devices (EMAD) for people who are deafblind was conducted by Vincent et al. (2014) using both the Miniguide and the Breeze devices. The researchers found that both participant satisfaction and performance improved while using both devices among four different types of activities: mobility, active leisure, community life, and socialization. Follow up interviews noted several practical problems with the use of the existing systems but still rated satisfaction high. The Miniguide is a hand-held device that uses echolocation to detect objects in the path of the traveler and alerts them to the location of these objects through changes in vibration in the palm as one gets closer or farther from the object. The Breeze is a talking GPS navigation and orientation device that is designed for people who are blind or low vision and verbally announces location based on streets, intersections, and landmarks. For this device to work, the person must have a minimal level of hearing.

Educational AT for those who are deafblind: A review of extant research of educational AT for people who are deafblind by Hartmann and Weismer (2016) found that there is little evidence available on the effectiveness of the variety of available educational technologies and little guidance on how they should be implemented. These authors note the prospective promise of educational AT for those who are deafblind. They note that the use of digital text is increasing accessibility by students as users are able to manipulate the text by enlarging, through text-to-speech tools or through refreshable Braille reading devices. Tablet technologies also allow them to enlarge video or to use screen readers.

Blind AT:

Navigation for Blind and Low Vision:

Electronic travel aids (ETAs): ETAs have numerous possibilities for supporting people with visual impairments and include options such as obstacle detection systems, tracking systems, portable computer interfaces, and map planning programming are being used more and more and are replacing traditional cane and guide dog navigation methods (Brassai, Bako, & Losonczi, 2011). Those using GPS systems were found to be insufficient as of this review in 2011 (Brassai, Bako, & Losonczi), particularly in rural areas where GPS is not available, though one should note that these networks have improved over the past several years. Efficacy studies of these systems are still needed.

A review of ETA literature by Bujacz and Stumillo (2016) found two main types of ETA technologies being used: obstacle detection devices and/or environmental imaging devices. The obstacle detectors use sonic or laser sensors and the environmental devices use more complex camera and imaging interfaces/programs. The authors note that the obstacle detection devices are more basic but are also more commonly used. The Laser Cane was one of the most popular and successful ETAs (in the 1970s). More modern and advanced options are the Teletact and the EyeCane (Bujacz & Stumillo). The authors describe environmental imaging devices, though they all appear to be in prototype testing phases.

Hakobyan et al. (2013) described the use of tele-assisted travel systems, where the individual who has a visual impairment carries a digital webcam and is assisted remotely by a sighted guide who conveys information back to the user through an earpiece.

Navigation and mobility systems (such as Voice Maps) are becoming successful in supporting the mobility of people with visual disabilities (Hakobyan et al., 2013). Voice Maps uses Android's text-to-speech and vibration to help users in finding routes and can monitor the user's location to give them feedback if they are off route and to help them adjust (Hakobyan et al., 2013). The authors note that evaluations of this technology are not available yet. Examples provided of common standalone GPS navigation devices are the Trekker Breeze and the BrailleNote GPS.

Obstacle detection and guidance: Obstacle detection provides assistance in assisting people with visual impairments to navigate around obstacles along their paths. The white cane is considered the most common and successful AT device for people with visual disabilities (Hakobyan et al., 2013). Other options, like the NavBelt and GuideCane, have been developed but the NavBelt has been shown to have difficulty keeping up with walking speed and these devices appear to be in various stages of testing (Hakobyan et al., 2013). Martins, Santos, Frizera-Neto, and Ceres (2012) reviewed mobility device research and noted robotic cane options like the SmartCane, which is a "well accepted" AT device that has advanced obstacle detection, and the GuideCane, which also helps guide users and detect obstacles through a GPS and others sensors built into a robotic attachment at the end a cane which is controlled by joystick.

Cognitive mapping: This is the creation of a representation of the space around an individual that can be interpreted by someone with a visual impairment. These technologies appear to still be in developmental stages (Hakobyan et al., 2013).

Independent shopping: A few AT devices are available to help shoppers navigate in stores and read labels on products within the store. The ShopMobile-2 helps scan barcodes and provide audio feedback. (Hakobyan et al., 2013). Other smart device applications are currently being developed (e.g. Trinetra and BlindShopping), though again, testing for efficacy is needed. A RoboCart, robot assisted shopping device, helps the user with location within a store using RFID tags placed around the store, laser range finding, and a barcode scanner to help with product identification. There is some evidence of utility but this remains in the development phase (Hakobyan et al., 2013).

Haptics for navigation for those who are blind: A review by Shull and Damina (2015) describe the use of haptics for individuals who are blind to sense objects in the user's path and in navigating directions. Examples are handheld portable devices, belts, gloves, tongue stimulators, or finger tactile displays that can relay information on obstacles, distance of objects, or directional information for navigation. The mouth and fingertips tactile displays offer the possibility of higher resolution image feedback, but the soles of the feet and waist may be more practical.

Reading low tech AT for people who are blind or low vision: The following low tech AT options are summarized from Mulloy, Gevarter, Hopkins, Sutherland, & Ramdoss (2014):

> Large print text documents show improvements in reading rates for low vision students. These can either be from large print documents or electronic formats (American Printing House for the Blind and American Foundation for the Blind) that can be enlarged through the use of word processor software.
>
> Typoscopes are writing guides that help with orientation on the page and focus on the correct line for reading (cutout spaces for a line of text that can be overlaid on a printed line of text). Some evidence of assistive benefit and satisfaction of people using these devices.
>
> Lamps may enhance reading abilities for low vision clients, though there were findings that often people are trying to read in low light conditions without enhanced lighting.
>
> Magnifying lenses may enhance student's reading rate and comprehension, though use may be personal preference.
>
> Electronic magnification through EVES (electronic vision enhancement systems), or CCTV (closed circuit television) appear to offer benefit though there is conflicting evidence whether they offer more benefit than magnifying lens devices. Again, personal preferences may play a part here and should be evaluated as per the individual's comfort level, needs, and goals for the device.
>
> Braille displays, Braille translation devices, and Braille computer print-outs: Students may be able to use Braille translation software and computer printers to convert electronic format text (or converted print text) to Braille, which can be printed out. Two translation software packages are Duxbury Braille Translator and Braille 200 by Computer Application Specialties. There are also refreshable Braille displays that use electronic text (or screen readers) to produce a line of Braille on a tactile display that refreshes as the individual moves across text within the

document or webpage. There is limited research evidence on these refreshable displays and they are limited in popularity (decreasing numbers of individuals who read Braille because of screen readers with synthetic speech), though these may be an alternative for individuals who are deafblind and cannot hear synthetic speech.

Audio books include numerous materials such as Booksense by HIMS, Easy Reader by Dolphin, and modern operating systems like the IPod or IPhone (Apple products).

Screen reading software: Students use hotkeys to navigate on a screen, webpage, or inside a document. These can include operating system software (like Narrator for Windows; Voiceover for IOS/Macintosh) or dedicated software (such as JAWS from Freedom Scientific or Kurzweil 3000 by Kurzweil Educational Systems. There is other software, such as ABBYY FineReader, that is an optical character recognition (OCR) software, which recognizes printed text (or PDF images) and converts it to editable electronic formats that can be read by screen readers. The current research supports the use of OCRs and screen readers, though research also suggests that this requires significant training and support and that participants often deal with frustration and frequent problems while using these software options (Mullroy et al., 2014).

Screen reader usage information: An online survey (N = 2515) conducted by WebAIM (2015) found that the following options were used as their primary screen reader (from most to least): JAWS (30.2%), ZoomText (22.2%), Window-Eyes (20.7%), NDVA (14.6%), and VoiceOver (7.6%). The respondents noted that they commonly use the following (from most to least used): JAWS (43.4%), NVDA (41.4%), VoiceOver (30.9%), Window-Eyes (29.6%), and ZoomText (27.5%). This survey also asked questions about mobile platforms and screen readers that are utilized on mobile platforms. The results showed that mobile screen reader usage increased from about 12% in January, 2009 to 82% in January, 2014. In 2015, the most utilized mobile platform for people with disabilities was Apple IPad, IPhone, or IPod touch (69.6%) with Android being a distant second (20.8%). The most commonly used mobile screen reader options were VoiceOver (56.7%), TalkBack for Android (17.8%), Nuance Talks (4.5%).

Computer screen magnification: Computer users who are blind or low vision may need assistance with computer navigation and may benefit from screen magnifiers such as the ZoomText Magnifier by Ai Squared which can magnify a screen up to 36 times actual size (Scherer, 2012).

Reading pens: These are small portable pen-like AT that can scan text and then display the text on a larger screen or converted into speech to read the text aloud (Scherer, 2012). Examples of these pens include the VoiLa Voiced Label Reader for the Blind, the Voice Stick, the ReadingPen, TopScan Pen, the C-Pen, or various Wizcom pen devices.

Learning (Higher Education) AT for those who are Blind/Low Vision:

Research evidence shows that text reading AT has been shown to increase reading comprehension, access and use of websites, and studying efficiency in higher education (Lang et al., 2014b). The rest of the studies have very low sample sizes and have not been adequately replicated. Lang et al. (2014b) note that there are a broad range of AT devices available to assist students with disabilities, though most have not been evaluated for efficacy.

In a survey of 163 post-secondary students with disabilities, Ofiesh et al. (as cited in Lang et al., 2014b) found that people with visual and hearing impairments utilized AT at the highest rate, and the most common forms were voice recognition systems, reading machines, frequency modulation (FM) systems, and text enlargement systems, in that order. In 2005, Sharpe et al. (as cited in Lang et al., 2014b), interviewed 139 postsecondary students with disabilities, and found that digitized text, talking books, note taking devices, tape recorders, and voice recognition software were the most frequently used AT devices. The discrepancies between these two findings suggest this needs further study with greater sample sizes and improved methods.

Voice recognition software: This is among the most prevalent form of AT in postsecondary education (Lang et al., 2014b). This allows people to operate a computer through voice commands and to convert speech to text for writing. Dragon is among the most prominent voice recognition software companies, having numerous versions for desktop and mobile use (Dragon 13, Naturally Speaking, Dragon Premium, Dragon for Mac). Others include TalkTyper, IVR by Five9, MacSpeech Scribe, Apple Dictation, Microsoft Windows Speech Recognition, Google's Voice Search, PlainTalk by Apple, and Tazti. Modern versions of the voice recognition software allow the software to learn the individual's speech to more accurately understand their commands or speech (Lang et al., 2014b).

Screen reading or reading machines: These are some of the most utilized AT devices in higher education and produce audio synthetic speech from electronic forms of text (Lang et al., 2014b). Some forms can use camera scanners or readers to turn printed text into digital text, which can then be turned into audible text.

Frequency modulated (FM) listening systems: These systems, sometimes known as loop systems, assist people who have difficulty hearing speech that is low in volume or has other extraneous noise interfering (lectures movies, etc.). These devices use microphones, a transmitter, and a receiver (such as headphones or hearing aid) and can also be used to record audio content for later listening (Lang et al., 2014b).

Voice recorders: There are numerous options for voice recorders.

Blind Travel and Navigation Aids:

White canes and dogs are the most popular AT for travel support (Dakopoulos & Bourbakis, 2010).

A study by Dakopoulos and Bourbakis (2010) surveyed the use of (a) electronic travel aids (ETAs) "devices that transform information about the environment that would normally be relayed through vision into a form that can be conveyed through another sensory modality; (b) electronic orientation aids (EOAs), devices that provide orientation support during travel such as handheld receivers; (c) position locator devices (PLDs) like global positioning systems (GPS). With ETAs, environmental information can be taken in by cameras or scanners and relayed to the individual through audio (sounds or synthetic speech) or through tactile displays (or haptic feedback). Some of these ETAs include echolocation and Navbelt, which presents feedback on the images in the environment or an obstacle map. Another technology is "vOICe" which translates image mapping into sounds that can be processed by users after a rather extensive learning period (it is stated to be "simple, small, lightweight, and cheap," p. 27). The electron-neural system (ENVS) by Meers and Ward translates obstacles through visual sensors and GPS converted to tactile stimulation. All of these should be considered experimental at this time, including commercial products like K-Sonar Cane, Miniguide, Mini-Radar, Ultracane. The researchers found that no system currently contains all of the necessary features to be satisfactory for general wide reaching use because of lack of reliability, features, or performance.

Mobile AT devices for people with visual impairments: Many mobile devices and embedded applications are portable and widely used among the general public so do not carry added stigmatization. The recent innovations in accessibility of mobile AT for people with visual impairments have been in speech recognition, text-to-speech options, auditory feedback, haptic (vibration or tactile) feedback, and combined modes of input (Hakobyan, Lumsden, O'Sullivan, & Bartlett, 2013). Hakobya et al. (2013) note limitations in user interface with mobile devices and a few interface products such as the Slide Rule (talking and touch interface), Audio Browser (user gets feedback from touching the screen through voice and other audio signals), and MoBraille (connects the phone to a small Braille display).

Cognitive/Intellectual Disabilities

General Cognitive Impairments:

A systematic review of 91 studies related to assistive technology for cognition (ATC) found that ATC has been used to effectively support cognitive functions relating to attention, calculation, emotion, experience of self, planning and time management, and memory (Gillespie, Best, & O'Neill, 2012). These researchers showed considerable evidence for the benefit of AT for memory and reminder functions.

Personal digital assistants (PDAs): According to a review by Gentry, Kriner, Sima, McDonough, & Wehman (2015), there is research support for the use of personal digital assistants (PDAs) and other similar portable smart technologies to support cognition for people with brain injuries (Gentry et al., 2008), multiple sclerosis, intellectual disabilities (Gentry, 2008), Alzheimer's disease (Oriani et al., 2003), and mental illness (Simon and Gentry, 2012). Some of the most important contributions of these PDA AT devices are time management, task management, instruction through video modeling, locations/navigation, social interactions training, work supports, and communication supports (Gentry et al., 2015).

Cognitive prosthetics: A systematic review and meta-analysis of cognitive prosthetic technology studies (42 studies) for supporting people with memory impairments by Jamieson, Cullen, McGee-Lennon, Brewster, & Evans (2014) found evidence that this type of AT can improve performance on memory tasks. The AT they evaluated were memory prompting devices that were used within portable digital assistants or static prompting devices. Examples of technology used in these studies included Google Calendar, the Palm Zire, NeuroPage, and WatchMinder.

Transit apps for people with cognitive disabilities (and brain injuries): A review of the "state of the art" research of public transit applications "apps" for people with cognitive disabilities by Livingstone, Skelton, and Livingston (2014) found that there is little information available and that systematic searches of academic literature have found "few studies and no comprehensive review of personal navigation or transit apps for individuals with cognitive disability" (p. 209). The researchers also researched the availability of apps for use with people with cognitive disabilities and found very few that were specifically designed for people with cognitive disabilities. The reviewers recommended the following three apps: "OnTheBus" as having interesting features and development approaches, "Tiramisu" which is available but still in testing and TAD which was only available in Florida as of the article being published. There remains a shortage of apps for cognitive disabilities and lack of research on the efficacy of these devices.

Acquired Brain Injury (ABI):

Portable digital assistants and smartphones: A systematic review of literature was conducted by Charters, Gillett, and Simpson (2014) on the efficacy of portable electronic assistive devices (i.e. smart phones, paging systems, electronic voice memo devices, electronic organizers, personal digital assistants, and tablet/portable sized laptops). The study found 23 studies, of varying study quality, that met the standards for inclusion in the review. They did not find consistent evidence to support standards of practice but did conclude that there was considerable evidence to support the recommendation of the use of portable electronic assistive devices as reminder aides in daily living for people with acquired brain injury. There was insufficient evidence for other compensatory uses beyond reminder aides (e.g. communication or navigation). The authors note important benefits to use of portable electronic AT devices in that they are ubiquitously used and therefore highly socially acceptable and not stigma producing as some other forms of AT may be. They also have strong technical supports, are readily available and may be modifiable to individual needs. Of course there are drawbacks that the authors note, such as the complexity for those with cognitive or learning impairments, their expense, and training and support issues.

The Apple website has examples of various assistive options that can be used with Apple products, such as Switch Controls that allow the user to use switches, joysticks, or other AT devices to control the user's computer screen (http://www.apple.com/au/accessibility/).

It should be noted that software and hardware such as these are readily available but have not been scientifically studied to evaluate their efficacy. Unfortunately, due to the pace of technological advancement and the extended time necessary form conclusions from research, the most current technologies rarely have research validation. As Charters et al. (2014) note, 3 of the 4 studies rated highest in quality were published more than a decade ago, which highlights the urgent need for modern high quality research. When you consider the degree of technological advancement each decade, one can see how determining the efficacy of new technologies can be highly problematic for researchers.

Classifications of portable assistive devices according to the systematic review of literature by Charters, Gillett, and Simpson (2014):

> **Personal digital assistant:** "A handheld computer with the capability to store information (e.g. calendars, schedules, contact lists), recognize and store audio recordings and connect to external computing systems" (p. 89)
>
> **Electronic organizer:** A "small calculator-sized computer" with limited functions such as calendar, address book, and journal (p. 89)
>
> **Smartphone:** "Portable telephone with an advanced computing capability allowing additional features including a media player, navigation, camera, internet, and an enormous variety of applications" (p. 89)
>
> **Voice recorder:** A hand-held device that can record and play stored messages as a recording and reminder support (p. 89)

Pager: A paging system that can send and receive prompts or short text messages (p. 89)

AAC: An alternative and augmentative communication device that is portable and capable of supporting communication in an alternative format (low tech or electronic devices)

Laptops/tablets: A portable computer with a wide range of functions

Rispoli, Machalicek, and Lang (2014) contextualize AT use for ABI as enhancing these areas: (a) cognition, (b) communication, (c) leisure skills, and (d) vocational skills.

Brain Injury AT for Cognition:

There is considerable evidence of the use of AT for memory compensation and reminders (Gillespie, Best, & O'Neill, 2012; Rispoli, Machalicek, & Lang, 2014).

The researchers De Joode, van Heugten, Frans, & van Boxtel (2010) conducted a systematic review of literature and found that there was considerable support for the use of portable electronic aids (pagers, PDAs, and smart phones) to support cognitive functioning of people with brain injuries, though they lack adequate randomized controlled studies but should be considered a promising practice.

As of the early 2000s (Evans et al., 2003 as cited in Rispoli et al., 2014), most people were relying on low tech memory aids, such as personal notebooks and calendars. These notebooks are sometimes preferable because they are completely tailored to the individual's needs and in a format that they can choose.

Rispoli et al. (2014) describe that recently, there has been a shift toward research on high tech devices for use with ABI (such as pagers, smart phones, personal digital assistants, Internet calendar systems), electronic journals, to do lists, and a wide variety of available apps. These have disadvantages such as requiring significant training, being complex, and being expensive. High tech solutions offer several advantages, such as prompting (audio or text alerts).

Electronic memory aids: Electronic memory aids have been shown to be useful in supporting people with ABI in variety of daily living skills like driving, cooking, navigating, budgeting, household safety, and daily planning (Rispoli et al., 2014).

Portable AT devices: These include pagers, PDAs, electronic calendars, and smart phones and have been used successfully for prompting for reminders (meds, appointments, etc.) and serving as memory aids. The reminders can take a variety of forms including alarms; text alerts; directions; or text, video or audio instructions. Smartphones have an advantage as they are not stigmatizing because they are so widespread (Rispoli et al., 2014). They also have been shown to be useful in assisting with planning and organizational elements that contribute to supporting memory function, reminding to complete tasks, and navigation (Rispoli et al., 2014).

Online calendars: Rispoli et al. (2014) note that there is research support for the effectiveness of online calendars in supporting people with ABI in their planning and organization of daily appointments. Microsoft Outlook has been successfully used with people with ABI. There is some evidence that some people with ABI may find the typical software too complex and may benefit from ABI specific software that reduces the complexity.

Pager prompting: Rispoli et al. also describe how The NeuroPage (Hersh & Treagold, 1994) can be used as a simple pager system that can provide reminders of appointments and other types of information. The information is entered into a computer ahead of time and then the reminder system sends out reminders to the pager at the appropriate times. All of the calendars can be preset and can be coordinated with a helper or caregiver. This has shown some benefit in helping improve task completion.

Voice prompting: Voice prompting systems work in a similar manner to NeuroPage and can give audio prompts at appropriate times using prerecorded messages. Examples of these dedicated systems include VoiceCraft and Voice Organizer (Rispoli et al., 2014). The Voice Organizer has shown some support for improving task completion (Rispoli et al., 2014).

Microswitches: Microswitches may be used to allow individuals with little motor movement, limited consciousness, or those who lack strength or dexterity to affect something in their environment. There have been numerous examples of microswitches being used effectively to interact with their environments, leading to improvements in awareness, consciousness, and engagement (Rispoli et al., 2014). In a series of trials, Lancioni et al., (2010, 2012, 2009) taught individuals with minimal motor movement and consciousness, to independently operate his television set and radios, by using microswitches.

A Lancioni et al. (2010) study used a single subject design and showed that two students with multiple disabilities (intellectual and visual impairments) were able to use microswitches to improve learning and also showed a reduction in displaying inappropriate behavior.

Microswitches have been successfully used in cases of severe ABI where individuals have limited movement or were minimally conscious (Rispoli et al., 2014). They also may be custom adapted based on the individual's abilities, such as use of microswitch on the lip or eyelid. They have been successfully used to turn on/off household appliances and to turn channels/change stations on televisions and radios.

Virtual reality (VR) for ABI: Rispoli et al. (2014) note this as an emerging technology that can simulate real environments and help individuals with learning new skills or regaining functioning of old skills (e.g. driving, shopping, getting money out of an ATM, working). Evidence of effectiveness is still lacking, although a study by Fong et al (2010 as cited in Rispoli et al. 2014) trained individuals with ABI in making ATM transactions and found those in the VR group performed as well as those trained using other computer assisted training means.

Portable electronic devices: For people with TBI, PDAs and smart phones have shown to be helpful in short-term studies for managing cognitive deficits (i.e. scheduling and completing tasks) and participants and caregivers rated improved job performance and job satisfaction (Gentry et al., 2008 as cited in Rispoli et al., 2014).

General Cognition AT for Traumatic Brain Injury (TBI):

A systematic review by Leopold, Lourie, Petras, and Elias (2015) of AT for cognitive impairments in individuals with TBI (i.e. memory, concentration, organization, planning, judgments, scheduling) found research used a wide variety of interventions, such as computer software, email interfaces, smartphones, pagers, PDAs, text to speech software/devices, dictaphones, portable prompting devices, and cameras. All studies in the review found positive outcomes for participants in enhanced performance of tasks and improved ability to function independently, with more specific improvements to reading speed, work productivity, memory of events and tasks, using emails, initiating behaviors, and remembering medications. These studies all had methodological limitations and none were identified as high level empiricism (level 1 classification). The most commonly used AT device in these studies were PDAs, used as memory aids, reminders, daily organizers, and in financial management. Other devices used were SenseCam for remembering autobiographical events (memory retrieval), smartphone technology for comprehensive memory supports (particularly audible and visual reminders), use of text-to-speech (TTS) technology to increase reading rate and comprehension (text to speech supporting reading), Google Calendar for a memory aid for daily planning and scheduling, and emails were found to be a useful tool for improving social engagement.

Autism Spectrum Disorders

In general, there is evidence of the benefit of AT devices for assisting people with ASD in communication, social/emotional functioning, and daily living functions (Lang et al., 2014a). Similar to most AT, personal preferences and adequate support are needed to improve changes of successful adoption and use. According to Lang et al. (2014a), research concludes individuals with ASD will likely require intensive training to be able to use AT devices, particularly when they are more complex. Examples that Lang et al. give are speech generating devices (SGDs), social initiation prompting AT, or training in social behavior. Lang breaks AT research for ASD into three functional areas: communication, social/emotional, and daily living.

Communication AT for Autism:

AAC (augmentative and alternative communication) devices: AT to support communication or language functioning, which may be in low tech (like picture boards) or high tech like in speech-generating devices (SGDs; Lang et al., 2014a).

The 3 most common approaches supporting communication are SGDs (speech generating devices), PECS (picture exchange communication systems), and computer based instruction (CBI) (Lang et al., 2014b).

Speech generating devices (SGDs): a device that may have panels or other high tech computer input interfaces that can activate a synthesized or prerecorded voice so a person with limited language functioning may communicate (e.g. say hello, make a request, or convey information). These may be integrated into more sophisticated portable devices like Ipads or smartphones. These have shown some benefit and even may lead to some spoken communication acquisition (Schlosser & Wendt, 2008 as cited in Lang et al., 2014). A systematic review of literature of SGDs and ASD (23 studies) by van der Meer and Rispoli (2010; as cited in Lang et al., 2014) showed evidence for a variety of communication skills being enhanced by SGDs.

In a scoping review of research on the AT that produces substitute speech output for people with autism spectrum disorders that have communication disabilities, Schlosser and Koul (2015) cited 48 studies (1 randomized control trial) that included 187 subjects total. The authors noted that these speech generating devices (SGDs) came in dedicated devices, SGD software used on computers, or applications that can be used on mobile devices. Examples of these SGDs included IPad with the Proloquo2Go app, IPad with PECS Phase III app, IntroTalker, TechTalk, and GoTalk. Overall, the conclusions from the review of past research were that SGDs are considered a “viable and effective” option and that training with SGDs can improve the child’s use of SGDs and requesting abilities. The researchers state that in reviewing current research, there are “sufficiently robust number of studies showing that persons with autism can benefit from speech output technologies in intervention strategies that address increasing requesting behaviors and challenging behaviors” (p. 303).

A review of 23 SGD intervention studies (51 total children across studies) found positive results for exchanging basic messages (Rispoli, 2010 as cited in Sigafoos, 2014).

The Picture Exchange Communication System (PECS): PECS is a picture card based, alternative form of communication. This helps non-verbal clients communicate information by choosing cards and showing pictures of what they are trying to communicate.

There is a general consensus that the PECS shows substantial evidence of effectiveness in improving communication functioning in people with ASD (Lang et al., 2014a).

Across studies, the PECS has been shown to increase communication ability and to increase spoken communication in children with ASD (Lang et al., 2014).

Ganz et al. (2012, as cited in Lang et al., 2014) conducted a meta-analysis of 13 PECS studies with people with ASD, finding PECS is very effective, but the PECS system seems to work best with people with autism (Ganz et al, 2012) over other disabilities; it is more effective when started at a younger age, and those who complete more extensive PECS training tend to have better outcomes, as well.

Computer-Based Instruction (CBI) for Autism:

CBI is the use of computers for training and instruction to teach and to improve functioning, rather than as a compensatory aid. For example, HyperStudio 3.2 can use text, videos, and audio to present instructions or model behavior. It has been used to teach people with ASD communication skills. A review of literature by Ramdoss et al. (2011) found that CBI (only evaluated in younger children, 14 and younger) demonstrated some improvement for all participants in communication skills, so may be considered a promising practice, but there is insufficient evidence for CBI as a research-based approach. Software used was Hyperstudio, PowerPoint, and Baldi/Timo.

Social Skills AT for Autism:

A systematic review of 29 studies by Reed et al., 2008 (as cited in Lang et al., 2014a) found AT to be useful in teaching social skills to children with ASD, such as initiating conversations, using greetings and other social conventions, responding to others, and emotional regulation.

FaceSay is an example of a computer program for teaching social skills that helps children with Autism practice “discriminating between facial expressions, recognizing faces, and identifying emotions” (Lang et al., 2014, p. 168). In a study of 47 children with Autism, both high and low functioning groups saw improvements in social interactions with peers and family members (Hopkins et al., 2011, as cited in Lang et al., 2014a).

Video modeling: Video modeling can be described as the production of videotaped sessions with actors that model the use of proper social interactions. These are designed as teaching instruments which can be viewed repeatedly through the use of a computer or portable device (e.g. IPad). Often, there is one or a set of target skills which are the focus of the video. Video modeling is used as a form of CBI to help them develop improved social functioning, such as in play, gesturing, expression, social initiation, exchanging toys, etc. Numerous studies have been conducted that show evidence for the benefit of video modeling for teaching social skills to people with ASD (Lang et al., 2014a). Again, these results have cautions related to potential research limitations.

AT for script training: Script training is a manner of teaching individuals with autism to use socially appropriate verbal responses when in social situations. A social response is scripted out, and then the individual reads or listens to the response so that they may repeat it at an appropriate time. The goal is for the individual to learn socially acceptable responses, to be able to express them at an appropriate time, and finally to be able to improvise new responses (Lang et al., 2014a). The script may include behaviors, as well, like initiating a conversation, hand shaking, eye contact, listening to the other person, etc. (Lang et al., 2014a). Voice-over recording devices are often used for script training.

This type of script training has been used to increase the duration and quality of social interactions and in a few cases, to increase more general social skills (Lang et al., 2014). Research support for script training is limited but appears to warrant further investigation (Lang et al., 2014).

Daily Living Skills Enhancement in Autism:

Mechling (2008) as cited in Lang et al. (2014a) reviewed studies related to cooking AT for people with ASD and found that instructions given through personal computers, picture instructions, video recorded modeling, and auditory prompting could help individuals prepare their own meals.

In a review of literature, video modeling (IPhone, video tapes delivered by video player), picture based instructions, and other CBI instruction ("I Can" software for step by step instruction; Project SHOP computer simulation to teach grocery shopping; laptops with video simulations) have been used to teach food preparation, housekeeping skills, shopping skills, and the use of public transportation (Lang et al., 2014a).

General conclusions: Lang et al. (2014a) concluded that three types of AT have been able to enhance communication effectively with people with ASD: picture-exchange systems (PECS; low tech and high tech), speech generating devices (SGDs), and computer-based instruction (CBI).

They also concluded that CBI and video modeling have both shown research support for their use in improving a range of different social and emotional skills, such as recognizing emotional states and initiating social interactions. Finally, they concluded that AT (video modeling and CBI) can successfully be used to enhance a range of daily living skills such as food preparation, housekeeping, shopping, or using public transit.

Vocational Assistance in Autism:

Gentry et al. (2015) conducted a randomized clinical trial study (50 adults in the sample) of the use of and Ipod Touch (4^{th} Generation; PDA) as an AT device to support their work success in adults with autism (N = 49). The results showed that using an Ipod Touch PDA significantly reduced the need for job coaching supports for people with ASD in work settings and did not reduce the functional performance of those workers. The apps used were not standardized but rather were individualized to the employee's needs based after an assessment of needs.

Physical Disabilities

Microswitches: These are switches that can be operated through micro-movements of the body. These switches may be used to allow individuals with little motor movement or those who lack strength or dexterity to activate other assistive devices or technology in their environment. There have been numerous examples of microswitches being used effectively to interact with their environments leading to improvements in awareness, consciousness, and engagement (Rispoli et al., 2014). In a series of trials, Lancioni et al., (2010, 2012, 2009) taught individuals with minimal motor movement and consciousness, to independently operate his television set and radios by using microswitches.

Cerebral palsy: A systematic review of research by Davies, Mudge, Ameratunga, and Stott (2010) found there is inadequate evidence for AT for self-directed computer use for those with CP.

Amputation (haptics): A review by Shull and Damina (2015), describe how haptic feedback can help restore the sense of touch and grip force in prosthesis by relaying vibrations from pressure sensors within the prosthesis to the skin of the wearer. They note that studies have shown "clear benefits" of wearable haptics for upper-limb prosthetics by restoring the sense of grip force, slip, and proprioception senses.

Balance (haptics): Haptic feedback has been shown to improve balance and gait for people with balance or peripheral neuropathy (Shull & Damina, 2015).

Spinal cord injury pressure sore AT: A review of studies by Tung, Stead, Mann, Pham, and Popovic (2015) found a low to moderate effectiveness for using computer based educational technologies to train in pressure sore management, pressure mapping technologies to improve pressure-relief schedules, electrical stimulation, and telemedicine to support pressure sore self-management.

Orthoses for spinal cord injury: A review of research (1960-2010) related to orthoses for people with paraplegia by Karimi (2012) found that among the various types of orthoses, mechanical orthoses appear to help people with SCI with walking better than other types. When comparing the two most common mechanical orthotics, hip guidance orthosis (HGO) to reciprocal gait orthosis (RGO), HGO appear to perform the best. Even with these results, users tend to prefer wheelchairs to walking orthoses for mobility because of the effort needed and number of other complications (e.g. fear of falling, time needed, and needing assistance from others).

Robotics AT for mobility (Smart Walkers): Martins, Santos, Frizera-Neto, and Ceres (2012) conducted a review of research of the "state of the art" in robotic AT used for mobility related disabilities. Smart wheelchairs utilize advanced technologies like brain computer interfaces and electromyography signals to operate the AT devices. These advanced AT may come in stand-up (bipedestation) position options. The researchers discuss how smart walkers may assist people with physical support, sensory assistance, cognitive support, and health monitoring. The IWalker is an example that provides physical support and cognitive assistance through navigation assistance programming. The Personal Adaptive Mobility Aid

(PAM-AID) walker provides multiple supports such as physical and sensory support for blind users. The SIMBIOSIS supports user's weight and has an advanced human interface that senses forearm force and guides the users intended navigation direction. The authors note great advances in robot smart walkers but also several limitations of current options, most importantly the majority of options in the review have not been evaluated with their target users (elderly or users with disabilities), so their efficacy for use within this populations is unknown.

Robotics AT for rehabilitation: A review of studies of robot devices for upper limb rehabilitation by Maciejasz, Eschweiler, Gelach-Hahn, Troy, and Leonhardt, (2014) found devices with various types of assistance such as active devices, passive devices, haptic devices, or feedback producing (coaching devices) that come in various forms, such as end-effector based and exoskeleton designs. The authors stress that over the last 20 years there have been advancements in the mechanical aspects and control interfaces, but there is still little research on the efficacy of these devices for rehabilitation purposes, and the available studies are difficult to compare to each other due to differences in devices, methods, goals, and patients. The authors note that systematic review and meta-analyses of trials with people with strokes found that robotic training can increase motor functioning and strength but has not shown the ability to improve activities of daily living.

Robotics AT for upper limb motor impairment: A scoping review of research evidence by Beaudoin, Routhier, Lettre, Archambault, and Lemay (2015) for the use of robotic arms found that the robotic arms have shown more positive than negative impacts in activities of daily living, leisure activities, work activities, and participating in games. The authors caution about the quality of the research available, and more rigorous research is needed.

Electrical stimulation: Electrostimulation has shown a number of benefits for people with spinal cord injuries. When combined with exercise therapy, it has shown benefits in improving motor control or functional ability in the arms, reducing spasticity, improving tissue health, reducing atrophy, range of motion, improving strength, pain management, and reducing progression of osteoporosis (Bryden, Ancans, Mazurkiewicz, McKnight, & Scholtens, 2012).

Functional electrical stimulation systems: These systems are neuroprosthetics and rehabilitation systems, such as the Bioness H200, which have electrodes on the surface of the skin and help the individual with exercise, muscle conditioning, and functional activities. A hand device, such as the Bioness H200, may help the individual regain movement and perform functions like writing or grasping. These devices have been shown to improve grip strength, grasping ability, and other like tasks in people with limited muscle function (Bryden, Ancans, Mazurkiewicz, McKnight, & Scholtens, 2012).

Electromyography (EMG): This is a practice used in central nervous system injuries and involves detecting EMG activity in the muscle (action potentials), and: (a) using visual and auditory biofeedback to train people to help them learn how to activate the muscles, (b) in EMG trigger stimulation (Bryden, Ancans, Mazurkiewicz, McKnight, & Scholtens, 2012). This has been shown to have promising effects in 2 studies.

AT for computer access and interface: Those with strength/neuromuscular/fine motor control disabilities may find benefit of the following for interfacing with computers: speech-recognition software, include trackballs for mouse application, head-point mouse options (Tracker Pro, Head-Mouse, TrackIR), eye-gaze tracking/methods for navigation, brain-computer sensors (implanted or surface) that may act as mouse movement for interface with a computer (Bryden, Ancans, Mazurkiewicz, McKnight, & Scholtens, 2012).

Neuroprostheses: These are implanted devices that stimulate muscles to perform actions in the target area, such as in opening and closing the hand, grasping an object, or holding a pen. These have had trials in arm/hand functioning, lower extremities for standing, for greater trunk stability in those with high level spinal cord injuries, to assist with coughing, to assist with breathing, and bladder/bowel functioning. Further efficacy studies are needed, though these neuroprotheses have been implanted in thousands of individuals as of the study date (Bryden, Ancans, Mazurkiewicz, McKnight, & Scholtens, 2012).

AT devices for athletic purposes in those with physical disabilities: A review of literature on AT for athletic purposes by Hill, Scarborough, Berkson, and Herr (2014) stated that modified wheelchairs are currently the most used and effective AT devices. They note that for powered AT devices in recreational sports are paramobile devices for mobilizing those with paraplegia. They describe that lower-limb prostheses for running have gained in recent innovation (such as "cheetah" technology) and improved socket designs. Some powered (robotic) prostheses are currently in development but are untested and evaluated at this time. Other advances have been made in snow ski prosthetics, snowboard prostheses, swimming prostheses, and boat rowing prostheses (Hill et al., 2014).

Non-invasive movement control: A comprehensive review of research related to non-invasive control interfaces that operate mobility and movement AT devices was completed by Lobo-Prat et al. (2014). These researchers concluded that current non-invasive brain computer interfaces (controlled brain signals such as EEG or MEG) still have significant limitations in their speed, accuracy, and reliability in how they interface with other movement AT devices, though these are improving steadily. These researchers state that myoelectric-based interfaces (controlled by activation of muscles that still remain) are still the most common method for controlling active prosthetic or orthotic AT. The researchers caution that many control interfaces have been developed, but the efficacy and usability is unknown and requires further research, particularly in real world application. Interfaces with parallel systems are common and may include eye-movement control interfaces, tongue controlled interfaces, head movement interfaces, speech command controlled, and hand joystick interfaces. The researchers concluded that these parallel systems are "suitable solutions" for controlling movement and mobility AT for those with significant paralysis.

Powered robotic exoskeletons: Louis, Eng, and Lam (2015) conducted a systematic review (15 studies) of gait speed using powered robotic exoskeletons as AT for walking for those with spinal cord injuries. The researchers concluded that those with complete spinal cord injuries at the thoracic level could use powered exoskeletons to walk at "modest" speeds. The age, injury level, and amount of training the individual received was significantly correlated with the speed they could walk with the exoskeleton. The authors noted significant challenges in the methodology of these studies including no control groups, no comparisons to other types of AT, and differences in procedure/methods across studies.

Speech, Language, & Communication Disabilities

Communication involves the exchange of a message between entities. Information is sent, received, interpreted, and then responded to. Communication disorders can have a variety of etiologies including those from speech production, language comprehension, and hearing. (Schindler et al., 2010 as cited in Sigafoos et al., 2014). Sigafoos et al. (2014) note an increasing amount of research on AT for communication disorders but very few reviews of this research to make sense of the landscape.

Augmentation and alternative communication (AAC) devices: AAC devices are a broad range of assistive devices meant to support people with language and communication disabilities.

As Rispoli et al. (2014) note, both low tech and hi-tech communication AT have shown promise in assisting people with communication disabilities to express themselves more effectively. The cognitive and motor abilities of the individual will sometimes determine the sophistication of the method, but most methods require the manual activation so the person's fine motor skills will have to be taken into account to use these devices (microswitches may be useful in some circumstances). The cognitive abilities of the client must also be taken into account in determining the sophistication of the device (i.e. text, pictures, picture board, touch screen, smart technology devices).

AAC devices use objects, pictures, boards with text, or electronic formats of visual cues to help people with communication related disabilities express themselves (Rispoli, Mahcalicek, & Lang, 2014).

A review of literature from 2000-2010 by Baxter, Pam, Philippa, and Simon (2012) found 65 papers reporting interventions using high-tech AAC devices. The authors surmised that there was good evidence that high-tech AAC devices may be beneficial for communication support across a variety of disabilities.

Low tech AT: According to Rispoli and colleague's (2014) review of literature, low tech AT is still the most common form of AT for communication disorders in acquired brain injury because they are inexpensive, easy to make and modify, and portable. Examples are paper and pencil notebooks or photograph boards.

Communication books for people with ABI: A book depicting a variety of information that is personalized and important to that individual. The person can store these in a communication book and can be used to share information with other people by showing the symbols or pictures (Rispoli et al., 2014; McKelvey et al. 2010; Ho et al., 2005).

Speech-generation devices (SGD): A device or program that can produce audible verbal messages in the form of digital, synthesized or recorded voice output (Rispoli et al., 2014). The input is controlled by the user and the voice is generated by the SGD. They can be single button or with a typing text or complex communication board interface. Many have touch screens that may be triggered through the use of touch, eye gaze, joysticks or microswitches.

Lancioni et al (2009) used a microswitch and a SGD to help teach an individual with severe TBI who was in a minimally conscious state to be able to call for assistance from caregivers when needed.

Hi-Tech Communication AT for People with Intellectual Disabilities or ASD:

IPad and SGD use: Kagohara et al. (2013) presented evidence that individuals with developmental disabilities with little or no speech can successfully use IPads/IPhones and related technologies as SGDs.

Kagohara et al. (2013) conducted a systematic review of the use of IPad (IPod and IPhone) technology for assisting people with developmental disabilities (ASD or intellectual disability) in areas of learning, communication, employment, leisure, and transitioning across school settings. All studies had very low sample sizes, so results should be taken with caution. Findings revealed that IPad technology showed promise in helping individuals learn academic skills, develop employment skills such as learning new tasks and reduced need for prompting, learn how to independently operate IPads to watch movies or play music, and to engage in appropriate behavior. Additionally, they found eight studies that found promising potential in using IPads to help people with intellectual disabilities or autism with communication. One study used Proloquo2Go software loaded on an IPad to be used as a SGD. The participant was able to become successful at requesting snacks using the SGD with appropriate trainer behavior shaping interventions. A second study also showed that individuals could be taught to use the Prologuo2Go software on an IPad to successfully request food and toys. A later study was able to demonstrate success in more advanced use of an IPod touch in teaching 2 adolescents with ASD to turn the device on, unlock the screen, navigate to a Proloquo2Go page, and select stimuli within the program. A later study compared the use of an IPad based communication system and a picture based communication board system and found that these systems appeared to have comparable effectiveness. A group of three studies looked at the use of the IPad with Proloquo2Go SGD software and found that participants preferred the IPad SGD to using manual signs or picture-exchange systems for communication. They showed better maintenance of behavior when using the IPad.

SGDs: Sutherland et al., (2010) conducted a review of literature (11 studies with 15 total participants) to investigate the use of SGDs. Overall, the results showed benefit for SGDs in communication for those with intellectual disabilities and autism.

Hill and Corsi (as cited in Sigafoos et al., 2014) note that there is a growing need for AT to provide support for people with communication disorders, although this is a rapidly developing area so clinicians become knowledgeable and stay up to date in order to be effective.

The following section summarizes information from the Sigafoos et al. (2014) chapter on AT for supporting communication disabilities:

Speech-generating devices (SGDs): SGDs are devices or programs that produce synthetic speech or recorded voice output. SGDs can serve as communication aides for individuals with intellectual disabilities, autism, motor disabilities, and severe multiple disabilities (Sigafoos et al., 2014). An example of an SGD is Tech/Talk by Advanced Multimedia Devices, which has 48 symbols on a board that can be pressed to communicate messages through speech generated by the SGD (Sigafoos et al, 2014).

Two reviews of studies of SGDs for people with developmental disabilities and autism (58 studies total) found there were positive results showing SGDs show promise in supporting basic message exchanges after appropriate training (Sigafoos et al., 2014). Sigafoos et al. (2014) state that reviews of research support the use of SGDs as AT to support communication for those with intellectual disabilities, autism, and severe and profound multiple disabilities (Sigafoos et al., 2014).

In a review of 13 studies of SGDs showed benefit for supporting communication for those with cerebral palsy (Sigafoos et al., 2014). AT examples include Mega Wolf, Liberator, Delta Talker, Message Mate, Vanguard II Unity, DynaVox DV 4, WiViK (virtual keyboard), and microswitches. The findings are cautionary due to small sample sizes and other methodological challenges.

In a review by Sutheraland (2010; as cited in Sigafoos, 2014), using SGDs for those with severe communication impairments due to intellectual disabilities, participants were taught to be able to communicate simple responses to make requests. They note that generalizability is limited.

Lancioni et al. (2013; as cited in Sigafoos et al., 2014) conducted a review of literature across 54 studies on the use of SGDs to support communication for those who were not verbal. Overall, the SGDs showed positive benefit in improving communication of choices, social interactions, and reducing negative behaviors.

Sigafoos et al. (2014) also described studies for those with motor speech disorders (e.g. developmental apraxia of speech (DAS), dysarthria, ALS), specifically describing ten studies that used various SGD technologies (The Macaw SGD, Wolf, Sharp Memo Writer, The "Dialo" speech synthesizer, Talking Mats, microswitches, optic microswitch solutions, eye gaze communication boards, and Clicker 5 software). Overall, these technologies may provide benefits in increasing communication, making preferred requests and advanced communication in ALS using optic microswitches and can help them remain socially connected to friends and family.

AT for those with aphasia: Sigafoos et al. (2014) described 14 studies on the use of assistive technology for addressing communication disorders in those with aphasia. The studies employed a variety of different technologies, including primarily voice recognition software (Dragon Naturally Speaking, Light Writer, MossTalk Words, Dialect, Speaking Dynamically Pro, TouchSpeak software), and computer writing aids. TouchSpeak showed significant increases, but after 3 years, only 2 of 12 participants were still using it. Evidence from 3 studies show significant benefit of MossTalk Words for improving picture naming skills in people with non-fluent aphasia. There was encouraging support for Dragon with an individual with autism. They noted research showing that in some cases voice recognition software can be trained to recognize speech that is "highly unintelligible" (Sigafoos, 2014, p.96).

AT for those with motor speech disorders: According to Sigafoos et al. (2014), when talking about AT research for communication disorders, SGDs were the most prevalent devices. This is also true for those with severe and profound intellectual and multiple disabilities. There were several types of SGDs utilized including Mega Wolf, DynaVox, Macaw, and Vanguard II. Several studies also looked at speech recognition software for use with those with unintelligible speech. Use of microswitches (via small movements such as throat vibrations, tongue movement, finger movement, optic activated, or head tilting) to increase communication capacity or to perform simple communication necessary motor tasks like making phone, Skype calls, or texting shows promise. A number of computer software programs appears to help improve picture naming spelling and comprehension. They recommend more research here due to the rise in use and variety of apps available in the iPhone and IPad.

**(Sigafoos et al. (2014) noted "there is sufficient evidence to support the use of assistive technology in the treatment of communication disorders associated with cerebral palsy, apraxia, dysarthria, ALS, and aphasia" (p. 108).

General AT Usage

According to Anttila et al. (2012), the prevalence or usage information on AT specific devices is unknown or stems from single surveys which have limited generalizability. There is little recent information available on the general usage of AT in the United States. As Scherer (2012) reported, the most recent large scale data collection on AT usage in the United States was completed by National Center for Health Statistics, Centers for Disease Control and Prevention in 1994. This data reported that the most frequently used AT devices were for mobility impairments (about 7.4 million users), orthopedic impairments (4.6 million users), hearing impairments (4.5 million users), and vision impairments (0.5 million users of glasses and contacts).

A 2005 study by Carlson and Erhlich for the National Institute of Disability and Rehabilitation Research (NIDRR) of 1,414 individuals with disabilities, found canes, wheelchairs, hearing aids, and walkers were the most prevalent AT devices used at home, school, work, and in the community. Six of the top seven devices used were to support mobility impairments. The eleven top devices were wheelchairs, canes, walkers, hearing aids, scooters, crutches, electric wheelchairs, oxygen tanks, other personal-use AT, shower seats, and back braces. It is evident from these findings that the research has not caught up to the rapid technological advancements in computer and mobile devices and further research is needed to determine accurate usage statistics.

In a survey of 163 post-secondary students with disabilities, Ofiesh et al. (as cited in Lang et al., 2014) found that people with visual and hearing impairments utilized AT at the highest rate, and the most common forms of AT for higher education were voice recognition systems, reading machines, frequency modulation (FM) systems, and text enlargement systems, in that order. In 2005, Sharpe et al. (as cited in Lang et al., 2014) interviewed 139 postsecondary students with disabilities, and found that digitized text, talking books, note taking devices, tape recorders, and voice recognition software were the most frequently used AT devices for learning. The discrepancies between these two findings suggest this needs further study with greater sample sizes and improved methods.

An analysis of AT usage from the 2009 National Health Interview Survey by Tshiswaka, Clay, Chiu, Alston, and Lewis (2015) explored the usage rates of AT by race. Within their sample of 25,352, the researchers found that 8% of Americans used AT: 7.5% of European Americans used AT and 10.0% of African Americans used AT.

Prominent Acronyms within the Report

AAC: alternative and augmentative communication device

ABI (acquired brain injury): a brain injury that occurs after birth and may involve trauma, stroke, hypoxia, or illness, but that usually does not include genetic or degenerative neurological disorders

ALD (assistive listening device): an amplification device to help support communication for those with hearing impairments in environments with background noise interference

“Apps” (computer applications): mobile computer programs

ASD (autism spectrum disorder): a developmental disability characterized by impairment in communication and social interactions, as well as restricted or repetitive behavior patterns

AT (assistive technology): a device or system used by people with disabilities to improve functioning

CAI (computer assisted instruction): an equivalent to computer based instruction

CBI (computer based instruction): this involves teaching behaviors or tasks through the use of a computer or electronic device

ETAs (electronic travel aids): devices to enhance travel for people with visual impairments

FM (frequency modulation): a looping audio system for people with hearing impairments that have a microphone, transmitter, and receiver which sends audio signals to a personal listening device

PDA (personal digital assistant): a hand-held portable device that performs basic computer functions like journaling, calendars, reminders, and in some cases Internet access

PECS (picture exchange communication systems): a system for sending sound from a microphone to a receiver where it can be heard more clearly

SCI: spinal cord injury

SGD (speech generation device): a device or program that produces synthetic speech or recorded voice output

TBI (traumatic brain injury): a brain injury caused by a blow to the head, penetrating injury, or rapid acceleration or deceleration of the head

TTS (text-to speech): technology that voices text in through a synthesized or natural sounding audible voice

VRS (video relay services): the use of video sign language interpreters for distance telecommunication

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