Research Article

High-Technology Augmentative and Alternative Communication in Poststroke Aphasia: A Review of the Factors That Contribute to Successful Augmentative and Alternative Communication Use

Shannon Taylor,[a] Sarah Jane Wallace,[a] and Sarah Elizabeth Wallace[b]

Purpose: This article aims to explore current knowledge about factors influencing successful use of high-technology augmentative and alternative communication (AAC) in poststroke aphasia through a literature review and narrative synthesis methodology (Grant & Booth, 2009). These factors and their impact on clinical practice are discussed within the context of the International Classification of Functioning, Disability and Health.
Conclusion: High-technology AAC has the potential to enable communicative autonomy for the many people with aphasia (PWA) who experience chronic communication difficulties. While evidence of the effectiveness of AAC continues to grow, there remains a lack of understanding regarding specific factors that contribute to the successful use of high-technology AAC among PWA. While recommendations for current practice are provided, future research is needed to better understand these factors to enable clinicians to make informed decisions regarding the selection and implementation of AAC devices and strategies with PWA.

It is estimated that one quarter to one third of stroke survivors experience aphasia (Dickey et al., 2010; Laska, Hellblom, Murray, Kahan, & Arbin, 2001; Maas et al., 2012). Although efforts are made to remediate language in the early stages post-stroke, approximately 43% of people with aphasia (PWA) in the acute stage continue to have significant language impairments at 18 months post-stroke (Laska et al., 2001). These communication difficulties limit independence, social relationships, and employment in the longer term (Davidson, Howe, Worrall, Hickson, & Togher, 2008; Graham, Pereira, & Teasell, 2011; Kauhanen et al., 2000; Parr, 2007; Ross & Wertz, 2003). The International Classification of Functioning, Disability and Health (ICF; World Health Organization [WHO], 2001) can be used as a framework for considering these broad and often long-lasting impacts of aphasia, and for planning service provision, which combines both compensatory and impairment-based therapies (Simmons-Mackie & Kagan, 2007; Weissling & Prentice, 2010).

High-technology augmentative and alternative communication (AAC) is one compensatory strategy that offers innovative methods for supporting PWA to communicate more effectively. As high-technology AAC is a relatively new and evolving field, it can be challenging for practicing clinicians to gain skills and confidence in assessing and implementing these communication systems (Sutherland, Gillon, & Yoder, 2005). In the current article, a literature review and a narrative synthesis methodology (Grant & Booth, 2009) have been used to explore current knowledge about factors influencing successful use of high-technology AAC in poststroke aphasia. Available literature and associated limitations are reviewed followed by a discussion of potential factors and their management within the context of the ICF framework (WHO, 2001).

[a]School of Health and Rehabilitation Sciences, The University of Queensland, St Lucia Campus, Brisbane, Australia
[b]Speech-Language Pathology, Duquesne University, Pittsburgh, PA
Correspondence to Sarah Jane Wallace: s.wallace3@uq.edu.au

Editor: Peter Meulenbroek
Received November 29, 2018
Revision received February 25, 2019
Accepted March 25, 2019
https://doi.org/10.1044/2019_PERS-SIG2-2018-0016

Disclosures
Financial: Shannon Taylor has no relevant financial interests to disclose. Sarah Jane Wallace has no relevant financial interests to disclose. Sarah Elizabeth Wallace has no relevant financial interests to disclose.
Nonfinancial: Shannon Taylor has no relevant nonfinancial interests to disclose. Sarah Jane Wallace has no relevant nonfinancial interests to disclose. Sarah Elizabeth Wallace has no relevant nonfinancial interests to disclose.

AAC

AAC refers to any communication strategy that is used to replace or supplement spoken expression, auditory comprehension, written expression, or reading comprehension to facilitate communicative participation for people with complex communication needs (Beukelman & Mirenda, 2013). AAC can be broadly categorised into no-, low-, and high-technology systems (Koul, Lloyd, & Arvidson, 2011).

High-technology systems are those with a dynamic display that uses power, and most often generate synthetic speech or text (Koul et al., 2011). High-technology devices can vary greatly in their input and output method as well as the amount and type of vocabulary stored. Traditionally, high-technology AAC devices include a grid display in which vocabulary is represented by graphic symbols and/or written words displayed in rows and columns. Individuals combine isolated symbols to formulate messages (Beukelman & Mirenda, 2013). More recently, visual scene displays have been developed and trialed. Within these displays, vocabulary is represented by personally relevant, high-context photographs that create a conversational support that is shared between the person with complex communication needs and their communication partner (Dietz, McKelvey, & Beukelman, 2006). While there is accumulating research on these design and display characteristics (Brock, Koul, Corwin, & Schlosser, 2017; Dietz, Weissling, Griffith, McKelvey, & Macke, 2014; Steele & Woronoff, 2011), the current article focuses on the barriers and facilitators (e.g., cognitive and linguistic factors) that may influence PWA's capability to utilize and benefit from these systems.

Advances in High-Technology AAC

Although there are many forms of AAC, those using high technology warrant specific consideration due to the rapid growth in technology during the 21st century. In particular, the emergence of an AAC software that can function on mainstream consumer devices, such as iPads, has had a significant impact on the accessibility and availability of high-technology AAC (McNaughton & Light, 2013). In contrast to traditional high-technology systems that were manufactured for the sole purpose of aiding communication, mainstream consumer devices are generally more affordable, portable, and efficient (McNaughton & Light, 2013).

The use of mainstream devices for AAC has further potential benefits in terms of increased social awareness and acceptability of AAC (McNaughton & Light, 2013). It is increasingly commonplace to use technology as an adjunct or replacement for spoken communication. Visual representation of language (such as photos, videos, and emojis) are increasingly utilized over linguistic means to share life events and express feelings across the general population (Baruah, 2012; Deruyter, McNaughton, Caves, Bryen, & Williams, 2007; Foley & Ferri, 2012; Hemsley & Murray, 2015). The common place use of AAC-like communication and technology may increase the comfort and confidence of communication partners who interact with people with complex communication needs as they are likely more familiar with multimodal communication and the operating systems (McNaughton & Light, 2013). For individuals who use AAC, the use of mainstream systems that are valued by the general population may reduce feelings of isolation and apprehension that can occur with the use of disability-specific assistive technology (Louise-Bender Pape, Kim, & Weiner, 2002; McNaughton & Light, 2013). Given the many potential benefits of high-technology AAC systems, it is essential to develop an understanding of how best to support clinicians in implementing these systems with PWA.

Use of High-Technology AAC in aphasia

Since the early 1980s, various high-technology AAC techniques have been trialed with PWA to improve communication (Kraat, 1990). However, the literature in this area is still predominantly focused on younger populations and people with developmental disorders (Russo et al., 2017). In fact, only 17% of publications in the *Augmentative and Alternative Communication* journal in the past 30 years have been related to acquired communication disorders (McNaughton & Light, 2015), and only 30 experimental papers published between 1989 and 2016 explored the effects of high-technology AAC as a compensatory strategy for poststroke aphasia (Russo et al., 2017). The lack of a strong evidence base in this area can create challenges for clinicians in providing best practice high-technology AAC services to PWA.

While research regarding high-technology AAC as a compensatory tool for PWA is continuing to come to the forefront, studies documenting positive results are beginning to accumulate (Russo et al., 2017). For example, Koul, Corwin, and Hayes (2005) conducted a single-subject study to explore the effects of a training protocol on the ability of individuals with severe Broca's aphasia or global aphasia to produce graphic symbol sentences using an AAC software. They found that eight of the nine participants were able to use the symbol-based AAC system to produce sentences of varying syntactic complexity following training of specific items. This study, and others, provides evidence that, with specific instruction, PWA can use high-technology AAC for trained stimuli within experimental contexts (Beck & Fritz, 1998; Koul et al., 2005; McCall, Shelton, Weinrich, & Cox, 2000; Nicholas, Sinotte, & Helm-Estabrooks, 2011; van de Sandt-Koenderman, Wiegers, & Hardy, 2005; van de Sandt-Koenderman, Wiegers, Wielaert, Duivenvoorden, & Ribbers, 2007b). Additionally, advances in technology and increased research related to the best system design features for PWA have shown strong promise to increase the success with which PWA use high-technology AAC devices (Beukelman, Hux, Dietz, McKelvey, & Weissling, 2015; Dietz et al., 2014; Fried-Oken, Beukelman, & Hux, 2012; Wallace & Hux, 2014). For example, Wallace and Hux (2014) explored the effect of two different layouts on the ability of two PWA to navigate each high-technology AAC device. Although participants learned to use both interfaces, they demonstrated improved efficiency and accuracy of learning when provided with a navigation

ring versus a traditional home page interface (Wallace & Hux, 2014).

Although these positive outcomes have been documented, several challenges have been identified in the use of high-technology AAC by PWA. Some studies have suggested that PWA generally demonstrate slower rates of learning to use high-technology AAC devices as compared to other individuals with acquired communication disorders such as poststroke dysarthria (Beck & Fritz, 1998; Koul et al., 2005). Additionally, PWA as a population demonstrate variability in responses to high-technology AAC and poor generalization to untrained items and functional communication (Beck & Fritz, 1998; Koul et al., 2005; Russo et al., 2017; van de Sandt-Koenderman et al., 2005; van de Sandt-Koenderman et al., 2007b). Although researchers have acknowledged these potential limitations in AAC use by PWA, thus far, the research has provided limited insight into the range of factors that may be contributing to these patterns of performance.

Although there has been little research examining factors that influence successful AAC use among PWA, research in other populations is more highly developed. In a systematic review, Baxter, Enderby, Evans, and Judge (2012) identified 27 studies that reported high-technology AAC users, family, or therapist perspectives on factors that influence success of high-technology AAC. The majority of these studies focused on individuals with developmental intellectual disabilities, cerebral palsy, and/or autism spectrum disorder. Baxter et al. identified factors impacting the use of high-technology AAC devices that could be broadly grouped into three categories: (a) factors specific to the technology (e.g., ease of use, reliability, voice and language, speed of message generation); (b) factors specific to speech-language therapy service delivery (e.g., provision of technical support, decision-making processes/matching device to person, staff training, access to services, no plan for device maintenance); and (c) factors related to the person with the device and their environment (e.g., role of family, response from other people/society, attitude/motivation to use device). Although it is likely that many of these identified factors are consistent across multiple groups of people with complex communication needs, the degree of relevance for PWA has not been explored. Given that aphasia is a complex, heterogenous disorder, PWA likely experience population-specific factors that influence their success with high-technology AAC. A thorough understanding of the factors that influence how PWA respond to AAC will help clinicians to determine whether high-technology AAC is an appropriate option and guide the selection of the specific type of device and supports needed.

Potential Factors Affecting High-Technology AAC Use in PWA

Although few studies have empirically investigated factors influencing success of high-technology AAC in aphasia (Russo et al., 2017), many researchers have highlighted potential factors in discussions of study outcomes and within commentary articles (Beck & Fritz, 1998; Koul et al., 2005; Lasker, 2008; Nicholas et al., 2011; Purdy & Koch, 2006; van de Sandt-Koenderman et al., 2005; van de Sandt-Koenderman et al., 2007b). These factors will be discussed below with reference to the ICF framework (WHO, 2001).

The ICF is a multipurpose framework that presents a multidimensional, biopsychosocial perspective for describing health and disabilities. The framework acknowledges that environmental and personal factors, as well as the nature of the impairment (body structures and functions), interact in a complex manner to create activity limitations and participation restrictions that influence the disability that is experienced by the individual (WHO, 2001). This recognition of the integrated nature of such factors makes it an ideal framework for viewing how and why PWA might experience difficulties using currently available high-technology AAC successfully.

It is likely that a large number of factors interact in a complex manner to influence the success of high-technology AAC for PWA. A comprehensive discussion of all potential factors is beyond the scope of this article. However, Table 1 and the discussion below highlight a select set of factors that have emerging empirical and/or anecdotal evidence to support their relevance to AAC in aphasia. Consistent with the ICF framework (WHO, 2001), a comprehensive assessment of these factors, both during initial AAC assessments and following device trials, should be conducted to identify barriers and facilitators for high-technology AAC use in aphasia. Readers may refer to Goldman (2016); Simmons-Mackie, Raymer, and Cherney (2016); and Koch Fager, Fried-Oken, Jakobs, and Beukelman (2019) for additional information about environmental barriers and facilitators such as reimbursement and communication partner instruction as well as personal factors such as motor impairments, respectively.

Body Structure and Function Factors

Language Impairment

Aphasia results in impairments in multiple modalities of language including spoken and written expression as well as comprehension of auditory and written information. The nature of aphasia as a language impairment can create challenges to the use of high-technology AAC (Lasker, 2008). Researchers have suggested that the large variability in response to AAC and the slow rate of symbol learning, particularly in comparison to age-matched peers with dysarthria, may be reflective of the linguistic- rather than a motor-based impairment (Beck & Fritz, 1998; Koul et al., 2005). Many of the linguistic impairments (e.g., semantic processing, grammar, and syntax deficits) that are experienced by PWA can affect symbolic communication of all types, including the ability to understand or categorize icons that represent concepts within an AAC system (Vallila-Rohter & Kiran, 2013a, 2013b). High-technology AAC systems are also not designed to address auditory comprehension deficits that are present in all PWA. Therefore, clinicians and other communication partners need to use specific strategies

Table 1. Potential factors affecting high-technology augmentative and alternative communication (AAC) use in people with aphasia (PWA) and their management.

Factor	Influence	Management ideas
Body structure and function factors		
Language impairment	• Difficulty learning and using symbols (Beck & Fritz, 1998; Koul et al., 2005) • Requirement for extensive training periods (van de Sandt-Koenderman et al., 2005)	• Consider the linguistic demands inherent to each AAC system (Lasker, 2008) • Individual assessment of PWA's ability to communicate across all modalities (Lasker, 2008) • Consider visual scene display to reduce linguistic demands and facilitate co-construct for individuals with severe limitations across all modalities (Brock et al., 2017; Lasker, 2008) • Ensure service delivery will allow for the intensity of training that is anticipated
Cognition	• Large variation in response to AAC (Nicholas et al., 2005) • Poor generalization to untrained items (van de Sandt-Koenderman et al., 2007b) • Reduced ability to initiate use of an alternative strategy (executive functioning; Nicholas et al., 2011)	• Individual assessment of underlying cognitive deficits (Nicholas et al., 2011) • Consider the cognitive demands inherent to a system (Nicholas et al., 2011) • Ensure structured generalization tasks within therapy plan (van de Sandt-Koenderman et al., 2007a) • Consider providing training on recognizing when to initiate AAC use (Nicholas et al., 2011) • Consider therapy to remediate underlying cognitive deficits (Purdy & Van Dyke, 2011; Purdy & Wallace, 2016)
Personal factors		
Age	• Younger PWA may have difficulty accepting disability and, therefore, AAC (Louise-Bender et al., 2002; van de Sandt-Koenderman et al., 2005) • Older PWA may have less experience with technology and therefore require basic level training in this area (Charness et al., 2010)	• Explore PWA's attitudes toward technology, AAC, and disability. Provide education/support for this and/or refer onward to other relevant disciplines (e.g., psychology). • Explore participants experience with technology and provision of training on basic aspects of technology use as needed (e.g., how to charge, turn on, silence a device)
Insight and expectations	• Difficulty monitoring their communicative efficiency and, therefore, recognizing the benefits of AAC (True et al., 2010) • Disappointment and subsequent rejection of AAC due to initial unrealistically high expectations (Beukelman & Ball, 2002; True et al., 2010)	• Teach PWA to recognize the improvements in their own communication when using AAC (True et al., 2010) • Conduct early goal setting and review of expectations • Provide education regarding the expected role of AAC as complementary to residual speech use and any ongoing impairment-based therapy
Environmental factors		
Social supports	• Improved maintenance of the AAC device (van de Sandt-Koenderman et al., 2007a) • Increased opportunities to use the device in real-life contexts (Baxter et al., 2012) • Co-construction of messages (van de Sandt-Koenderman et al., 2007a) • Requirement for external monitoring of the effectiveness of their communication attempts (van de Sandt-Koenderman et al., 2007a)	• Provide early and ongoing education and training for communication partners
Therapist perspectives and beliefs	• Potential abandonment of trialed devices due to lower levels of AAC proficiency believed to reflect lack of success (van de Sandt-Koenderman et al., 2007b) • Introduction of AAC primarily in chronic stages (Fried-Oken et al., 2012; Weissling & Prentice, 2010)	• Redefine what successful AAC looks like (van de Sandt-Koenderman et al., 2007b) • Do not discount the value of lower level AAC proficiency and dependent use (van de Sandt-Koenderman et al., 2007b) • Allow success to be defined by achievement of goals set by the PWA and their family members (van de Sandt-Koenderman et al., 2007b) • Develop realistic expectations for PWA (van de Sandt-Koenderman et al., 2007b) • Consider AAC an adjunct to early rehabilitation-focused input (Weissling & Prentice, 2010)
Duration and intensity of speech-language pathology services	• Low-intensity input unlikely to facilitate meaningful success with AAC (Beck & Fritz, 1998; McCall et al., 2000; Nicholas et al., 2011; van de Sandt-Koenderman et al., 2005) • Gains in therapy unlikely to carryover without embedding specific generalization training (van de Sandt-Koenderman et al., 2007a)	• Ensure service delivery model allows for level of intensity required to facilitate success • Advocate for increased speech-language therapy services for PWA being introduced to AAC • Explore alternative service delivery models that will allow for increased intensity within constraints (e.g., group therapy)

such as augmented input (Wood, Lasker, Siegel-Causey, Beukelman, & Ball, 1998) to support auditory comprehension during conversation and AAC instruction.

Individualized language assessment is essential in determining how PWA's unique patterns of impaired and preserved linguistic skills match the linguistic demands of each AAC system being considered (Lasker, 2008). Such assessments may reveal a relatively preserved modality (e.g., reading) that can be utilized within a robust AAC system. Alternatively, the language assessment may identify a significant semantic impairment that limits PWA's ability to access language across all modalities. This will also limit use of pictorial supports within an AAC system because recognition of pictures is reliant on the ability to process their distinguishing semantic features. This may highlight the need for therapy to improve semantic processing alongside the introduction of an AAC device (Wallace & Kayode, 2017) and/or the need to reduce linguistic demands more broadly using visual scene display systems (Brock et al., 2017; Lasker, 2008). Further collaboration between software engineers and aphasiologists is needed to codesign apps that match particular linguistic profiles of PWA. There is also a great need for a clinical tool that will assist clinicians in matching their PWA's linguistic profile to AAC systems that provide the most appropriate features to compensate for their individual patterns of deficits and utilize their relative strengths.

Consideration must also be given to the intensity and duration of instruction required to facilitate successful AAC use for PWA. Unlike some motor-based conditions, the provision of a device will not typically result in PWA immediately expressing themselves more successfully (McCall et al., 2000; Nicholas et al., 2011; van de Sandt-Koenderman et al., 2007b). PWA need personalized, contextualized training over longer periods of time (van de Sandt-Koenderman et al., 2007a). Future investigations should explore the impact of different service delivery models, including group AAC therapy, to determine the most effective and efficient means of providing these supports. In the meantime, it is important that clinicians explore whether the degree of instruction required to achieve positive outcomes is feasible within the service constraints of their clinical setting.

Cognitive Deficits

Cognitive factors, including deficits in attention, memory, and executive functioning, are generally considered to affect use of AAC by PWA (Purdy & Dietz, 2010). Less is known about the specific influence of various cognitive factors on high-technology AAC use in this population. The few studies that have examined these factors directly or as a secondary purpose have provided mixed results (e.g., Nicholas, Sinotte, & Helm-Estabrooks, 2005; van de Sandt-Koenderman et al., 2007b; Wallace & Hux, 2014). For example, van de Sandt-Koenderman et al. (2007b) examined various factors including semantic processing and executive functions as factors potentially influencing functional use of a high-technology AAC device. Semantic processing was found to have a greater influence than cognitive factors. In contrast, results from another study with PWA using a different high-technology AAC device suggest that executive functions were more related to successful implementation than semantic processing skills (Nicholas et al., 2005). Finally, Wallace and Hux (2014) evaluated another high-technology AAC device, and although it was not the primary purpose of the study, their results suggest the potential effect of executive functions on learning to navigate a high-technology AAC device. These results were also supported, in part, by preliminary findings in people with traumatic brain injury who do not have aphasia (Wallace, Hux, & Beukelman, 2010).

A review of the available literature indicates that cognitive skills such as executive functions likely affect the ability to learn to use AAC devices and strategies effectively for PWA. However, given the paucity of research, the specific contribution of these impairments on high-technology AAC device use by PWA is unknown (Nicholas & Connor, 2017). More research is needed to further understand the effect of various cognitive factors on high-technology AAC device use including the effects of attention and memory impairments, which are not as well studied as the effectives of executive function impairments. In the meantime, clinicians can address the potential effects by carefully measuring cognitive factors and considering their potential effect on high-technology AAC device use. Some recommendations include using tasks that reduce the linguistic burden of the cognitive task (e.g., abstract design memory tasks instead of spoken word list memory tasks) and tasks that closely resemble the functions needed to successfully use high-technology AAC devices (e.g., visual-perceptual scanning). Finally, clinicians may consider intervention strategies that are designed to address potential cognitive impairments in individuals with acquired cognitive–linguistic disorders such as a multimodal communication program (Purdy & Van Dyke, 2011; Purdy & Wallace, 2016) and interventions for external aid use (Sohlberg & Mateer, 2001).

Personal Factors

Age

In terms of adult stroke survivors, older age is often assumed to be a factor that negatively influences the use of high-technology AAC devices due to their supposed reduced experience with technology and reluctance to upskill in this area. Consistent with these assumptions, a 2009 U.S. survey found that only about 25% of adults ages 75–84 years and about 5% of adults over 85 years of age were computer or Internet users (Charness, Fox, & Mitchum, 2010). Despite this low use of technology, an American Association of Retired Persons (AARP, 2008) report showed that older adults are interested in the use of technologies, such as AAC devices, particularly if they have a role in maintaining social connections and allowing them to remain independent. Therefore, older people may have more positive attitudes toward the use of high-technology AAC than anticipated, but their inexperience with technology may act as a barrier to successful AAC use.

Despite the natural inclination to assume older age is associated with less successful use of high-technology AAC, younger age may also produce barriers to AAC acceptance. In a study of the use of a handheld high-technology device, van de Sandt-Koenderman et al. (2005) found that unsuccessful users were typically younger. The researchers proposed that this is related to acceptance of disability, which may be harder for younger people (van de Sandt-Koenderman et al., 2005). Within the wider assistive technology literature, acceptance of disability is understood to play a major role in the determination of use of assistive technology including AAC (Louise-Bender Pape et al., 2002).

Findings thus far do not allow for using either young or old age to predict AAC success. However, they highlight the need to consider age and the relative challenges and benefits associated particularly as they relate to individuals' perceptions of technology and feelings about disability.

Insight and Expectations

PWA may have poor insight into the effectiveness of their communication that limits their motivation to use high-technology AAC (True, Bartlett, Fink, Linebarger, & Schwartz, 2010). Through interview research, True et al. (2010) found that participants thought that they were equally as informative during unaided and aided communication exchanges despite clear improvements with supported output. Without awareness of these improvements, it is unlikely that PWA with poor recognition of communication effectiveness will independently initiate the use of high-technology AAC. Clinicians may, therefore, consider explicitly training insight.

Additionally, many PWA maintain expectations that they will regain their natural speech, whereas others have unrealistically high expectations of AAC as an efficient replacement for spoken language (Beukelman & Ball, 2002; True et al., 2010). Both expectations can be detrimental to the success of AAC and highlight the need to provide education, set realistic goals, and consider the use of compensatory strategies in conjunction with impairment-based therapies.

Environmental Factors

Social Supports

The role of skilled support persons in promoting the use of AAC, maintaining the AAC device, and creating social situations for AAC is known to have an influence on the success of AAC in other populations (Baxter et al., 2012). Skilled communication partners are particularly valuable for PWA as ongoing support to initiate and construct messages with AAC in daily life contexts and external monitoring of the effectiveness of their communication attempts is often required (Beukelman, Ball, & Fager, 2008; True et al., 2010; van de Sandt-Koenderman et al., 2007b). Furthermore, having support persons available to maintain the device following initial clinician-led training has been associated with long-term successful use of high-technology AAC for PWA (van de Sandt-Koenderman et al., 2007a).

Although little is known about how best to prepare communication partners for these roles, clinicians should invest time in educating, training, and motivating key support people. Arroyo, Goldfarb, and Sands (2012) conducted a case study to examine the impact of communication partner training on PWA's use of a high-technology AAC device. The communication partner training resulted in increased communicative initiations and concurrent verbalizations from PWA. The training involved basic operational tutorials and facilitation techniques that are typically familiar to practicing clinicians, such as increased wait time and use of expectant pauses. Future studies should aim to further clarify what specific knowledge and skills communication partners require to effectively support PWA to use high-technology AAC as well as the best method to provide this training (e.g., Thiessen & Beukelman, 2019).

Clinicians' Perspectives and Beliefs

Clinicians' perspectives and beliefs around the role and value of high-technology AAC are likely to have a large influence on the success of AAC. Clinicians may assume that the benefits of high technology will enable PWA to become autonomous AAC users and that, if this level of proficiency is not achieved, the AAC trial has been unsuccessful. However, research shows that only a small proportion of PWA can be expected to use a device independently (van de Sandt-Koenderman et al., 2007b). Furthermore, research shows that lower levels of AAC use should not be discounted as they still add value to the lives of PWA. For example, van de Sandt-Koenderman et al. (2007b) found that individuals who were unable to use the AAC system independently still reported high user satisfaction and chose to purchase the device when the study ended.

Clinicians' belief systems can also influence the timing of AAC introduction and subsequently the opportunities PWA have to succeed with an AAC device. AAC is often introduced in the chronic stages of aphasia following a slowed rate of progress from restorative therapies (Fried-Oken et al., 2012). The reasons for this late introduction may relate to persisting beliefs that compensatory and restorative approaches are mutually exclusive and that introducing AAC reflects "giving up" on natural speech (Weissling & Prentice, 2010). Recently, researchers have been urging clinicians to abandon old biases toward sequential practices and to instead consider compensatory AAC approaches as complementary to restorative approaches in the early stages of intervention (Fried-Oken et al., 2012; Weissling & Prentice, 2010). This would prevent unnecessary delays in access to strategies that can improve the communication and quality of life of PWA. Furthermore, there is emerging evidence to show that use of an AAC device can facilitate gains in unaided speech production (Johnson, Hough, King, Vos, & Jeffs, 2008; van de Sandt-Koenderman, 2011; van de Sandt-Koenderman et al., 2007b).

Duration and Intensity of Input

A large amount of speech-language therapy is likely associated with improved success of AAC for PWA. As mentioned previously, most studies that report successful use of high-technology AAC involve initial high-intensity training to enable PWA to navigate the device and produce messages

or symbols (Beck & Fritz, 1998; McCall et al., 2000; Nicholas et al., 2011; van de Sandt-Koenderman et al., 2005). Further training is then needed to support generalization to real-world contexts (van de Sandt-Koenderman et al., 2007a). Finally, ongoing input to support device maintenance and updates in response to changes in PWA's impairment, environment, and goals is recommended (van de Sandt-Koenderman et al., 2007a). Achieving this level of input under the current constraints of health care services proposes a challenge for practicing clinicians. A better understanding of how the barriers within health care services influence AAC success through future research may facilitate improved access to therapy at higher intensities and over longer periods of time.

Recommendations for Clinical Practice

High-technology AAC is appropriately recognized as a powerful and exciting tool that can have a significant effect on the communication of PWA. However, simply providing the latest, most technologically advanced AAC system does not guarantee success. The AAC device itself is only one component of a complex communication system and intervention plan. Rather than focusing on the technology alone, clinicians must consider the myriad of factors that will influence PWA's ability to utilize a high-technology AAC device to communicate. Although this may be a challenge at present given the limited research, the factors described above (see Table 1) may serve as a guide for clinicians both when considering the introduction of high-technology AAC and when challenges are encountered during trials of such systems.

Before proposing high-technology AAC to PWA and their family members, clinicians are encouraged to reflect on their own perspective and biases in terms of the expected role and value of high-technology AAC. Clinicians should be particularly careful not to expect all PWA to be able to communicate autonomously with high-technology AAC as most will require ongoing partner support for message construction (Garrett & Lasker, 2009; van de Sandt-Koenderman et al., 2007b). Clinicians are urged not to be discouraged by this and to instead recognize their crucial role in providing communication partner instruction that will empower partners to co-construct messages with PWA via the AAC device (van de Sandt-Koenderman et al., 2007b). Furthermore, the expectations for device use and the likely need for ongoing communication partner involvement should be discussed early with PWA and their family members to enable realistic goals to be set collaboratively (Baxter et al., 2012).

In terms of planning the AAC intervention, it is essential that individual assessment of PWA's cognitive and linguistic strengths and weaknesses is carried out to identify key features that the selected AAC system will require and to determine the need for training of discrete skills that may be beneficial for device use (Lasker, 2008; Purdy & Dietz, 2010). Prior to the provision of an AAC device, clinicians are also encouraged to consider PWA's experience with technology as well as their attitude toward AAC, and more broadly, the chronic nature of their communication disability (van de Sandt-Koenderman et al., 2005). This is because these personal factors may highlight the need for additional supports such as instruction in basic technology use and/or psychology input to address any grief that may be acting as a barrier to acceptance of disability supports such as AAC.

When challenges arise during AAC device trials, consideration of the factors explored above may help to highlight treatment goals that can be addressed to overcome barriers and facilitate further success. Another consideration is for clinicians to implement check lists and tools to measure PWA's use of AAC (e.g., Brock, Koul, Corwin, & Schlosser, 2019). Evaluating these factors will help clinicians to make intervention efforts more effective and efficient. In turn, clinicians can hope to increase the appropriate provision of devices, reduce abandonment of strategies, and ultimately help PWA to participate better in their lives via high-technology AAC.

Conclusion

Recent technology advances have created new opportunities and challenges in providing high-technology AAC to PWA. One significant challenge is limited research evidence identifying factors that contribute to or detract from successful high-technology AAC use by PWA. The incomplete understanding of these factors affects clinical decision making regarding the selection and instruction of AAC devices and strategies. Although the influence of specific factors may not yet be understood, this article has highlighted potential influencing factors that warrant further exploration. Through the lens of the ICF, these factors include, but are not limited to, (a) body structure and function factors such as the language impairment and associated cognitive deficits; (b) personal factors such as the age, insight, and expectations of PWA; and (c) environmental factors such as social supports, duration and intensity of input, and therapists' perspectives and beliefs. Although clinicians are encouraged to use these potential factors to guide decision making, future research is needed to clarify the influence of such factors. This will subsequently enable the development of practical strategies that will support clinicians to anticipate challenges, mitigate barriers, and ultimately facilitate enhanced communicative competence in PWA through the use of high-technology AAC.

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