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AAC technologies for young children with complex communication needs: State of the science and future directions

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Abstract

Augmentative and alternative communication (AAC) technologies offer the potential to provide children who have complex communication needs with access to the magic and power of communication. This paper is intended to (a) summarize the research related to AAC technologies for young children who have complex communication needs; and (b) define priorities for future research to improve AAC technologies and interventions for children with complex communication needs. With the realization of improved AAC technologies, young children with complex communication needs will have better tools to maximize their development of communication, language, and literacy skills, and attain their full potential.

Keywords: aided communication, assistive technology, augmentative and alternative communication (AAC), children, cognitive process, communication, design early intervention, learning

Introduction

In their early years of development, most children rapidly acquire speech and language skills to allow them to express needs and wants, interact socially with adults and peers, expand their conceptual development, and develop the foundations for more advanced language and literacy skills (Light, 1997). However, some young children do not develop speech and language skills as expected due to motor, language, cognitive, and/or sensory perceptual impairments that may result from cerebral palsy, autism, Down syndrome, or other developmental disabilities. This heterogeneous group of children with complex communication needs typically experiences restricted access to the environment, limited interactions with their communication partners, and few opportunities for communication (Light, 1997). They are at significant risk in all aspects of their development. The challenge is to provide children who have complex communication needs with access to the magic and power of communication at the earliest possible age to circumvent the negative effects of communication disabilities (Light & Drager, 2002). Augmentative and alternative communication (AAC) systems[1] offer potential tools to meet this challenge. In order to be optimally effective, AAC systems must be designed to meet the needs and accommodate the skills of young children (Blackstone, Williams, & Wilkins, 2007).

The goals of this paper are two-fold: (a) to summarize the research related to AAC systems for young children, with a particular focus on the design of AAC technologies; and (b) to define priorities for future research to improve AAC technologies and enhance outcomes for children with complex communication needs. Although this paper focuses on young children, many of the issues discussed also have implications for older children and adults who are beginning communicators. Even though this paper focuses on the design of AAC technologies, it is critical to recognize that these technologies are but one of the important components of AAC interventions. If AAC interventions are to be maximally effective, they should ensure not only that children have access to appropriate AAC systems as a means to communicate, but also that they receive appropriate instruction to learn the linguistic, operational, social, and strategic skills required to communicate effectively and ensure that children have appropriate opportunities and support from their partners to communicate (Light, 2003).

Research on the use of AAC systems by young children

The selection and development of appropriate AAC systems is one key component in intervention for young children with complex communication needs to ensure that they have an effective means to communicate. What do we know specifically about the use of AAC systems by young children with complex communication needs?

Use of multiple modes of communication

One of the most robust findings in AAC research is that individuals with complex communication needs typically rely on multiple modes to meet their needs (Blackstone & Hunt Berg, 2003). Young children with a wide range of developmental disabilities typically use a variety of means (either simultaneously or sequentially) to communicate with others in daily situations, including speech and speech approximations, signs, nonelectronic systems (e.g., communication boards), and AAC technologies (e.g., Binger & Light, 2006;; Light, Collier, & Parnes, 1985; Light & Drager, 2005). Choices of modes often relate to the child's skills as well as the communication context, partners, tasks, and intent (Blackstone & Hunt Berg, 2003; Light et al.,).

Imapct of AAC on Natural Speech

Despite the documented benefits of AAC interventions on communication, many clinicians and parents still hesitate to adopt AAC for fear that it will impede the development of natural speech (Romski & Sevcik, 2005). However, the evidence suggests that this fear is unwarranted. Results of a meta-analysis by Millar, Light, and Schlosser (2006) indicated the following: (a) none of the 27 cases demonstrated decreases in speech production as a result of AAC intervention; (b) the vast majority (89%) demonstrated gains in speech after AAC intervention. For the most part, the gains observed were modest (i.e., +20 spoken words or less); however, in more than half of the cases, ceiling effects were observed in the speech measures, suggesting that these data may underestimate the effects. The majority of the participants (aged 2 – 60 years) had mental retardation or autism, and the AAC interventions involved manual signs or nonelectronic aided systems. Future research is required to delineate the effects of AAC technologies on natural speech across children with a wide range of disabilities. Romski, Sevcik, Adamson, and Cheslock (2006) are currently engaged in such research with toddlers with complex communication needs; results of their investigation will make an important contribution to the field.

Comparative effectiveness of AAC systems

There is evidence that many different types of AAC systems can have a positive impact on the communication skills of young children, including unaided systems such as signs and gestures (e.g., Bartman & Freeman, 2003; Sigafoos et al., 2004) and aided systems, both nonelectronic (e.g., Charlop-Christy, Carpenter, LeBlanc, & Kellet, 2002; Johnston, McDonnell, Nelson, & Magnavito, 2003); and electronic technologies (e.g., DiCarlo & Banajee, 2000; Romski et al., 2006).

To date, there is limited evidence of the comparative effectiveness of various types of AAC systems. For example, Mirenda (2003, 2005) conducted a narrative review of the research to determine the comparative effectiveness of unaided and aided AAC systems with children with autism spectrum disorders and concluded that manual signs, graphic symbols, and AAC technologies "… all have potential as communication aids for individuals with autism" (2005, p. 52). It seems doubtful that there will be a unilateral answer to the question of the comparative effectiveness of AAC systems. Instead it seems that effectiveness will be determined by a complex interaction between various factors, including factors intrinsic to the child, extrinsic factors such as communication partners and social context, as well as the overall purpose of the interaction. Mirenda (2005) concluded: "Which AAC technique is 'best' for a given individual depends on: the learning/developmental priorities for the person; the person's existing skills and abilities; the person's and family's preferences; the person's current and future communication needs; and the environments in which and the people with whom the person is likely to interact" (p. 52). It is highly unlikely that a single system will meet the needs of all children with complex communication needs across all daily interactions.

Despite the limited evidence of the relative effectiveness of different AAC systems, it seems that there are tendencies in practice to use certain types of AAC systems with young children. It is reported that most preschoolers with complex communication needs use gestures, nonelectronic communication boards, or simple AAC technologies with digitized speech output, with very few children reported to use AAC technologies that offer a greater breadth of communication options (Binger & Light, 2006; Hustad et al., 2005). Unfortunately, in many cases, these most frequently used systems may not provide sufficient capacity for language and communication development for young children. As a result, the child's development may be artificially constrained, not by factors intrinsic to the child, but by external factors such as (a) the limited capacity of simple AAC technologies with digitized speech to store a wide range of concepts, (b) failure to add vocabulary to systems on a regular basis, and/or (c) limited knowledge/use of signs by parents and other facilitators (Light & Drager, 2005). Paul (1997) argued that young children with complex communication needs require access to AAC systems "… that can grow with them. That is, the child needs a language system that has inherent in it the capacity to make the crucial transitions from one level of linguistic complexity to another … If these transitions are not built into an AAC system, the child is doomed to a limited modality of communication" (p. 142). Light and Drager (2005) found that young children with developmental disabilities (ages 1 – 3) demonstrated substantial increases in vocabulary acquisition when they were provided with access to dynamic display AAC technologies, vocabulary was added on a daily basis, and partners modeled functional use of this vocabulary in meaningful contexts via AAC and speech (Light & Drager, 2005). They concluded that expectations are often too low. It is critical to maximize opportunities for language development in the early years when children are neurologically primed for learning.

Research on redesigning AAC technologies to enhance their effectiveness

Although the positive benefits of a range of AAC systems have been documented, Light and Drager (2002) argued that the full potential of AAC technologies has not yet been realized for young children with complex communication needs. Current AAC technologies tend to reflect the conceptual models and priorities of nondisabled adults. These technologies do not have strong appeal for young children and they are difficult to learn to use. In order to enhance the positive effects of AAC interventions for young children with complex communication needs, Light and Drager (2002) proposed that AAC technologies should be redesigned to increase their appeal, expand their function, and reduce their learning demands. According to Blackstone et al. (2007), AAC technologies should be designed to foster the capabilities, preferences, and priorities of those who use them, and must take into account their strengths and challenges.

Enhancing the appeal of AAC technologies for young children

Young children with complex communication needs and their peers may be more apt to use AAC technologies if these technologies are appealing to them. To date, there has been only limited research to investigate techniques to enhance the appeal of AAC technologies: Light, Drager, and Nemser (2004) compared the features of award winning toys to those of AAC technologies; and Light, Page, Curran, and Pitkin (in press) used a modified participatory design methodology to investigate children's preferences and priorities in the design of AAC technologies. Results of these two studies suggested design specifications that may potentially serve to increase the appeal of AAC technologies for young children by integrating play and communication, providing meaningful fun contexts for interaction, expanding output options, enhancing aesthetics, and providing options for characterization and personalization (see Table 1). Overall the results indicated that children valued AAC technologies that were *cool* and served to enhance the user's self esteem and social image. Future research is required to determine empirically whether implementation of these design specifications results in increased engagement and use of AAC technologies by young children and their peers.

Enhancing the functions of AAC technologies

Traditionally, AAC technologies have been designed as speech prostheses that allow the user to speak out linguistic messages; they do not provide engaging contexts for children to support social interaction (Light et al., in press). In contrast, when children were asked to design technologies for young children with disabilities, they developed inventions that supported a wide range of interactive activities as contexts for social interaction (e.g., playing video games, engaging in imaginative play, watching movies, doing arts and crafts activities, listening to music, surfing the Internet, talking on the phone; Light et al., in press). Their designs suggested the need for future research to develop AAC technologies that support interconnectivity to allow integrated access to a broad array of functions (see DeRuyter, McNaughton, Caves, Bryen, & Williams, 2007.

Reducing the learning demands of AAC technologies for young children

AAC technologies must not only be appealing and meet the breadth of communication needs of young children, but they must also be easy to learn and use. It is challenging for beginning communicators to learn to use many AAC systems because of the multi-faceted attention demands. The children must monitor their own actions (communicative attempts) and they must also coordinate attention to at least two to three external foci: the partner(s), the AAC system(s), and the ongoing shared activity (Light, Parsons, & Drager, 2002). These attention demands are compounded because communication is not static; rather it is a dynamic interactive process (Blackstone et al., 2007). The child must constantly coordinate attention across the various foci (i.e., self, partner, AAC systems, shared activity) to monitor and accommodate changes within the dynamic interaction. This coordination is especially complex for beginning communicators with motor or visual impairments who may have difficulty with gaze shifting, and for those who have difficulty with joint attention (e.g., children with autism).

Cress (1999) proposed two ways to reduce these attention demands: (a) reduce the number of tools or external foci, and/or (b) reduce the complexity of the tools. The number of tools (and therefore the joint attention demands) can be reduced by integrating the AAC system with the play activity. For example, Light and Drager (2005) presented books, songs, and other play activities within AAC technologies along with communication vocabulary, thus reducing the need for the child to shift attention between the system and the activity. In addition, individual low-tech AAC symbols (backed with Velcro) can be easily infused into play activities; the symbols can be taken off the communication board and brought directly into the play activity, explicitly linking the symbol and the toy or other referent. To date, there are no controlled research studies that have investigated the effects of integrating AAC with play and other daily activities to reduce attention demands; future research is required to do so.

Another way to reduce the cognitive demands for young children is to re-design AAC technologies. Current technologies are not transparent to young children; and which impose significant motor, cognitive, linguistic, and sensory perceptual demands. As a result, some young children may not be able to understand and use current AAC technologies; others may need many hours of instruction to do so. AAC technologies should be redesigned to minimize the cost of learning while at the same time maximizing the power of communication (Beukelman, 1991). In recent years, a number of research studies have investigated learning of AAC technologies by young children. With one notable exception (Ferrier, Fell, Mooraj, Delta, & Moscoe, 1996), most of this research has focused on children who are symbolic. Ferrier and colleagues developed and implemented a baby babble blanket for infants with significant disabilities who were presymbolic. Future research is required to investigate technologies to maximize function for the youngest children and facilitate the development of symbolic communication.

The research on the design of AAC technologies for children at the "first words" stage and beyond has focused on the following components: representations of language concepts, organization/layout, navigation, selection, and output.

Representations of language concepts

What do we know about young children's understanding and use of various AAC symbols? There is evidence that, over time, young children can learn to understand and use a variety of AAC symbols, including signs, gestures, tangible symbols, Picture Exchange Communication (PECs), Mayer Johnson Picture Communication Symbols (PCS), Blissymbols, and so on (e.g., Barton, Sevcik, & Romski, 2006; Bondy & Frost, 1998; Romski & Ruder, 1984; Rowland & Schweigert, 2000). However, many of the current AAC symbols are not immediately transparent to young children (e.g., Mirenda & Locke, 1989; Mizuko, 1987; Musselwhite & Ruscello, 1984; Light, et al., 2007). Lund, Millar, Herman, Hinds, and Light (1998), and Light, et al. (2007), found that children's representations of early emerging language concepts differed significantly from the representations used in many current symbol sets; the latter may not be developmentally appropriate for young children. These researchers asked typically developing children to draw pictures of ten early emerging language concepts, then analyzed the children's drawings and descriptions, and compared them to the representations used in current AAC symbol sets. The children's representations differed significantly from those used in AAC symbol sets: They were grounded in context, typically involved familiar experiences, and used entire scenes to depict the concepts; they did not use isolated parts of objects or events. For the most part, results were consistent across a variety of ethnic/cultural groups, although there were a few differences in some of the representations for specific concepts (Light, et al., 2007). Redesigning AAC symbols may reduce the learning demands; future research is required to investigate the most appropriate representations for young children.

Layout and organization

Once a child has acquired more than one concept, then the challenge is to organize and display these concepts appropriately within AAC technologies. The organization and layout of representations can serve to facilitate or impede the accuracy and efficiency with which the child is able to locate, select, and functionally use the concepts. Until recently, little was known about effective layouts and organizations or about the factors that affect the location and use of target items.

Recently, Wilkinson and colleagues established a line of research to investigate the effects of color as one factor in the organization and layout of items. Color cues play an important role in visual processing and memory, but little attention has been focused on the impact of color in AAC systems (Wilkinson & Jagaroo, 2004). Wilkinson, Carlin, and Jagaroo (2006) determined that color of items in a search array influences the accuracy and efficiency with which typically developing preschoolers (4 – 5 years old) are able to locate a target. When the target stimulus is distinct in color from other stimuli, children are more accurate and faster in locating a target item.

Color is not the only variable to be considered. Other display variables that may influence learning and use include background, borders, shape, pattern, texture, size, position, and movement/animation (Scally, 2001). Future research is required to delineate the effects of these types of features to optimize the design of AAC technologies. This research should consider not only the performance of children whose vision is within normal limits, but also the performance of children with visual impairments. Aided AAC systems impose significant demands on visual perception and processing. Many children who require AAC are at risk for visual impairments (Kovach & Kenyon, 2003). To date there has been little research to investigate techniques to maximize learning and functional use of AAC by children with concomitant visual impairments.

Two critical aspects of layout and organization that may have an impact on learning and use are the groupings and arrangements of the representations on the screen. Light, Drager, and collegues conducted a series of experimental research studies to investigate with typically developing children (ages 2 – 5) the learning demands of different layouts and organizations of AAC technologies, including (a) a taxonomic grid layout (i.e., symbols organized according to hierarchical categories and displayed in a row-column layout), (b) a schematic grid layout (i.e., symbols organized according to events or experiences and displayed in a row-column layout), (c) a schematic visual scene layout (i.e., a contextual scene of an event with concepts embedded under hot spots in the scene), and (d) (for the 4- and 5-year-olds only) iconic encoding (i.e., an encoding technique in which line drawings that are rich in semantic associations are used in combinations as codes to retrieve single words or phrases). Drager, Light, Curran-Speltz, Fallon, and Jeffries (2003) found that the youngest children (age 2.5 years) were most accurate locating vocabulary using the visual scene displays compared to the grid layouts, even though the displays were not personalized to the experiences of the children in this study. Light, Drager, McCarthy et al. (2004) found that, by ages 4 and 5, the children were able to locate vocabulary with the visual scene displays and the grid layouts with similar levels of accuracy, but they had significant difficulty learning to use iconic encoding.

More recently, Light and Drager (2005) evaluated the effects of AAC intervention that used visual scene displays with young children with developmental disabilities (ages 1 – 3) and concluded the following: (a) all of the children were able to use the visual scene displays to participate in social interactions, upon initial introduction in the first session, once their use had been modeled; (b) the children demonstrated significant increases in turn taking immediately upon introduction of the AAC technologies utilizing visual scenes; (c) the children sustained these gains in turn taking over the long term; and (d) all of the children also learned to use other types of displays over time, including traditional grid displays and hybrid displays (i.e., displays that utilized visual scenes but had some concepts displayed in a traditional grid layout). Drager et al. (2005) found similar results in a study of preschoolers with autism (ages 3 – 5).

Shane (2006) explored the implementation of visual scene cues, utilizing a “complete visual scene that portrays, in pictorial form, a concept or command that is being presented simultaneously through spoken language” (p. 12). He proposed that visual scene cues be used with children with autism spectrum disorders in two ways: either (a) as compensatory strategies where the goal is to bypass the child's comprehension deficits or auditory processing difficulties, or (b) as therapeutic tools where the goal is to build comprehension of the oral language input by gradually reducing dependence on scene cues. Shane (2006) reported that use of scene cues, along with speech input, resulted in significant improvements in performance compared to spoken input alone.

Visual scene displays may offer several advantages for beginning communicators compared to traditional grid displays: (a) The scenes represent familiar events or activities within the children's lives, maximizing the meaningfulness of the representations; (b) they present language concepts in context, providing support for children's understanding in the early stages of language learning; (c) visual scene displays, by definition, organize language schematically according to event experiences, a mapping that is congruent with young children's organization of language concepts (cf., Fallon, Light, & Achenbach, 2003); and (d) the visual scene displays preserve the conceptual and visual relationships between symbols that occur in life (e.g., location, proportionality of concepts). In contrast, traditional grid displays decontextualize symbols and present them out of context; language is presented in a box, isolated from the context in which it occurs. Neither the conceptual nor visual relationships between concepts are preserved in a grid display (e.g., in a traditional grid display, the line drawing of the apple used to represent *apple* may be as big as the head of the boy used to represent the concept *boy*, which in turn may be as big as the entire person used to represent the concept *run*). Future research is required to better understand the effects of layouts and organizations and the factors that impact learning and use.

Navigation

One of the challenges of using AAC systems with multiple pages or screens is the need to navigate through the system to find the target concept. Drager, Light, and colleagues investigated the demands of navigating dynamic display systems for young children. Results indicated that typically developing children (ages 2 – 5) had more difficulty locating the correct page (from a main menu with a choice of four symbols/pages) than locating the target symbol when on the correct page (out of a choice of 12 – 30 symbols), even though the probability of finding the correct page by chance (0.25) was much greater than the probability of finding the correct symbol by chance (0.03 – 0.08) once on the correct page (Drager et al., 2003; Light, Drager, McCarthy, et al. (2004)). Navigation may be particularly difficult for young children for several reasons: (a) they must hold in mind a conceptual model of the hidden pages in the system; and (b) they must understand the relationship between the representations used on the menu page and the hidden pages of vocabulary. One way to potentially reduce navigational demands is to utilize representations on the menu page, such as screenshots, that provide a mnemonic cue and make explicit the relationship to the hidden vocabulary pages. Drager, Light, et al. (2004) investigated the learning demands of different approaches to menu pages and page layouts in AAC technologies with typically developing 3-year-olds, including: (a) visual scene displays that used screen shots of the four scenes on the menu page for navigation, (b) traditional grid displays that used screen shots of the four vocabulary grid pages on the menu page, and (c) traditional grid displays with a traditional menu page (i.e., four single symbols on the menu page used to represent navigation to the four pages of vocabulary). Results indicated that the children were more accurate locating vocabulary using the visual scene displays with screenshots of the scenes on the menu page for navigation; they were least accurate using the traditional grid display with the traditional menu design. Future research is required to investigate the navigational demands of AAC technologies as well as techniques to facilitate learning and use.

Selection Techniques

In addition to designing AAC systems that utilize appropriate representations, organizations, layouts, and navigational features, it is also critical to consider the techniques used to select target items to communicate. Most young children have difficulty using a standard keyboard or mouse, as use of these interfaces imposes significant motor, cognitive, linguistic, and sensory perceptual demands. Specifically, use of these interfaces requires fine motor control and precision of movement as well as an understanding of the relationship between the actions performed on the keyboard or with the mouse, and the resulting actions on the screen. Understanding this relationship is cognitively complex, because the keyboard and mouse are displaced physically from their resulting actions on the screen.

Use of touch screens integrated into the computer display is one way to simplify access for young children. In this case, the child's touch to the screen is directly related to the ensuing action; there is no physical displacement between the cause and the effect as with a traditional keyboard or mouse. Unfortunately touch screens are not a viable solution for many children who have motor impairments. Children with severe motor impairments are typically introduced to scanning as a means of alternative access.

Research suggests that it is difficult for young children to learn to scan (Mizuko & Esser, 1991; Mizuko, Reichle, Ratcliff, & Esser, 1994; Petersen, Reichle, & Johnston, 2000). Performance is affected by numerous factors related to the learner (e.g., motor, sensory perceptual, cognitive skills) as well as the scanning technique (e.g., type of scanning, scanning pattern, size of the array, length of wait time). Recent research suggests that it is possible to redesign scanning to reduce the learning demands and improve the performance of young children. McCarthy et al. (2006) redesigned scanning to make the offer of items and the feedback upon selection more explicit through the use of animation and speech output with appropriate intonation. Typically developing 2-year-olds demonstrated more rapid learning and performed more accurately with the redesigned scanning than with traditional scanning. Results suggest that by redesigning scanning we can reduce the instructional time required for children to attain mastery.

Despite the potential benefits of redesigned scanning techniques, this access method is still very slow. There is an urgent need for improved access techniques for young children, especially those with severe motor, cognitive, and/or sensory perceptual impairments. Light et al. (2005) reported on current research to develop and evaluate a personalized multimodal recognition interface to improve access to technology for people with disabilities. This innovative interface utilizes computer vision techniques to track the movements of a range of modalities (e.g., hand, head/eye, vocalizations/speech) and recognize the patterns of movement used for intentional selection, whether sequential or simultaneous (e.g., the coordination of eye and hand movement toward a target with vocalization used to designate actual selection of the target). The system is also intended to identify and ignore unintentional movement patterns (e.g., tremor, reflexes). Research is urgently required to develop improved access technologies (see Higginbotham, Shane, Russell, & Caves, 2007).

Output of AAC systems

Once target items are selected by the user, they must then be communicated to the partner. There are several methods for presenting the output of AAC technologies: the screen display, printed hard copy, and speech output. To date, research on the output of AAC technologies has focused primarily on the performance of adults and older children with synthesized speech output. Recent research investigated the performance of children (age 4 – 6) and found that both monolingual and bilingual speakers of English perform less accurately with synthesized speech than with natural speech, just as adults and older children do (Axmear et al., 2005). Young children (age 3 – 5) also perform less accurately with digitized single words than with single words communicated via natural speech (Drager, Ende, Harper, Iapalucci, & Rentschler, 2004). Children who are 4 and 5 years old do better than younger children (3-year-olds) in intelligibility tasks, but for all children in this age range, the intelligibility of single words is very low (55 – 77%) for both synthesized and digitized speech (Drager, Clark-Serpentine, Johnson, & Roeser, 2006). The intelligibility of sentences is higher, but it is problematic if children are constrained to the use of sentences only, as single words allow novel combinations and foster language and literacy skills. Future research is needed to improve the intelligibility of speech output at the single word and at the phoneme level in order to maximize the benefits of speech output for language and literacy development.

In addition to intelligibility, another issue to be considered is the choice of the human speaker used to make the recording of digitized speech for storage in AAC technologies. The current practice is to find a close age match between the sample voice and the child using the AAC system. To investigate the effectiveness of this practice, Drager, Ende, et al. (2004) had college students listen to words digitized by three female children: a 4-, 6-, and an 8-year-old. The results of this pilot study indicated that the intelligibility of the digitized speech produced by the 4-year-old speaker was significantly lower than that of the 6- and 8-year-olds. This study used only one speaker of each age, and thus results are preliminary; however, it seems that matching the digitized voice to the age of the child who is using AAC may not be appropriate for the youngest AAC users, given the low intelligibility of young speakers.

In summary, it is apparent that there have been significant advances in the research on use of AAC systems by young children with complex communication needs: (a) to understand the interplay of various modes of communication; (b) to investigate the effects of AAC on natural speech production; and (c) to improve the design of AAC technologies by beginning to investigate techniques to increase the appeal, enhance functions, and reduce the learning demands.

Priorities for future research

Future research is urgently required to further understanding and improve the design and implementation of AAC technologies to maximize outcomes for young children with complex communication needs and older individuals who are beginning communicators. Specifically, future research is required to investigate the following: (a) preferences and priorities of young children with complex communication needs and their families, (b) improved designs of AAC technologies to better meet the needs of young children and older beginning communicators, (c) improved designs of AAC technologies to better support parents and professionals in implementing AAC effectively with young children and other beginning communicators, (d) effective interventions to support beginning communicators in learning the skills to become competent communicators, (e) advocacy and public policy to ensure early identification of and early intervention for young children with complex communication needs, and (f) preservice and inservice training to close the gap between research and practice to improve services and results for beginning communicators who require AAC.

Preferences and priorities of young children and their families

If AAC interventions are to be effective, they must be responsive to the needs of young children with complex communication needs and their families. The early years of childhood are times of rapid development involving both quantitative and qualitative changes in children's needs and skills. These years are challenging ones for families as they adjust to the changing needs of their children and try to understand the complexities of the service delivery system. To date, there has been only minimal research to investigate the perspectives of parents of children with complex communication needs (e.g., Angelo, Jones, & Kokoska, 1995; Bailey, Parette, Stoner, Angell, & Caroll, 2006). Future research is required to better understand family preferences and priorities to ensure that AAC technologies and services are truly consumer-responsive.

Improved designs for AAC technologies for young children

Future research is required to redesign AAC technologies to better meet the needs of young children, specifically to (a) enhance the appeal in order to increase motivation and use; (b) reduce the learning demands through utilization of developmentally appropriate representations, organizations, layout, navigation, selection, and output; (c) support dynamic *just in time* programming to provide young children with the language they require to communicate in the moment as it occurs; (d) support seamless transitions to accommodate quantitative and qualitative developmental changes; (e) serve as dynamic interactive contexts to support young children and their partners (adults and peers) as they communicate (rather than as static speech prostheses alone); (f) provide integrated access to multiple functions (e.g., communication, play, social interaction, entertainment, companionship, telecommunication, artistic expression); and (g) integrate developmentally appropriate learning opportunities to enhance language and literacy development and support participation in the educational curriculum. Specific attention is required to meet the needs of children at the very earliest stages of communication development. "It is never too early to incorporate AAC into language and communication intervention for the young child with a significant communication disability" (Romski & Sevcik, 2005; p. 182).

Improved designs for AAC technologies for older beginning communicators

In addition to young children, beginning communicators include older children or adults with significant cognitive impairments and/or multiple disabilities. The needs of this latter group have frequently been neglected. There are numerous challenges in providing effective AAC services to this group, including the following: (a) slow rates of learning necessitating AAC systems that impose few learning demands and that offer cognitive supports, (b) years of learned passivity or challenging behaviors necessitating AAC technologies and interventions that offer significant immediate impacts, (c) difficulties identifying and adapting chronologically age appropriate valued activities as contexts for meaningful communication, (d) negative societal and professional attitudes and low expectations necessitating advocacy for services and funding, and (e) large numbers of caregivers/partners with frequent turnover, necessitating AAC systems that are easy to implement and that provide explicit partner supports. Future research is urgently required to investigate effective AAC technologies and interventions for older children and adults who are beginning communicators, to allow them to attain their full potential.

Improved designs for AAC technologies for partners

Communication is a transactional interactive process in which participants jointly negotiate meaning (Blackstone et al., 2007). The success or failure of interactions involving individuals who require AAC is determined not only by their own actions, but also by their communication partners (Light, 2003). This is especially true of beginning communicators who have yet to develop communicative competence; they require support from their partners to communicate successfully. In order to ensure effective interaction, parents and other partners require competence in the operation, maintenance, customization, and implementation of AAC systems. Usually it takes parents and professionals a significant amount of time to develop technical competence with AAC systems. Current systems provide few, if any, built in supports for partners to facilitate their interactions with beginning communicators. Future research is required to better support parents and other partners in implementing AAC systems effectively with young children and older beginning communicators. Specifically, research is required to develop a new generation of AAC technologies that (a) provide dynamic contexts to support interaction with beginning communicators (i.e., provide partners with something to do with the beginning communicator and something to talk about); (b) incorporate easy instruction to guide partners in learning how to interact effectively with the beginning communicator (e.g., video instructions, prompts, text support); (c) are easy to learn to operate and program; (d) are fast to program; (e) allow just in time programming that can be done in real time during a dynamic interaction; and (f) are easy to modify in response to quantitative and qualitative changes in the developing child. As Blackstone et al. (2007) indicated, AAC technologies must be designed to recognize the unique roles that communication partners play during interactions.

Realizing these advances in AAC technologies will require concerted research to better understand the process of language and communication development in young children who require AAC and to investigate human factors issues related to child – technology – partner interaction. In addition, there will need to be effective transfer of these research and development efforts to assistive technology manufacturers to ensure the successful production of a new generation of AAC technologies for young children.

Effective AAC interventions to maximize outcomes

Although it is critically important to improve the design of AAC technologies for beginning communicators and their partners, simply providing appropriate technologies will not guarantee positive outcomes. Concerted intervention is required to ensure that beginning communicators learn the linguistic, operational, social, and strategic skills required to become competent communicators (Light, 2003). To date, the research has largely focused on establishing what is possible. There is evidence that AAC interventions utilizing a variety of instructional procedures can have positive effects on the communication skills of young children, including interventions that utilize structured behavioral methods and those that use child-centered, social pragmatic methods (Romski, Sevcik, Hyatt, & Cheslock, 2002). Future research is required to better delineate factors that positively impact outcomes for beginning communicators, to better understand the critical components of effective AAC interventions, and to investigate the relative effectiveness of different types of AAC interventions. For example, Romski et al. (2006) reported on the preliminary results of a study designed to investigate the effects of two different parent-implemented AAC interventions and a spoken communication intervention on the communication skills of toddlers with complex communication needs.

Research on AAC interventions is especially challenging given the heterogeneity and low incidence of the population, the complexity of AAC interventions, and the necessity to consider not only child, but also family and partner variables. To date, most of the research has focused on AAC interventions with preschoolers (ages 3 – 5). With a few notable exceptions (e.g., Arens, Cress, & Marvin, 2005; Ferrier et al., 1996; Light & Drager, 2005; Romski et al., 2006; Smidt & Cress, 2004; Wilcox, Kouri, & Caswell, 1990), there has been a paucity of research to investigate AAC interventions for children under the age of 3, despite the critical importance of early intervention. Future research is urgently required to address the needs of the youngest children, including those with a wide range of disabilities and associated sensory impairments.

Public policy and advocacy

Despite the demonstrated benefits of AAC, in practice, many children who require AAC are still not referred for services until they are older and have already missed out on valuable opportunities for learning (Hustad et al., 2005). Efforts are urgently required to (a) increase knowledge of AAC by medical personnel, speech language pathologists (SLPs), and early intervention professionals to ensure early identification of children who would benefit from AAC; and (b) increase public awareness in order to reduce opportunity barriers for young children with complex communication needs. Advocacy efforts are also required to increase expectations of professionals who work with young children with complex communication needs through research to demonstrate the substantial gains in communication, language, and literacy skills that can be realized with appropriate AAC interventions. Efforts are required to ensure the efficient availability of funding for appropriate AAC technologies for young children, which should include not just simple digitized systems, but also AAC technologies that provide greater capacity for language learning and communication development.

Preservice and inservice training for early intervention professionals

There is a substantial gap between what the research suggests is possible through AAC interventions and what is actual practice for most young children with complex communication needs. Improved preservice and inservice training of SLPs and early intervention professionals is necessary to enhance their knowledge of evidence-based practice in AAC and to improve services and results for beginning communicators. Research is required to investigate the best training approaches to effect changes in the practices of professionals and to demonstrate the impact of this type of preservice and inservice training on outcomes for children with complex communication needs.

Conclusion

This research agenda is an ambitious one. It will require the effective collaboration of many stakeholders: consumers who use AAC and their families, researchers well versed in a variety of methodological tools, educational and rehabilitation professionals with expertise in AAC, assistive technology manufacturers, and experts from a wide range of related disciplines. This research will lead to more effective AAC systems and interventions for young children with complex communication needs. With access to appropriate AAC systems and early evidence-based AAC interventions, young children with complex communication needs will have the opportunity to maximize their functional communication, language development, and literacy learning, and will be able to attain their full potential.

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TABLE 1 Design features to enhance the appeal of AAC technologies for young children.

Type of feature	Specific recommendation
Function	• Integrate multiple functions (e.g., social interaction, communication, play, humor, entertainment, telecommunication access, companionship, artistic expression, environmental controls) • Provide dynamic contexts to facilitate social interaction • Incorporate motivating interactive activities (e.g., games, play activities, songs, music, books) • Provide access to innovative functions (e.g., sound effects, virtual educational/play environments) to enhance self-esteem/image
Color/Lights	• Use multiple bright colors for symbols & hardware • Provide multi-colored removable covers to allow personalization • Use color to designate different operations or functions • Use lights to provide feedback & create visual effects
Shape/appearance	• Use a variety of shapes including character shapes • Incorporate transformable configurations and moveable parts • Develop modular AAC systems that can be built up and taken apart into individual units to accommodate development • Develop light weight systems proportionate to young children • Use various materials including plastics, soft plush materials, etc.
Output	• Incorporate a library of sound effects (e.g., animal sounds, car sounds, burping) • Include sounds to express emotions (e.g., laughter, anger, crying) • Provide access to music (e.g., songs, MP3 files, musical instruments) • Include a wide range of voices that appeal to children to facilitate imaginative play (e.g., voices of popular children's characters) • Provide access to speech sounds at phoneme level to support sound play and the development of phonological awareness skills
Personalization	• Incorporate popular themes (e.g., sports teams, movies, books, television characters) • Characterize the system as a companion (e.g., name, personality) • Provide choices to allow personalization of name, voices, personality, attitude, external appearance