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Alternative Access for Adults Who Rely on Augmentative and Alternative Communication

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Individuals with complex communication needs and severe physical impairment often require the use of alternative access options to control speech-generating devices and other communication support technologies. For those with severe physical impairments, access options have expanded and improved substantially. This article will describe some of the advances in access technology already being employed as access solutions to speech-generating devices and highlight areas for future advancement and refinement of access technologies.

Physical access challenges are common for many individuals with complex communication needs (CCN) who rely on speech-generating devices (SGDs). Individuals with acquired (e.g., brainstem stroke, severe traumatic brain injury, and Guillain-Barré), degenerative (e.g., amyotrophic lateral sclerosis [ALS] and multiple sclerosis), and congenital (e.g., cerebral palsy and muscular dystrophy) conditions often experience decreased physical movements and/or limited control over physical movements (Ball, Beukelman, & Bardach, 2007; Culp, Beukelman, & Fager, 2007; Doyle, Kennedy, Jausalaitis, & Phillips, 2000; Fager, Doyle, & Karantounis, 2007; Hurtig & Downing, 2008; Klasner & Yorkston, 2000; Mathy, Yorkston, & Gutmann, 2000; Traviranus & Roberts 2003; Yorkston & Beukelman, 2007). These movement challenges cause direct selection to a touch screen on an SGD and/or the use of a traditional keyboard and mouse to be extremely difficult or impossible. A myriad alternative access devices and technologies now exist to support the access needs of individuals with CCN and severe physical impairments (Beukelman & Mirenda, 2013; Dowden & Cook, 2012; Hurtig & Downing, 2008).

Evaluation and decision making for access to SGDs often include input from multiple augmentative and alternative communication (AAC) team members (e.g., speech-language pathologist, occupational therapist, physical therapist, and individual with CCN and their family, caregivers, and physicians), and the number of members and configuration of this team can change across settings for individuals with CCN who have severe physical impairments (Beukelman & Mirenda, 2013). Collectively, the clinical team evaluates the physical capabilities of the individual with CCN through observation and trials with equipment and technology to recommend access options that best meet the individual's unique needs. The goal of this article is to describe some of the current access options available (technology description, uses, and challenges) and introduce some of the new and emerging access technology options that may become available in the future for individuals with CCN and severe physical impairments.

Current Access Solutions for Individuals With Severe Physical Impairments

Switches to Support Scanning Access

Switches are devices that send an electrical signal to elicit an action, such as making or breaking a connection in an electrical circuit. These switches are used to make a selection on an SGD. A range of switches and mounting options (e.g., equipment that attaches switches to wheelchairs, bedrails, desks, and tables) are available to support switch-activated scanning access to SGDs. Many switches now can accommodate a variety of physical needs, including light touch switches (Microlight and Specs Switch[1]) for those with reduced movements, switches that can be activated via small muscle twitches (P-switch[2]), and switches that are durable/rugged (Jelly Bean and Pillow Switch [see Footnote 1]) for those with limited control over the strength of their movements due to tone and spasticity. For limited movement capabilities, electromyography switches that can detect isolated muscle contraction (NeuroNode Switch[3]), infrared switches that can detect blinks (ScatIR Switch [see Footnote 1]), and a range of pneumatic switches that detect subtle changes in air pressure that can be used via oral sip-and-puff are available. Although this list of currently available switch options is not exhaustive, it illustrates the breadth of switch access now available to accommodate the needs of individuals with a range of physical movement challenges.

Switch access is described as an indirect access option that can be difficult for individuals to learn and implement. The cognitive/learning challenges associated with switch scanning has been documented (Fager, Bardach, Russell, & Higginbotham, 2012; Light & Drager, 2007; Marina, Drynan, & Tiessen, 2012; McCarthy & Boster, 2017; McCarthy et al., 2009). For example, switch-activated scanning requires the user to understand the connection between the switch activation and scanning array that is triggered by the switch. For young children and/or those with severe cognitive impairments, this can be challenging to learn (Light & Drager, 2007; McCarthy & Boster, 2017; McCarthy et al., 2009). Because of the cognitive/learning load associated with switch-scanning, this method is often a secondary choice if direct access methods are not feasible. Additionally, switch scanning can be a slow and laborious method of access particularly for those who primarily rely on spelling to communicate messages and/or for those who require navigation through multiple pages of nested communication content to support their communication needs.

Eye- and Head-Tracking Access

Eye- and head-tracking technologies provide alternative direct access solutions for individuals with CCN and severe physical impairments. Eye-tracking technology uses an infrared light source that reflects off of the cornea. These reflections are tracked by a camera. The user can look at their intended communication target and either dwell, blink, or activate a switch with another physical movement to make their selection. Head tracking uses infrared technology that can detect reflective markers placed on an individual's forehead, headband, or baseball cap, translating head movement into cursor movement on a computer or SGD interface. Some of these technologies require that the user recalibrate the system while in use by moving the cursor to the extreme corners of the computer interface (e.g., HeadMouse Nano[4] and CameraMouse[5]) as the cursor can lose calibration during use. This technology is often best suited for individuals who have typical range of movement of their neck muscles. For individuals whose condition has affected their neck muscle control and range of movement (e.g., spinal cord injury and brainstem

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[1]Ablenet, Inc., 1-800-322-0956, https://www.ablenetinc.com
[2]Prentke Romich Company, 1-800-262-1984, https://store.prentrom.com/p-switch-sensor-large?search=switch https://store.prentrom.com/nueye-tracking-system-br-accent-1400-accent-1200-and-accent-1000
[3]Control Bionics Inc. 1-855-831-7521, http://www.controlbionics.com/neuronode/
[4]Origin Instruments Corporation, 1-972-606-8741, http://www.orin.com/access/headmouse/
[5]CameraMouse, http://www.cameramouse.org/

stroke), this technology can be difficult to use. Some head-tracking devices allow the user to calibrate upon initial use so that the calibration stays constant during use (e.g., SmartNav[6] and AccuPoint[7]). Others include software options that can scale the individual's movements up to increase the sensitivity of the head tracker resulting in full screen cursor control with reduced head movements (e.g., AccuPoint [see Footnote 7]). Eye-safe laser-pointing technology has also been developed to support access to digitized speech devices and text-to-speech via Bluetooth connection to a tablet (Safe Laser System [see Footnote 7]; Fager, Beukelman, Karantounis, & Jakobs, 2006). A range of head tracking is now available that can accommodate a variety of physical movement challenges.

The most substantial recent advances in alternative direct access technology have focused on the development of eye-tracking access to SGDs. Many devices now incorporate eye tracking as a built-in or external accessory to the SGD (e.g., I12+[8], NuEye [see Footnote 2], WinSlate 12D with EnableEyes[9], and Eye Gaze Edge[10]). Eye tracking has been documented as particularly useful for individuals with brainstem stroke, Guillain-Barré syndrome, and ALS due to the severity of physical movement deficits that accompany these conditions. Development and integration of eye-tracking technology into current SGDs has supported independent communication early in recovery (e.g., brainstem stroke) and extended access to communication up until or close to the time of death (e.g., ALS; Ball, Fager, & Fried-Oken, 2012; Ball et al., 2010; Beukelman, Fager, & Nordness, 2011; Fager, Beukelman, Fried-Oken, Jakobs, & Baker, 2012).

Eye-tracking technology, however, does come with some challenges. The technology can be impacted by lighting in the environment (ambient light, overhead lighting), positioning (the distance of the camera from the user and the angle of the camera to the user's face), glasses, use of rigid gas permeable (hard) contacts, the overall health condition of the user's eyes (e.g., dry eyes), ptosis (eyelid droop), and ocular motor control issues (eye ataxia, decreased eye motor control). All of the challenges mentioned can also change throughout the day within a particular individual (e.g., positioning changes, eye becoming dry after administration of certain medications, and increased ptosis when fatigued). Fortunately, a range of eye-tracking technologies exists, and depending on the specific eye-tracking device being used, some of these challenges can be alleviated.

Setup, calibration, and maintenance of this technology often require specifically trained communication support persons. Reports of successful use of this technology have described training and support that extended well beyond the evaluation and initial setup of the technology (Ball et al., 2010; Beukelman, Fager, Ball, & Dietz, 2007; Fager, Bardach et al., 2012; Spataro, Ciriacono, Manno, & La Bella, 2014).

Advances in Access Technology to Look for in the Future

Opportunities for further refinement and development of new access methods continue to be explored. This section will highlight a few possible developments that may emerge in the future that will benefit individuals with CCN who have severe physical access challenges.

Movement Sensing Technology

For individuals with severe impairments, initiating movements at the right time can be difficult as the motor planning and execution of the movement is delayed. For others, movements that are initiated can trigger other movements that interfere with accuracy. For example, an

[6]NaturalPoint, 1-541-753-6645, https://www.naturalpoint.com/smartnav/
[7]Invotek, Inc., 1-479-632-4166, https://www.invotek.org/collections/products/products/accupoint https://www.invotek.org/collections/products/products/safe-laser-system
[8]Tobii Dynavox, 1-800-344-1778, https://www.tobiidynavox.com/en-us/devices/eye-gaze-devices/i-12-with-communicator-5/
[9]Forbes AAC, 1-888-84-2190, https://www.forbesaac.com/winslate-12-enable-eyes
[10]LC Technologies, Inc., 1-703-385-8800, http://www.eyegaze.com/tag/eyegaze-edge/

individual recovering from a brainstem stroke with ataxia may experience excessive movements and decreased muscle control with volitional movement attempts. Therefore, initiating a movement to access a switch could cause a variety of uncontrolled movements making selection of the switch difficult. For others, initiating a physical movement can trigger increased muscle tone, causing extension of the arms and legs, moving the individual away from their access device. Sensor technology may begin to provide solutions to these challenges by detecting volitional movements and filtering out extraneous movements. Reports of access devices that incorporate accelerometers, gyroscopes, and magnetometers to more accurately identify intentional movements and translate these movements into switch closures are beginning to emerge. Researchers in the Rehabilitation Engineering Research Center on AAC (https://rerc-aac.psu.edu/research/) described the development of a prototype switch for a young woman with severe movement challenges due to brainstem impairment. In their case illustration, the young woman was able to achieve slight thumb raises to signal for attention and access a switch. However, for this movement to be easily identified by caregivers and used to activate a switch for communication, her hand had to be optimally positioned in her lap when she was upright. If she was lying down, coughed, and laughed or if her hand moved slightly out of position, she no longer had access to communication using this movement. A switch was developed using sensor technology that could differentiate between intentional and unintentional movements. This device was not dependent upon positioning and was housed within a small brace that could be placed upon her hand, eliminating the need for mounting equipment.

The need for optimal positioning and extraneous equipment, such as mounting devices, may be able to be eliminated through the design of a new genre of switch technology that can be worn or easily placed near the individual with CCN. For example, Fager et al. (2017) have begun preliminary investigations of capacitive sensor technology that can be used as a single or multiswitch interface. The capacitive sensors, embedded into flexible pads, can be placed in a range of locations. The individual with CCN can then gesture near the sensor to trigger a switch selection or a full message or command can be associated with this movement.

Brain Computer Interface

Brain computer interface (BCI) technology involves harnessing the brain's electroencephalography signals to interface with computers. Currently available noninvasive BCI technology has focused on development for gaming applications (e.g., Emotiv[11]). However, augmentative and alternative communication (AAC) researchers have been investigating the use of noninvasive BCI using alternative interfaces (Akcakaya et al., 2014). The RSVP keyboard is an example of such an interface where the letters of the alphabet are rapidly presented to the individual. When the target letter is presented, the BCI is able to detect the change in the electroencephalography signal to make the letter selection (Fried-Oken, Mooney, Peters, & Oken, 2015; Orhan et al., 2012). Other work is examining the integration of statistical language modeling during text generation using BCI (Moghadamfalahi et al., 2015; Oken et al., 2013). Although the integration of BCI technology into SGDs has not occurred, the use of noninvasive BCI as an alternative switch access option may be a practical solution in the future for individuals with CCN who are completely paralyzed due to their condition (e.g., late-stage ALS and brainstem stroke) and are in a physically locked-in state (no control over any physical movement; Chavarriaga, Fried-Oken, Kleih, Lotte, & Scherer, 2017).

Multimodal/Multi-Input Access

Many individuals with CCN and severe physical impairments typically rely on a single access method to SGDs (e.g., switch scanning and eye tracking). However, many are able to use other physical movements and access methods to some extent. To date, current SGDs provide multimodal/multi-input access in very limited ways. For example, individuals using eye and head tracking for cursor movement can make selections with other movements, including eye blinks

[11]Emotiv, https://emotiv.com/

(for eye tracking) or by activating a switch. Although multi-input SGDs include settings to change the access options being used, this cannot be done independently by the individual with CCN if they are using eye tracking or switch scanning as changing the access option requires disabling the option in use. However, some individuals who rely on SGDs to support communication do use a variety of access methods. Researchers in the Rehabilitation Engineering Research Center on AAC (https://rerc-aac.psu.edu/) have collected preliminary anecdotal evidence from individuals who rely on AAC regarding the kinds of access strategies they use to support communication activities (https://rerc-aac.psu.edu/). For example, one individual who had severe spastic cerebral palsy described his use of eye tracking and scanning within his SGD. Specifically, he used his eye tracker to spell messages on a large onscreen keyboard, and he used a scanning software to control the cursor on his SGD to navigate between software applications and to open/close documents. This required extensive support and initial setup from his speech-language pathologist along with the technical support staff from two different AAC device manufacturers to allow both access hardware and software options to work together. SGDs, to date, have limited options available to users that allow them to independently switch between access methods.

Another population for whom multimodal/multi-input access could be beneficial is individuals who typically are not candidates for certain access options (i.e., eye tracking) but with the integration of an additional modality; such access may be possible. Researchers (https://rerc-aac.psu.edu) have begun exploration of the combination of these methods with individuals with severe physical impairments. In a current case example, a young woman who sustained a brainstem stroke resulting in severe physical impairments that included impaired occulomotor control and diplopia (double vision) requiring spot patches to be applied to her glasses trialed a multiaccess system. Her impaired eye movement control coupled with spot patching that obscured her eyes and pupils made eye tracking an inaccurate and frustrating access method for her. However, a multimodal/multiaccess system that included eye tracking coupled with switch scanning was a viable access method for this individual. The system used eye tracking to narrow down a group of letters on an onscreen keyboard, not requiring the user to precisely eye gaze to the target letter. When the target letter was within the group being highlighted, the individual using the system activated a switch. This smaller group of four to five letters was then scanned, and the target letter was then selected. This technology allowed the individual with CCN due to brainstem stroke use eye tracking as a way to narrow down the selection set, and then, she was able to make her selection via switch scanning. This work is currently underway, and investigation of this technology with other individuals with severe physical impairments and CCN is required to more fully understand its use for individuals who have challenges with eye tracking.

Conclusion

A range of access solutions currently exist to support the access needs of individuals with CCN and severe physical impairments. Opportunities exist for the field to learn from the limitations of the current technology (e.g., optimal setup and single modality access limitations), capitalize on advances in new technological developments (e.g., sensor technology), and conceptualize new solutions that take advantage of the best aspects of current access technology to produce combinations and new genres of access devices that can further support the needs of greater numbers of individuals with CCN and severe physical impairment.

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