Clinical Forum

Toward Functional Augmentative and Alternative Communication for Students With Autism: Manual Signs, Graphic Symbols, and Voice Output Communication Aids

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Perhaps one of the greatest challenges faced by speech-language pathologists who work in school settings is how to provide communication supports to students with autism and related disorders. It is estimated that one third to one half of children and adults with autism do not use speech functionally (National Research Council, 2001). Thus, many individuals with autism are candidates for augmentative and alternative communication (AAC) systems, either to supplement (i.e., augment) their existing speech or to act as their primary (i.e., alternative) method of expressive communication. Although there is a growing a body of research regarding

ABSTRACT: Many individuals with autism are candidates for augmentative and alternative communication (AAC) systems, either to supplement (i.e., augment) their existing speech or to act as their primary (i.e., alternative) method of expressive communication. The purpose of this article is to summarize research and directions for future research with regard to two questions related to the delivery of AAC supports to these individuals: (a) What AAC modality is preferable to use? and (b) What do we know about the use of voice output communication aids with people with autism?

KEY WORDS: autism, manual signing, aided communication, augmentative and alternative communication

the potential of AAC for students with autism (see Mirenda, 2001, and Schlosser & Blischak, 2001, for recent reviews), many questions in this area remain unanswered.

The purpose of this article is to summarize, in narrative form, what we know, what we do not know, and directions for future research with regard to two questions that are frequently asked by speech-language pathologists who provide support to these students:

- Are unaided AAC approaches such as manual signs or aided AAC approaches such as photographs and line drawings preferable for use with students with autism?

- What do we know about the use of voice output communication aids (VOCAs, also known as speech-generating devices) with students with autism?

In order to accomplish this, existing research was reviewed along content rather than methodological parameters. Stringent criteria such as those typically used in a meta-analysis to evaluate the adequacy of various research methodologies were not applied. Rather, the research was reviewed at face value, under the assumption that all of the studies had adequate internal validity that led to empirically sound outcomes. This approach is admittedly more subjective and less conservative than a more formal meta-analytic approach; hence, the conclusions should be taken as suggestive rather than definitive. Nonetheless, this narrative review should provide preliminary guidelines for

speech-language pathologists who provide support in this very challenging and controversial area (see Shafer, 1993, and Sundberg, 1993).

FUNCTIONAL COMMUNICATION

There are two types of AAC techniques: unaided and aided.

- *Unaided communication* does not require any equipment that is external to the body and involves the use of symbols such as manual signs, pantomimes, and gestures.
- *Aided communication* incorporates devices that are external to the individuals who use them (e.g., communication books and VOCAs) and involves the use of symbols such as photographs, line drawings, letters, and words.[1]

Most people use a combination of unaided and aided communication techniques, depending on the context and communication partner (Beukelman & Mirenda, 1998).

The primary purpose of any AAC endeavor is to "compensate (either temporarily or permanently) for the impairment and disability patterns of individuals with severe expressive communication disorders" (American Speech-Language-Hearing Association [ASHA], 1989, p. 107). Thus, for individuals who never acquire speech, AAC techniques should result in generalized, functional communication in natural contexts over the long term. The most critical question with regard to this issue is, "What empirical evidence exists to support the use of one technique over another for functional communication?"

One way to assess whether a new communicative behavior is truly functional pertains to the question: Does the individual use it in a generalized manner (i.e., across people and settings) over time? Schlosser and Lee (2000) conducted a meta-analysis of 20 years of AAC research to identify strategies that effectively induced generalization and maintenance in addition to initial acquisition of new communication behaviors. They used the percentage of nonoverlapping data technique (Scruggs, Mastropieri, & Casto, 1987) to integrate data from 50 studies in terms of intervention, generalization, and maintenance effectiveness. Across all age groups and participant populations, they found that unaided AAC approaches (e.g., manual signing) were significantly more effective than aided approaches (e.g., graphic symbols) with regard to acquisition ($p = .04$), whereas no differences were found with regard to either generalization ($p = .18$) or maintenance ($p = 1.0$). However, it is important to note that fewer than 10% of the 232 data comparisons that met their inclusion criteria involved participants with autism (either with or without mental retardation). Furthermore, Schlosser and Lee noted the dearth of studies that have directly compared the two types of approaches, and the fact that only one such study met their inclusion criteria (Iacono, Mirenda, & Beukelman, 1993). Nonetheless, their results suggest that, in general, there may be an initial learning advantage for manual signs over aided techniques, although this advantage does not appear to result in generalized communication that persists over time.

Total Communication (Speech and Manual Signing)

There is a considerable body of research in which total communication was compared with speech alone and/or with manual signing alone to teach receptive and/or expressive vocabulary to children with autism who had limited or no functional speech. In general, the results of these studies suggest that manual signing or total communication results in faster and more complete receptive and/or expressive vocabulary acquisition than does speech alone (e.g., Barrera, Lobatos-Barrera, & Sulzer-Azaroff, 1980; Barrera & Sulzer-Azaroff, 1983; Brady & Smouse, 1978; Remington & Clarke, 1983; Yoder & Layton, 1988). However, it is important to note that almost all of the research studies in this area were designed to teach receptive or expressive *labels* (i.e., tacts) in response to questions such as "What is this [hold up object]?" or "Show me the sign for [object label]." In only a few exceptions (e.g., Layton, 1988; Yoder & Layton, 1988) was the dependent variable of interest spontaneous communication in the form of requesting or some other pragmatic function.

In addition, not all children with autism perform equally well with regard to manual sign learning, and one variable that appears to be related to outcome is fine motor ability. Although the incidence of autism and motor coordination problems co-occurring is not clear, there is evidence to suggest that some individuals experience difficulty in this area (e.g., Bonvillian & Blackburn, 1991; Jones & Prior, 1985; National Research Council, 2001; Page & Boucher, 1988). With regard to manual signing in particular, Seal and Bonvillian (1997) found that manual sign vocabulary size and the accuracy of sign formation were both highly correlated with measures of apraxia and fine motor age in 14 students with autism and severe intellectual disabilities. Thus, there is some evidence to suggest that students with poor manual fine motor skills are likely to have difficulty learning and using even single signs for functional communication. This may account for Layton and Watson's (1995) conclusion that "even after intensive training with signs, a significant number of nonverbal children continue to be mute and acquire only a few useful signs" (p. 81). Thus, although it may be appropriate to teach children with poor fine motor skills a limited number of simple, functional signs (e.g., EAT, HUG, MORE, STOP), they will probably require aided communication techniques as well.

Aided Communication

Numerous studies have demonstrated success in teaching individuals with autism to use nonelectronic aided symbol

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[1]Facilitated communication (Biklen & Cardinal, 1997; Green & Shane, 1994) is a form of aided communication that involves typing or pointing to letters. A discussion of facilitated communication is not included in this article because the issues related to its use are even more complex than those related to conventional unaided and aided AAC techniques.

displays for communication (Mirenda, 2001). Participants in these studies were usually taught to make requests (i.e., mands) for desired items or activities using symbols such as real or partial objects, photographs, and line drawings or other types of pictures (e.g., Hamilton & Snell, 1993; Keen, Sigafoos, & Woodyatt, 2001; Kozleski, 1991; Mirenda & Santogrossi, 1985; Reichle & Brown, 1986; Rotholz, Berkowitz, & Burberry, 1989; Rowland & Schweigert, 2000; Sigafoos, 1998; Sigafoos, Laurie, & Pennell, 1996; Stiebel, 1999). From this research, it is clear that—given appropriate opportunities and instruction—many children, adolescents, and adults with autism across the range of ability (i.e., including those who communicate primarily via prelinguistic behaviors such as reaching or grabbing) can learn to use aided techniques for functional communication (see Sigafoos & Mirenda, 2002, for a review of effective instructional techniques). In addition, the use of such techniques with some individuals appears to have positive side effects such as decreased rates of severe problem behaviors (Frea, Arnold, & Vittimberga, 2001) and/or increased rates of social interaction (e.g., Garrison-Harrell, Kamps, & Kravits, 1997).

Total Communication Versus Aided Communication

There are a few studies comparing total communication to aided communication techniques, many of which suffer from significant methodological flaws. Some studies have focused on symbol learnability as it relates to discrimination learning, short-term memory, iconicity, or the amount of physical effort involved; others have explored the relative intelligibility of the two types of symbols for communication partners. In the sections that follow, theoretical arguments in each of these areas are presented, along with summaries of the related research.

Discrimination learning and short-term memory. One of the key arguments presented in favor of manual signing is that it involves an easier discrimination than does the use of graphic symbols (Michael, 1985; Sundberg & Michael, 2001; Sundberg & Partington, 1998). Michael (1985) and others have argued that aided symbol systems require conditional (i.e., multiple stimuli) discriminations, whereas topography-based systems such as manual signing require unconditional (i.e., single stimulus) discriminations. For example, Sundberg and Partington noted that, in order for a child to request a cup using an aided symbol display, the child's motivation for a cup (stimulus one) and the presence of a symbol for CUP (stimulus two) are both required. However, if manual signing is used, the child's motivation for a cup is the only stimulus required because the manual sign for CUP does not exist in spatial form and therefore does not need to be "present." They argued that the latter type of (unconditional) discrimination is less complicated to acquire than is the former because it involves only a single stimulus and a single response. This is closely related to a second argument, which is that manual signing is easier to learn because it involves a single-component rather than a multiple-component motor

response (i.e., the child only has to form the sign, rather than first scanning and then selecting a specific symbol from an array; Michael, 1985; Potter & Brown, 1997).

In contrast, other researchers have argued that the distinction between a conditional and an unconditional discrimination is somewhat nebulous when applied to decisions about the "best" communication modality for a specific individual to learn because such decisions depend on a host of symbol, referent, and instructional variables (Koul, Schlosser, & Sancibrian, 2001). In addition, there is considerable research to suggest that individuals with autism generally do not experience deficits in discrimination learning, especially when the stimuli are concrete in nature (Sigman, Dissandyke, Arbelle, & Ruskin, 1997). Thus, there is no reason to suggest that these individuals, for whom visual–spatial learning appears to be relatively intact, are likely to find it easier to learn manual signs than aided symbols; in fact, the opposite case has often been made (Koul et al., 2001; Mirenda & Erickson, 2000; Quill, 1997). In addition, some researchers have argued that there *is* an array from which a manual sign selection must be made, which consists of "all of the signs I know and all of the other possible things I can do with my hands"—a very large array, indeed! In the person's repertoire, this array can be thought of as present but "invisible" (i.e., existing solely in the mind) rather than "visible" (i.e., existing in space), and as requiring recall rather than recognition memory (Bristow & Fristoe, 1984; Iacono et al., 1993; Kiernan, 1983; Light & Lindsay, 1991; Oxley & Norris, 2000).

Recall memory appears to involve a two-stage process: (a) a search of one's memory for potential candidates (in this case, manual signs) that suit a particular situation and (b) a discrimination process to decide which of the potential candidates (i.e., signs) is correct (Light & Lindsay, 1991). Recognition memory, on the other hand, does not require the first step of this process—the search—because the potential candidates (i.e., the graphic symbols on a communication display) are already visible to the user. Cognitive scientists would argue that any discrimination that requires recognition rather than recall memory is easier to achieve because fewer cognitive resources are involved (Berk, 2002). On the other hand, behaviorists who dismiss the concept of memory as an "internal scanning process" (Michael, 1985, p. 3) that has been invented by "cognitivists" (p. 2) would argue against the notion that the selection of signs from recall memory presents a significant challenge to many learners.

Goossens' (1984) specifically addressed this issue in a study that compared the learnability of manual signs and two types of graphic symbols: rebuses, which are quite pictographic, and Blissymbols, which are quite abstract. She found that 30 participants with moderate mental retardation who showed evidence of memory constraints had more difficulty learning signs than either rebuses or Blissymbols, whereas those participants who did not have memory constraints learned signs and rebuses equally well, followed by Blissymbols. This provides some support for the suggestion that graphic symbols may make fewer demands on memory than manual signs. On the other hand, two more recent studies provided some evidence in favor

of manual signing as an easier modality to learn in response to a verbal mand (Sundberg & Sundberg, 1990; Wraikat, Sundberg, & Michael, 1991). In these studies, adults with mild to profound mental retardation (not autism) were taught sets of nonsense (i.e., arbitrary) manual signs, graphic symbols, and (in Wraikat et al.) spoken labels corresponding to nonsense objects. For example, one set in the Wraikat et al. study consisted of an oddly shaped cloth object called a "doof," a symbol that resembled the Greek letter sigma, and a manual sign that involved pointing down with an open hand. In the Sundberg and Sundberg study, three participants required fewer trials to learn the nonsense manual signs and the fourth participant required approximately the same number of trials to learn both manual signs and symbols. In the Wraikat et al. study, the results again favored manual signs, although to different degrees across the 7 participants.

In both of these studies, artificial stimulus sets were taught in highly contrived instructional contexts, and it is unclear whether these factors influenced the results. In addition, the participants were taught to produce the signs or symbols in response to verbal mands (e.g., "What's this? [show object]" and "What's doof?") rather than to communicate requests or other functions. However, a recent study (Adkins & Axelrod, 2001) that incorporated more natural stimuli and instructional techniques in the context of functional communication instruction provided evidence against the argument that manual signs are easier to learn. In this study, a boy with pervasive developmental disorder (PDD) and attention deficit hyperactivity syndrome was taught to use both manual signs and the Picture Exchange Communication System (PECS; Bondy & Frost, 2001b; Frost & Bondy, 2002) to request preferred objects. In the PECS, learners are taught to exchange symbols for desired items rather than to point to them on a communication display. For the study, target words were selected on the basis of both preference and manual sign iconicity. Both manual signs and graphic symbols were taught using hand-over-hand physical prompts to elicit the desired behavior, prompt fading, and delivery of the requested item paired with relevant verbal feedback (e.g., "Oh, you want the _____"). The results indicated that the boy required fewer instructional trials to learn the pictures (an average of 7.1 per picture and 15.7 per sign) and showed evidence of both more spontaneous picture use and better generalization with pictures compared to signs. Future research is needed to determine whether the unique selection technique inherent in the PECS (i.e., exchanging rather than pointing to symbols) contributed to the results (Frost & Bondy, 2002; Sundberg & Partington, 1998).

Based on the few studies that have compared manual signs and aided symbols directly, it would appear that the jury is still out with regard to the relative learnability of aided symbols and manual signs for persons with developmental disabilities in general. However, it is important to note that there was only 1 participant with autism (Adkins & Axelrod, 2001) across the four studies reviewed in this section; the others were all adults with various degrees of mental retardation. The fact is that, empirically speaking, we know almost nothing about the applicability of the

theoretical arguments on either side of the debate to individuals with autism. Clearly, this is an area that requires additional research in natural communicative contexts.

Learning and iconicity. A second issue related to symbol learnability and functional use involves the iconicity hypothesis, which states that "symbols having a strong resemblance to their referents [are] easier to learn and remember than those symbols having a weak visual relationship" (Fuller & Stratton, 1991, p. 52; see Fristoe & Lloyd, 1979, for the original discussion of this hypothesis). The iconicity hypothesis was supported in at least one study examining manual sign learning in children with autism (Konstantareas, Oxman, & Webster, 1978). This suggests that, for example, the American Sign Language (ASL) signs for EAT, DRINK, and SLEEP, which bear a close visual resemblance to their referents, are likely to be learned more readily than the signs for HELP, PLAY, and TOILET, which do not. Yet, all of these words are highly functional and are often included in the initial sign lexicon that is taught to most children (Karlan, 1990). In fact, many of the most basic and functional manual signs would fail the iconicity test that is implied by the hypothesis and thus are likely to be at least somewhat difficult for many individuals with autism to learn and use spontaneously (see Bryen & Joyce, 1985).

Some post hoc evidence in support of the iconicity hypothesis for graphic symbols was also provided in a study by Kozleski (1991) that focused on teaching labeling rather than requesting; however, because iconicity was secondary to the purpose of the study, the evidence is not conclusive (Schlosser & Sigafoos, 2002). Nonetheless, visual inspection of the symbols for both nouns and verbs that appear in graphic symbol sets such as the widely used Picture Communication Symbols (PCS; Mayer-Johnson, 1994) suggests that many would readily pass the iconicity test, as would simple color photographs of objects, activities, and actions. It is important to note, however, that AAC users' experience and background will greatly affect their perceptions of the meanings of graphic symbols that may be quite obvious to their more knowledgeable adult partners. Of course, more complex language concepts such as adjectives (e.g., big, lonely), adverbs (e.g., quickly), and pronouns (e.g., he, them) appear to be more difficult to represent, regardless of the type of symbol that is used.

Learning and physical effort. As noted previously, another argument that has been made in favor of aided techniques for communication is that the pointing or reaching response they require involves less physical effort than does the execution of manual signs, which may be especially important for students with autism who also have fine motor deficits (Mirenda & Erickson, 2000; Seal & Bonvillian, 1997). Two recent studies explored this issue, although neither provided specific information about the fine motor abilities of the participants. In one study, Shane, an adolescent boy with severe mental retardation and "autistic-like" behavior, learned to use both a simple VOCA that said "I want more" and the manual sign for WANT to ask for desired items (Sigafoos & Drasgow, 2001). He required 11 prompts to learn the sign and 1 prompt to learn to activate the VOCA. When the VOCA was present, Shane

always used it rather than the manual sign; however, when the VOCA was not available, he used the manual sign. The authors suggested that the results favoring the VOCA might be accounted for by some combination of visual salience and physical ease with regard to its use.

In a similar study, Richman, Wacker, and Winborn (2001) compared the use of a communication card that meant "I want toy" with a manual sign for PLEASE in a 3-year-old boy with PDD. The boy, Mike, was taught to use both the card and the manual sign to ask his mother for toys, as an alternative to tangible-motivated problem behavior (i.e., aggression). Following instruction in card use only, Mike primarily used the card instead of engaging in aggression. However, once he learned to sign PLEASE, he always opted for this response even when the card was available. The authors suggested that this occurred because use of the manual sign was more efficient (i.e., required less physical effort; see Horner & Day, 1991). This is probably true because card use required Mike to (a) orient and move toward the card, (b) pick it up from the floor, (c) walk to his mother, and (d) place it in her hand, whereas sign use only required him to (a) orient toward his mother and (b) make the sign. A more appropriate comparison would have been to attach the card to Mike's body (perhaps on the end of an extendable cord) and then teach him to simply (a) orient toward his mother and (b) show her the card. Hence, because the two interventions were not matched to control for physical effort, the results do not provide support for either approach in this regard.

Intelligibility. Finally, in order for communication to be truly functional, it must be easily understood by both familiar and unfamiliar communication partners (Mirenda & Erickson, 2000). In this regard, there is some research evidence that the use of manual signs may impede communication with natural speakers who do not sign. For example, a study by Rotholz et al. (1989) illustrated the intelligibility limitations of manual signing used with unfamiliar community members. When two adolescents with autism were taught to use both manual signs and PCSs to order food in a restaurant, almost none of the students' manual sign requests were understood by the restaurant counterperson without assistance from a teacher. In contrast, successful request rates of 80% to 100% were reported when PCSs were used in the students' communication books. Although the conclusions that can be drawn from this study are preliminary because of several methodological flaws (Schlosser, 2003), it provides suggestive evidence in favor of graphic symbol intelligibility.

It is important to note that aided approaches must also be selected carefully to match environmental demands and listener capabilities. For example, Doss et al. (1991) compared the use of four aided AAC devices: a picture wallet with PCSs, two different VOCAs, and a VOCA that also provided printed output. They measured the amount of time it took for participants to order a standard set of food items in a fast food restaurant. Results indicated that the quality of the speech output delivered via the VOCAs had a significant impact on the success of requests, and that the

picture wallet was more effective than a VOCA with low-quality speech.

It seems clear from these few studies that the intelligibility of any AAC approach is an important issue for communication partners. Given that most adults do not understand manual signs, this suggests advantages for printed words, printed words plus graphic symbols, and high-quality speech delivered through a VOCA when the communication partners are literate adults. When partners include children and others who have not acquired literacy skills, VOCAs or graphic symbols that bear clear visual relationships to their referents would be more appropriate.

Summary

There are substantial bodies of research documenting the potential of both total communication and aided AAC techniques for individuals with autism. However, many of these studies suffer from significant threats to internal validity (Schlosser, 2003), and thus offer evidence that is suggestive but not conclusive. A small number of studies suggests that individuals with good fine motor abilities are most likely to benefit from total communication, whereas no similar co-requisite skills have been identified for aided techniques. Research in the area of total communication has focused primarily on teaching receptive and expressive labeling, whereas research on aided techniques has largely focused on teaching functional communication related to requesting. Thus, the evidence in the latter group of studies, while often weak, is much more aligned with the question at hand regarding techniques that support functional communication. Few studies have directly compared manual signs and aided AAC approaches in individuals with autism, and the results are somewhat mixed: Some results suggest that aided approaches (i.e., pictures or PCSs, with or without VOCAs) are easier to learn and to use, and some support the use of manual signs. Finally, the small body of research that has examined the impact of manual signing and aided techniques on the communication partners of persons with autism suggests that the latter has advantages over the former. It is clear that there is a need for focused and systematic research in this area in order to guide clinical decisions about the type(s) of communication approaches that are mostly likely to result in functional communication for students with specific abilities and impairments (Schlosser, 1999).

NATURAL SPEECH DEVELOPMENT

Another issue that may influence the selection of one AAC technique over another is the question, "Which approach is more likely to lead to the development of natural speech?" Some behaviorists argue that manual signs are superior in this regard because of a phenomenon known as "automatic reinforcement" (Skinner, 1957). In essence, the research on automatic reinforcement has shown that, when infants and children with language delays are presented with a neutral stimulus (e.g., an adult saying a

spoken word, such as "tickle") that is repeatedly paired with a reinforcer (e.g., a desired activity, such as being tickled), they begin to produce at least approximations of the spoken word themselves (e.g., Smith, Michael, Partington, & Sundberg, 1996; Sundberg, Michael, Partington, & Sundberg, 1996; Yoon & Bennett, 2000). Thus, at least theoretically, if manual signs and spoken words are presented *together* as neutral stimuli (e.g., COOKIE + "cookie") and are followed by a reinforcer (i.e., a cookie), *both* the sign *and* the spoken word should increase in frequency. However, Frost and Bondy (2002) argued that the principles of automatic reinforcement also apply to the PECS, in which pictures and spoken words are presented together as neutral stimuli (e.g., BALL + "ball") and are followed by a reinforcer (i.e., a ball). Their argument can also be extended to include other types of aided techniques as well.

In fact, the autism research literature does provide some evidence that natural speech may develop concurrent with manual signing in the context of total communication (Goldstein, 2002). Layton and Watson (1995) noted that "learning to communicate initially by sign transfers to the spoken word after the child learns approximately 200 signs and starts to chain two or more signs together" (p. 81). However, whether natural speech development occurs in conjunction with total communication appears to depend largely on whether or not the learner has mastered generalized verbal imitation at the time of intervention (e.g., Brady & Smouse, 1978; Carr & Dores, 1981; Carr, Pridal, & Dores, 1984; Layton, 1988; Remington & Clarke, 1983; Schaeffer, Kollinzas, Musil, & McDowell, 1978; Schepis, Reid, Fitzgerald, Faw, Van den Pol, & Welty, 1982; Yoder & Layton, 1988).

Yoder and Layton (1988), in the only study to date that has specifically explored this issue, found that verbal imitation accounted for the 63% of the variance between learners who did and did not demonstrate spoken language after manual sign instruction. The addition of age and IQ to the regression model accounted for only 15% more of the variance, suggesting that neither age nor IQ was as important as verbal imitation as a predictor of natural speech outcomes concurrent with signing. However, a recent study (DiCarlo, Stricklin, Banajee, & Reid, 2001) provided data that appear to contradict Yoder and Layton's findings. The study involved 11 typical toddlers and 12 toddlers with autism and other disabilities who attended an inclusive preschool in which manual signing was used by teaching staff. All but one of the toddlers with disabilities imitated motor movements, and most used word approximations to communicate. Over a 4-month period (C. DiCarlo, personal communication Sept. 6, 2002), the frequency of the children's communicative verbalizations neither increased nor decreased as a result of manual sign instruction that occurred in the context of specific activities; signing, however, did increase for almost all of these children. Thus, it appears that, although speech development in conjunction with manual signing is most likely to occur in learners who already have some spoken language ability, this outcome cannot be guaranteed.

Aided Techniques

There is also a growing body of research to suggest that the use of aided AAC techniques may facilitate speech development and production. Evidence in this regard for students with autism is now available across aided techniques that include facilitated communication (Broderick & Kasa-Hendrickson, 2001), communication boards with pictures and words (Garrison-Harrell et al., 1997), tangible symbols (Rowland & Schweigert, 2000), PECS (Charlop-Christy, Carpenter, Le, LeBlanc, & Kellet, 2002), and VOCAs (Mirenda, Wilk, & Carson, 2000; Romski & Sevcik, 1996).

In the first empirical study to assess the acquisition and impact of the PECS, Charlop-Christy et al. (2002) documented a clear increase in both spontaneous and imitative speech production in 3 young children with autism. All 3 children had some imitative abilities before learning to use the PECS, but none were able to produce speech without prompting. These results are consistent with prior anecdotal reports that, of 67 children with autism aged 5 years and younger who used the PECS for more than 1 year, 59% developed independent speech—that is, they stopped using the PECS and used speech as their sole mode of communication (Bondy & Frost, 1994). Another 30% used speech + the PECS, and the remaining 11% used PECS only. Bondy and Frost noted that speech tended to develop once the children were able to use 30 to 100 symbols to communicate. Similarly, Schwartz, Garfinkle, and Bauer (1998) reported that 6 out of 11 children with autism (55%) developed independent speech following 12 months of the PECS use. Interestingly, the children's preintervention communication abilities in this study did not appear to be related to whether or not they developed speech. Finally, in a study that involved a 6-year-old girl with autism, Kravits, Kamps, Kemmerer, and Potucek (2002) documented significant increases in the frequency of both spontaneous speech and symbol use following PECS training, although the range of spoken vocabulary (i.e., the number of different words) did not increase. Research data presented in a number of recent conference presentations have also documented improved speech development following PECS use over time (Bondy & Frost, 2001a; Frost & Bondy, 2002).

Romski and Sevcik (1996) reported the results of a 2-year research project that investigated the System for Augmented Language (SAL) which, among other things, involved the use of VOCAs with abstract lexigrams accompanied by printed words. Seven of the 13 project participants, including the 2 with autism, increased the proportion of spoken words in their vocabularies that were rated intelligible over the course of the project. The participants' speech improvements appeared to be related neither to their vocal imitation abilities nor to their rate of symbol use with SAL. Although the extent to which VOCA output contributed to the participants' speech development is not clear, the researchers speculated that the consistent models of spoken words provided by the VOCAs immediately following each symbol selection may have had a positive impact in this regard. Similarly, Mirenda et al. (2000) reported that the speech of 7 out of 58 students

with autism who were provided with VOCAs improved so significantly that they no longer needed their devices. All seven of these students had limited functional speech when they received their VOCAs, 5 of the 7 received their VOCAs as young children (ages 5 to 8), and the group included students across the range of cognitive ability.

Summary

The limited research on natural speech development following AAC use suggests that both manual signs and aided techniques may have a facilitative effect in this regard. However, this conclusion is tempered by the results of a recent meta-analysis of research published between 1975 and 1998 that included some documentation of speech production during and/or following either unaided or aided AAC interventions (Millar, Light, & Schlosser, 2000). The meta-analysis focused on the outcomes for 58 participants across 24 studies that met a stringent set of inclusion criteria; 16 (28%) of the participants had autism. The evidence related to natural speech development for each participant was rated as conclusive, preponderant, suggestive, or inconclusive as a result of significant methodological flaws. There were no participants with autism at the conclusive or suggestive levels of evidence, 1 at the preponderant level, and 15 at the inconclusive level (R. Schlosser, personal communication, April 5, 2002). The authors emphasized that methodological limitations in most of the studies reviewed posed a significant barrier to adopting the findings as certain. Nonetheless, this study found no evidence to suggest that manual signing is more likely than aided techniques to lead to natural speech development, or vice versa. It is clear that this is an important area for research, and that those who support both sides of the debate should endeavor to include speech development as a dependent variable in future examinations of the outcomes of one or both approaches (Schlosser, 1999).

In the final sections related to this issue, the issues of practicality and the availability of natural communities of communication partners are considered.

PRACTICALITY

There is no question but that manual signs are more portable, more permanent, and more readily used at a distance from the listener than are graphic symbol displays without voice output. In addition, the vocabulary size that is possible through manual signing is limited only by learner variables (e.g., fine motor ability, memory) rather than by display size and other factors that impact aided communication. Interestingly, a recent report by the National Research Council (2001) concluded that "it is very rare to find a child with autism who learns to sign fluently (in sentences) and flexibly. Signing is not generally an entry point into a complex, flexible system" (p. 58). Thus, although many individuals with autism who use manual signs may not be able to take advantage of the extensive lexicon afforded by this modality, manual signing—because

of its portability and other advantages—may facilitate an understanding of communication in general.

NATURAL COMMUNITIES OF USERS

Another argument that has been made is that manual signing is preferable to aided communication because it allows access to an existing community of manual signers (i.e., people who are deaf and hard of hearing). In fact, the likelihood that individuals with autism will even be exposed to—let alone embraced by—the deaf community just because they are able to use a few signs is extremely low. The fact is that *neither* students with autism who use manual signs *nor* those who use aided communication are likely to be exposed to "functioning verbal communities" of competent individuals who can act as communication models. Because of the extensive learning demands that manual signing places on communication partners, it is not uncommon for teachers, parents, and others who support students who use this technique to have extremely limited sign vocabularies themselves, often in the range of 10 to 100 words (Bryen, Goldman, & Quinlisk-Gill, 1988). Similarly, instructional programs that incorporate the use of aided language stimulation and other strategies in which teachers and others provide explicit models of graphic symbol use across environments are still all too rare. Clearly, there is a critical need for instructional environments that emphasize "AAC use in contexts that allow students to see symbols being used repeatedly, interactively, and generatively, during…meaningful ongoing activit[ies]" (Goossens', Crain, & Elder, 1992, p. 14). Educational models currently exist for teaching both aided communication (e.g., Cafiero, 1998, 2001; Goossens' et al., 1992; Romski & Sevcik, 1996) and unaided communication (e.g., Miller & Eller-Miller, 2000) in such language-rich environments.

SUMMARY

Table 1 summarizes the arguments both for and against total communication and aided techniques for persons with autism, along with a summary of the quality of the research evidence related to each argument. From this review, it appears that the subset of children with autism who have *both* good fine motor skills *and* good verbal imitation skills may be appropriate candidates for a total communication approach, especially when speech development is a primary goal of intervention. On the other hand, aided communication techniques may make fewer memory and cognitive demands on learners and may also have clear advantages with regard to ease of use and intelligibility for communication partners.

Of course, in the end, decisions concerning which AAC technique(s) should be attempted with a given student must be evaluated regularly with regard to the outcomes of those attempts. One important outcome question is, "Is the student learning new vocabulary words at a rate that is likely to lead to functional communication within a

Table 1. Advantages and rationales regarding total communication and aided augmentative and alternative communication techniques for persons with autism.

Advantage/rationale	Research evidence favors...			Quality of evidence
	Manual signing (total communication)	Aided techniques	Neither technique	
Fewer fine motor skills (i.e., less physical effort) required		X		Good
Less cognitively demanding with regard to memory requirements (recall vs. recognition)			X	Weak; only one study assessed this in adults with mental retardation
Symbol discriminations are easier to learn (conditional vs. unconditional discriminations)			X	Weak; only one study involved a participant with autism
Symbols more closely resemble their referents (iconicity)			X	Weak; few studies have made direct comparisons
More intelligible to unfamiliar partners		X		Good
More likely to lead to the development of natural speech			X	Weak; few studies; results support both
More portable	X			Good
Less easily misplaced or lost	X			Good
Does not require listeners to be in close proximity; easier to communicate from a distance			X	Depends on the aided technique; neither the Picture Exchange Communication System nor voice output communication aids require this, but other aided techniques do
Unlimited vocabulary space	X			Good
Functioning community of symbol users exists to provide models			X	No studies exist in favor of either technique
Easier for communication partners to learn and use		X		Good

reasonable amount of time?" The student who, over a 1-year period, has learned only a few new manual signs; or the student who, after hundreds of learning trials, can discriminate between only a few photographs or line drawing symbols, is not acquiring new vocabulary at a reasonable rate and should undoubtedly be reassessed to determine a more appropriate AAC technique. A related outcome question is, "Is the student able to communicate functionally and spontaneously using the technique, across a variety of people and environments?" The student who requires continuous prompting to use either signs or aided symbols, or the student whose communication can be understood by only a few familiar people clearly is not achieving this outcome. Finally, the question, "Is natural speech developing along with functional communication?" may also be important, although this outcome is usually considered to be a positive side effect of functional communication through AAC rather than a specific goal. In addition, it may be important to consider the use of VOCAs as an alternative to either total communication or nonelectronic aided techniques, as discussed in the next section.

VOCAs

VOCAs are portable electronic devices that produce synthetic or digitized speech output. A variety of graphic symbols can be used in conjunction with VOCAs to represent messages that are activated when an individual uses a finger, hand, or some other means to select a symbol from the VOCA's display. In the United States, the provision of assistive technologies such as VOCAs is mandated by the Individuals with Disabilities Education Act Amendments of 1997, and many states also operate equipment loan programs through the Assistive Technology Act of 1998. In other countries, appreciation of the potential for VOCA use with students with autism has also increased over the past decade (e.g., Bornman & Alant, 1999; Mirenda et al., 2000). Thus, speech-language pathologists are frequently asked to provide input regarding the appropriateness of VOCAs. In an attempt to answer the question, "What do we know about the use of VOCAs by students with autism?," the limited research in this area is reviewed in this section.

Only one published research study to date has investigated the relative effectiveness of VOCA versus non-VOCA feedback in persons with autism; however, the study focused on spelling rather than on communication (Schlosser, Blischak, Belfiore, Bartley, & Barnett, 1998). Martin, a 10-year-old boy with autism, was taught to spell novel words under three conditions. In the first condition, synthetic speech was delivered after Martin typed each letter using the VOCA. In the second condition, letters and words appeared on the VOCA's display; and in the third condition, both synthetic speech and letters were provided as Martin spelled. Martin learned to spell the new words that were taught in all three conditions, but he learned to do so more efficiently (i.e., faster) in the speech and speech + print conditions. It is important to note that the study did not include a condition in which *natural* speech (as opposed to synthetic speech) was provided as feedback. Thus, although it appears that the provision of speech feedback enhanced Martin's learning efficiency with regard to spelling, it was not clear whether this occurred specifically because *synthetic* speech feedback via a VOCA was provided. Perhaps natural speech feedback (e.g., a teacher or peer announcing letters and words as they were typed) would have had the same effect. Nonetheless, this study suggests that learning may be enhanced through the use of VOCA feedback, although this conclusion is preliminary because the study involved only one participant.

Another potential advantage of VOCAs is their ability to facilitate natural interpersonal interactions and socialization by virtue of the speech output they provide. Schepis, Reid, Behrmann, and Sutton (1998) investigated this issue in a study of 4 young children with autism (3 to 5 years of age) who had little or no functional speech and attended a self-contained classroom with 4 other children with autism. The children were taught to use individual VOCAs with line drawing symbols to represent messages such as "I want a snack, please," "more," and "I need help." Each message was represented by a single symbol on the VOCA displays. Naturalistic teaching procedures (e.g., child-preferred stimuli, natural cues such as expectant delays and questioning looks to elicit communication, and non-intrusive prompting techniques) were used to teach the children to interact with classroom staff using their VOCAs. Over a 1- to 3-month period, all 4 children learned to make requests, respond to questions, and make social comments (e.g., "thank you") during natural play and/or snack routines in the classroom. By the end of formal training, the majority of VOCA interactions by the children were spontaneous (i.e., unprompted) and contextually appropriate. In addition, classroom staff engaged in a higher frequency of communicative interactions with the children following naturalistic teaching with the VOCA; however, no such effects were seen with regard to child–child interactions.

The use of VOCAs to teach basic requesting to individuals with autism has also been demonstrated in several reports. Dyches (1998) studied the use of a simple VOCA—a loop tape + microswitch—to teach 4 children with autism and severe intellectual disabilities to make requests for a drink. A human voice asking for a drink was recorded on the tape and the children were taught to activate the tape by depressing a microswitch with a symbol on it for "drink." Although the data suggest that the intervention was effective in increasing requesting behavior, the study has many methodological and design flaws that call this conclusion into question (Schlosser & Blischak, 2001).

In a case study report, Brady (2000) reported successful use of a VOCA to teach a 5-year-old girl with autism to make requests in the context of preferred activities. Interestingly, this report provided evidence of increased speech comprehension for object names following successful VOCA use for requesting. As noted previously, Sigafoos and Drasgow (2001) taught conditional use of a VOCA and manual sign to teach a generalized "want" request. Similarly, the use of VOCAs to teach generalized requesting (e.g., "I want more," "I need help") was demonstrated in a study in which 5 children (2 with autism) learned to use VOCAs to produce alternative communicative behaviors that served the same functions as their problem behaviors (Durand, 1999). This study also demonstrated a concurrent reduction in the frequency of problem behaviors such as aggression and tantrums.

Finally, Van Acker and Grant (1995) examined the use of a computer with a speech synthesizer, touch screen, and specially designed software to teach 3 girls with Rett syndrome to make requests for desired food or drink items. The students were taught to touch a computer screen that displayed a symbol representing either a preferred or a nonpreferred food/drink item (e.g., MILK) accompanied by a synthetic speech prompt (e.g., "Would you like some milk?"). If the learner touched the screen, (a) the computer presented an animated graphic picture of the desired item (e.g., milk being poured from a carton into a glass) and a synthesized speech response (e.g., "Yes, I would like milk") and (b) a teacher delivered a small portion of the selected item. If the student did not touch the screen, neither (a) nor (b) occurred. All 3 girls showed general improvements in requesting behavior and were able (to various degrees) to discriminate between preferred and nonpreferred items. The results of this well-controlled study are especially important given the girls' diagnoses and their extremely impaired cognitive functioning (i.e., below Piaget's sensorimotor stage 5).

A unique case study report also provided evidence for the potential of a multimodal communication system that included a VOCA in a school setting. Light, Roberts, Dimarco, and Greiner (1998) described the support provided to John, a 6-year-old boy with autism whose communication system included natural speech, pointing and other conventional gestures, a communication book and dictionary, and a Macintosh Powerbook with a high-quality speech synthesizer and Write:Out:loud software (Don Johnston). The authors described their use of the participation model (Beukelman & Mirenda, 1998) and a combination of assessment strategies—including interviews with parents and teachers, a communication needs survey (Beukelman & Mirenda, 1998), ecological inventories (Reichle, York, & Sigafoos, 1991), systematic observations, and both formal and informal (i.e., criterion-referenced) assessment protocols—to design the intervention. This case study example is unique in that it illustrates the application

of state-of-the-art AAC assessment procedures in addition to VOCA use.

Finally, Mirenda et al. (2000) provided information concerning the use of VOCAs over a 5-year period by 58 students with autism in a retrospective examination of the database of a province-wide technology loan program in British Columbia, Canada. The students who used VOCAs ranged in age from 5 to 17 years and all had diagnoses on the autism spectrum. Before receiving their VOCAs, 41% had no functional speech, 50% had limited functional speech (i.e., 1–2-word utterances), and the remaining 9% had functional speech but at a level that was considered inadequate for their daily ongoing communication needs. Approximately 26% were estimated to have cognitive abilities in the average range, and the remainder had some degree of cognitive impairments (mild = 19%; moderate = 36%, and severe = 19%). Their VOCAs included both dedicated speech output devices (e.g., IntroTalkers [Prentke Romich, Wooster, OH]) and laptop computers + communication software packages (e.g., Macintosh computers with Speaking Dynamically software [Mayer Johnson]).

Annual, written follow-up reports of students' use of the VOCAs were analyzed and assigned "success scores" in three categories: little or no success, limited or some success, and successful or very successful. Interrater reliability of a randomly selected 30% of the categorical assignments across two independent observers was 90%. Overall, only 8 of the 58 students (14%) had little or no success with their VOCAs. On the other hand, 31 students (53%) were rated as successful or very successful, and the remaining 19 students (33%) had limited or some success. The 31 students who were rated as successful or very successful represented all levels of cognitive ability (average ability = 26%, mild delay = 16%, moderate delay = 35%, and severe delay = 23%). Across all three "success categories," students used a variety of VOCAs—including computers with IntelliKeys (IntelliTools) or Speaking Dynamically (Mayer Johnson) software, Intro/AlphaTalkers (Prentke Romich, Wooster, OH), and Macaws (Zygo Industries, Portland, OR)—and none appeared to be more successfully used than the others. Although this was not a controlled research study, the results provided no evidence of a relationship between cognitive ability and successful VOCA use, and suggested that VOCAs can be used successfully by many students with autism.

Summary

There is growing evidence that both dedicated VOCAs and computers with communication software can be used effectively to support students with autism in school settings. However, almost no research has investigated the use of these technologies with this population in home or community settings (cf. Durand, 1999). Future research is also needed to answer questions such as:

- What types of support from school personnel and peers contribute to successful VOCA outcomes?
- What instructional techniques are most likely to lead to successful VOCA outcomes?

- What role does the initial use of nonelectronic AAC techniques (both unaided and aided) play in successful VOCA use later on?
- What are the variables that contribute to the development of functional speech following VOCA use?

In addition, although the Mirenda et al. (2000) results suggest that students across the range of cognitive ability may be considered appropriate candidates for VOCA use, there are no empirically validated methods for making this decision at this point in time. Thus, speech-language pathologists who consider prescribing VOCAs for students with autism must continue to rely on their own instincts, expertise, and experience when making this important and potentially costly decision. Guidelines and protocols for decision making that are based on sound research in this area are sorely needed.

CONCLUSION

From this review, it should be clear that decision making related to AAC interventions for individuals with autism is a complex and challenging endeavor. Selection of one or more types of symbols requires careful assessment and individualization, and at this point in time is more of an art than a science. Although passionate theoretical arguments both for and against the use of aided symbols, total communication/manual signing, and VOCAs abound, the fact of the matter is that very little comparative research currently exists to inform clinical practice in this area. Despite this lack, decisions concerning appropriate AAC techniques cannot and should not be made in the abstract; rather, they must be made for specific learners, in specific contexts, to meet specific needs (Beukelman & Mirenda, 1998). The ultimate measure of a successful intervention is the extent to which it results in functional, unprompted communication across environments and people, and interventions with such outcomes deserve and should be awarded both respect and support, regardless of the modality involved. Needless to say, removing access to communication techniques that result in such outcomes—even for theoretically sound reasons—is unacceptable and unethical.

In addition, it is important to note that the success or failure of any AAC intervention is not simply a matter of choosing the type(s) of symbol(s) that are easiest to learn, even for a specific individual. Instructional variables are also critically important; indeed, it may very well be that the historic "failure" of many total communication interventions to generate functional communication is the result of limitations in the procedures and methods used for instruction rather than an inherent limitation in the use of manual signs per se (Sundberg & Partington, 1998). The same can be said of intervention failures related to the use of aided symbols, which are often taught either haphazardly or in artificial contexts that fail to promote meaningful communication. Fortunately, recognition of the fact that instructional procedures may "make or break" the success of any AAC endeavor is being increasingly acknowledged in recent clinical and research literature (e.g., Frost & Bondy, 2002;

Koul et al., 2001; Light & Binger, 1998; Reichle, Beukelman, & Light, 2002; Rowland & Schweigert, 2000; Sundberg & Partington, 1998). In the end, the combination of individualized modality selection, excellent instruction, and "goodness-of-fit" (Bailey et al., 1990) with regard to environments, communication partners, and communication needs are all needed to maximize the possibility of successful communication for individuals with autism.

ACKNOWLEDGMENTS

REFERENCES

Adkins, T., & Axelrod, S. (2001). Topography-based versus selection-based responding: Comparison of mand acquisitions in each modality. *The Behavior Analyst Today, 2,* 259–266.

American Speech-Language-Hearing Association. (1989). Competencies for speech-language pathologists providing services in augmentative communication. *Asha, 31*(3), 107–110.

Assistive Technology Act, Pub. L. 105-394, 29 U.S.C. § 3001 *et seq.* (1998).

Bailey, B. D., Simeonsson, R. J., Winton, P. J., Huntington, G. S., Comfort, M., Isbell, P., et al. (1990). Family-focused intervention: A functional model for planning, implementing and evaluating individualized family services in early intervention. *Journal of the Division for Early Childhood, 10,* 156–171.

Barrera, R., Lobatos-Barrera, D., & Sulzer-Azaroff, B. (1980). A simultaneous treatment comparison of three expressive language training programs with a mute autistic child. *Journal of Autism and Developmental Disorders, 10,* 21–37.

Barrera, R., & Sulzer-Azaroff, B. (1983). An alternating treatment comparison of oral and total communication training programs with echolalic autistic children. *Journal of Applied Behavior Analysis, 16,* 379–394.

Berk, L. (2002). *Infants and children: Prenatal through middle childhood* (4th ed.). Boston: Allyn & Bacon/Longman.

Beukelman, D. R., & Mirenda, P. (1998). *Augmentative and alternative communication: Management of severe communication disorders in children and adults* (2nd ed.). Baltimore: Paul H. Brookes.

Biklen, D., & Cardinal, D. (1997). *Contested words, contested science: Unraveling the facilitated communication controversy.* New York: Teachers College Press.

Bondy, A., & Frost, L. (1994). The Delaware Autistic Program. In S. Harris & J. Handleman (Eds.), *Preschool education for children with autism* (pp. 37–54). Austin, TX: Pro-Ed.

Bondy, A., & Frost, L. (2001a). The picture exchange communication system. *Behavior Modification, 25,* 725–744.

Bondy, A., & Frost, L. (2001b). *A picture's worth: PECS and other visual communication strategies in autism.* Bethesda, MD: Woodbine.

Bonvillian, J., & Blackburn, D. (1991). Manual communication and autism: Factors relating to sign language acquisition. In P. Siple & S. Fischer (Eds.), *Theoretical issues in sign language research* (pp. 255–277). Chicago: University of Chicago Press.

Bornman, J., & Alant, E. (1999). Training teachers to facilitate interaction with autistic children using digital voice output devices. *South African Journal of Education, 19,* 364–373.

Brady, D., & Smouse, A. (1978). A simultaneous comparison of three methods for language training with an autistic child: An experimental single case analysis. *Journal of Autism and Childhood Schizophrenia, 8,* 271–279.

Brady, N. (2000). Improved comprehension of object names following voice output communication aid use: Two case studies. *Augmentative and Alternative Communication, 16,* 197–204.

Bristow, M., & Fristoe, M. (1984). Learning of Blissymbols and manual sign. *Journal of Speech and Hearing Disorders, 49,* 145–151.

Broderick, A., & Kasa-Hendrickson, C. (2001). "SAY JUST ONE WORD AT FIRST": The emergence of reliable speech in a student labeled with autism. *Journal of the Association for Persons with Severe Handicaps, 26,* 13–24.

Bryen, D., Goldman, A., & Quinlisk-Gill, S. (1988). Sign language with students with severe/profound mental retardation: How effective is it? *Education and Training in Mental Retardation, 23,* 129–137.

Bryen, D., & Joyce, D. (1985). Language intervention with the severely handicapped: A decade of research. *Journal of Special Education, 19,* 7–39.

Cafiero, J. (1998). Communication power for individuals with autism. *Focus on Autism and Other Developmental Disabilities, 13,* 113–121.

Cafiero, J. (2001). The effect of an augmentative communication intervention on the communication, behavior, and academic program of an adolescent with autism. *Focus on Autism and Other Developmental Disabilities, 16,* 179–189.

Carr, E., & Dores, P. (1981). Patterns of language acquisition following simultaneous communication with autistic children. *Analysis and Intervention in Developmental Disabilities, 1,* 1–15.

Carr, E., Pridal, C., & Dores, P. (1984). Speech versus sign comprehension in autistic children. Analysis and prediction. *Journal of Experimental Child Psychology, 37,* 587–597.

Charlop-Christy, M., Carpenter, M., Le, L., LeBlanc, L., & Kellet, K. (2002). Using the Picture Exchange Communication System (PECS) with children with autism: Assessment of PECS acquisition, speech, social-communicative behavior, and problem behavior. *Journal of Applied Behavior Analysis, 35,* 213–231.

DiCarlo, C., Stricklin, S., Banajee, M., & Reid, D. (2001). Effects of manual signing on communicative verbalizations by toddlers with and without disabilities in inclusive classrooms. *Journal of the Association for Persons with Severe Handicaps, 26,* 120–126.

Doss, S., Locke, P., Johnston, S., Reichle, J., Sigafoos, J., Charpentier, P., et al. (1991). Initial comparison of the efficiency of a variety of AAC systems for ordering meals in fast food restaurants. *Augmentative and Alternative Communication, 7,* 256–265.

Durand, V. M. (1999). Functional communication training using assistive devices: Recruiting natural communities of reinforcement. *Journal of Applied Behavior Analysis, 32,* 247–268.

Dyches, T. (1998). Effects of switch training on the communication of children with autism and severe disabilities. *Focus on Autism and Other Developmental Disabilities, 13,* 151–162.

Frea, W., Arnold, C., & Vittimberga, G. (2001). A demonstration of the effects of augmentative communication on the extreme aggressive behavior of a child with autism within an integrated preschool setting. *Journal of Positive Behavior Interventions, 4,* 194–198.

Fristoe, M., & Lloyd, L. L. (1979). Nonspeech communication. In N. R. Ellis (Ed.), *Handbook of mental deficiency: Psychological theory and research* (pp. 401–430). New York: Lawrence Erlbaum Associates.

Frost, L., & Bondy, A. (2002). *Picture Exchange Communication System training manual* (2nd ed.). Newark, DE: Pyramid Education Products.

Fuller, D., & Stratton, M. (1991). Representativeness versus translucency: Different theoretical backgrounds, but are they really different concepts? *Augmentative and Alternative Communication, 7,* 51–58.

Garrison-Harrell, L., Kamps, D., & Kravits, T. (1997). The effects of peer networks on social-communicative behaviors for students with autism. *Focus on Autism and Other Developmental Disabilities, 12,* 241–254.

Goldstein, H. (2002). Communication intervention for children with autism: A review of treatment efficacy. *Journal of Autism and Developmental Disorders, 32,* 373–396.

Goossens', C. (1984). The relative iconicity and learnability of verb referents differentially represented by manual signs, Blissymbols, and rebus symbols: An investigation with moderately retarded individuals (Doctoral dissertation, Purdue University). *Dissertation Abstracts International, 45,* 0529.

Goossens', C., Crain, S., & Elder, P. (1992). *Engineering the preschool environment for interactive, symbolic communication.* Birmingham, AL: Southeast Augmentative Communication Conference Publications.

Green, G., & Shane, H. (1994). Science, reason, and facilitated communication. *Journal of the Association for Persons with Severe Handicaps, 19,* 151–172.

Hamilton, B., & Snell, M. (1993). Using the milieu approach to increase spontaneous communication book use across environments by an adolescent with autism. *Augmentative and Alternative Communication, 9,* 259–272.

Horner, R., & Day, H. M. (1991). The effects of response efficiency on functionally equivalent competing behaviors. *Journal of Applied Behavior Analysis, 24,* 719–732.

Iacono, T., Mirenda, P., & Beukelman, D. R. (1993). Comparison of unimodal and multimodal AAC techniques for children with intellectual disabilities. *Augmentative and Alternative Communication, 9,* 83–94.

Individuals with Disabilities Education Act, Pub. L. 105-117, 20 U.S.C. § 1407 *et seq.* (1997).

IntelliKeys [Computer software]. Petaluma, CA: IntelliTools.

Jones, V., & Prior, M. R. (1985). Motor imitation abilities and neurological signs in autistic children. *Journal of Autism & Developmental Disorders, 15,* 37–46.

Karlan, G. (1990). Manual communication with those who can hear. In H. Bornstein (Ed.), *Manual communication: Implications for education* (pp. 151–185). Washington, DC: Gallaudet University Press.

Keen, D., Sigafoos, J., & Woodyatt, G. (2001). Replacing prelinguistic behaviors with functional communication. *Journal of Autism and Developmental Disorders, 31,* 385–398.

Kiernan, C. (1983). The use of nonvocal communication

techniques with autistic individuals. *Journal of Child Psychology and Psychiatry, 24,* 339–375.

Konstantareas, M., Oxman, J., & Webster, C. (1978). Iconicity: Effects of the acquisition of sign language by autistic and other severely dysfunctional children. In P. Siple (Ed.), *Understanding language through sign language research* (pp. 213–237). New York: Academic Press.

Koul, R., Schlosser, R., & Sancibrian, S. (2001). Effects of symbol, referent, and instructional variables on the acquisition of aided and unaided symbols by individuals with autism spectrum disorders. *Focus on Autism and Other Developmental Disabilities, 16,* 162–169.

Kozleski, E. (1991). Visual symbol acquisition by students with autism. *Exceptionality, 2,* 175–194.

Kravits, T. R., Kamps, D. M., Kemmerer, K., & Potucek, J. (2002). Brief report: Increasing communication skills for an elementary-aged student with autism using the Picture Exchange Communication System. *Journal of Autism and Developmental Disorders, 32,* 225–230.

Layton, T. (1988). Language training with autistic children using four different modes of presentation. *Journal of Communication Disorders, 21,* 333–350.

Layton, T., & Watson, L. (1995). Enhancing communication in nonverbal children with autism. In K. A. Quill (Ed.), *Teaching children with autism: Strategies to enhance communication and socialization* (pp. 73–101). New York: Delmar.

Light, J., & Binger, C. (1998). *Building communicative competence with individuals who use augmentative and alternative communication.* Baltimore: Paul H. Brookes.

Light, J., & Lindsay, P. (1991). Cognitive science and augmentative and alternative communication. *Augmentative and Alternative Communication, 7,* 186–203.

Light, J., Roberts, B., Dimarco, R., & Greiner, N. (1998). Augmentative and alternative communication to support receptive and expressive communication for people with autism. *Journal of Communication Disorders, 31,* 153–180.

Mayer-Johnson Company. (1994). *The Picture communication symbols combination book.* Solana Beach, CA: Author.

Michael, J. (1985). Two kinds of verbal behavior plus a possible third. *The Analysis of Verbal Behavior, 3,* 1–4.

Millar, D., Light, J., & Schlosser, R. (2000). The impact of AAC on natural speech development: A meta-analysis. In *Proceedings of the 9th biennial conference of the International Society for Augmentative and Alternative Communication* (pp. 740–741). Washington, DC: ISAAC.

Miller, A., & Eller-Miller, E. (2000). The Miller Method®: A cognitive–developmental systems approach for children with body organization, social, and communication issues. In The Interdisciplinary Council on Developmental and Learning Disorders (Eds.), *ICDL practice guidelines: Redefining the standards of care for infants, children, and families with special needs* (pp. 489–515). Bethesda, MD: ICDL Press.

Mirenda, P. (2001). Autism, augmentative communication, and assistive technology: What do we really know? *Focus on Autism and Other Developmental Disabilities, 16,* 141–151.

Mirenda, P., & Erickson, K. (2000). Augmentative communication and literacy. In A. Wetherby & B. Prizant (Eds.), *Autism spectrum disorders: A transactional developmental perspective* (pp. 333–367). Baltimore: Paul H. Brookes.

Mirenda, P., & Santogrossi, J. (1985). A prompt-free strategy to teach pictorial communication system use. *Augmentative and Alternative Communication, 1,* 143–150.

Mirenda, P., Wilk, D., & Carson, P. (2000). A retrospective analysis of technology use patterns in students with autism over a five-year period. *Journal of Special Education Technology, 15*, 5–16.

National Research Council. (2001). *Educating children with autism*. Washington, DC: National Academy Press.

Oxley, J., & Norris, J. (2000). Children's use of memory strategies: Relevance to voice output communication aid use. *Augmentative and Alternative Communication, 16*, 79–94.

Page, J., & Boucher, J. (1988). Motor impairments in children with autistic disorder. *Child Language, Teaching, & Therapy, 14*, 233–259.

Potter, B., & Brown, D. (1997). Review of the studies examining the nature of selection-based and topography-based verbal behavior. *The Analysis of Verbal Behavior, 14*, 85–104.

Quill, K. (1997). Instructional considerations for young children with autism: A rationale for visually cued instruction. *Journal of Autism and Developmental Disorders, 27*, 697–714.

Reichle, J., Beukelman, D., & Light, J. (2002). *Exemplary practices for beginning communicators*. Baltimore: Paul H. Brookes.

Reichle, J., & Brown, L. (1986). Teaching the use of a multipage direct selection communication board to an adult with autism. *Journal of the Association for Persons with Severe Handicaps, 11*, 68–73.

Reichle, J., York, J., & Sigafoos, J. (1991). *Implementing augmentative and alternative communication: Strategies for learners with severe disabilities*. Baltimore: Paul H. Brookes.

Remington, B., & Clarke, S. (1983). Acquisition of expressive signing by autistic children: An evaluation of the relative effects of simultaneous communication and sign-alone training. *Journal of Applied Behavior Analysis, 16*, 315–327.

Richman, D., Wacker, D., & Winborn, L. (2001). Response efficiency during functional communication training: Effects of effort on response allocation. *Journal of Applied Behavior Analysis, 34*, 73–76.

Romski, M. A., & Sevcik, R. (1996). *Breaking the speech barrier: Language development through augmented means*. Baltimore: Paul H. Brookes.

Rotholz, D., Berkowitz, S., & Burberry, J. (1989). Functionality of two modes of communication in the community by students with developmental disabilities: A comparison of signing and communication books. *Journal of the Association for Persons with Severe Handicaps, 14*, 227–233.

Rowland, C., & Schweigert, P. (2000). Tangible symbols, tangible outcomes. *Augmentative and Alternative Communication, 16*, 61–78, 205.

Schaeffer, B., Kollinzas, G., Musil, A., & McDowell, P. (1978). Spontaneous verbal language for autistic children through signed speech. *Sign Language Studies, 21*, 317–352.

Schepis, M., Reid, D., Behrmann, M., & Sutton, K. (1998). Increasing communicative interactions of young children with autism using a voice output communication aid and naturalistic teaching. *Journal of Applied Behavior Analysis, 31*, 561–578.

Schepis, M., Reid, D., Fitzgerald, J., Faw, G., Van den Pol, R., & Welty, P. (1982). A program for increasing manual signing by autistic and profoundly retarded youth within the daily environment. *Journal of Applied Behavior Analysis, 15*, 363–379.

Schlosser, R. (1999). Comparative efficacy of interventions in augmentative and alternative communication. *Augmentative and Alternative Communication, 15*, 56–68.

Schlosser, R. (2003). *The efficacy of augmentative and alternative communication: Toward evidence-based practice*. New York: Academic Press.

Schlosser, R., & Blischak, D. (2001). Is there a role for speech output in interventions for persons with autism? A review. *Focus on Autism and Other Developmental Disabilities, 16*, 170–178.

Schlosser, R., Blischak, D., Belfiore, P., Bartley, C., & Barnett, N. (1998). The effectiveness of synthetic speech output and orthographic feedback in a student with autism: A preliminary study. *Journal of Autism and Developmental Disorders, 28*, 309–319.

Schlosser, R., & Lee, D. (2000). Promoting generalization and maintenance in augmentative and alternative communication: A meta-analysis of 20 years of effectiveness research. *Augmentative and Alternative Communication, 16*, 208–226.

Schlosser, R., & Sigafoos, J. (2002). Selecting graphic symbols for an initial request lexicon: An integrative review. *Augmentative and Alternative Communication, 18*, 89–110.

Schwartz, I., Garfinkle, A., & Bauer, J. (1998). The Picture Exchange Communication System: Communicative outcomes for young children with disabilities. *Topics in Early Childhood Special Education, 18*, 144–159.

Scruggs, T. E., Mastropieri, M. A., & Casto, G. (1987). The quantitative synthesis of single subject research methodology: Methodology and evaluation. *Remedial and Special Education, 8*, 24–33.

Seal, B., & Bonvillian, J. (1997). Sign language and motor functioning in students with autistic disorder. *Journal of Autism & Developmental Disorders, 27*, 437–466.

Shafer, E. (1993). Teaching topography-based and selection-based verbal behavior to developmentally disabled individuals: Some considerations. *The Analysis of Verbal Behavior, 11*, 117–133.

Sigafoos, J. (1998). Assessing conditional use of graphic mode requesting in a young boy with autism. *Journal of Developmental and Physical Disabilities, 10*, 133–151.

Sigafoos, J., & Drasgow, E. (2001). Conditional use of aided and unaided AAC: A review and clinical case demonstration. *Focus on Autism and Other Developmental Disabilities, 16*, 152–161.

Sigafoos, J., Laurie, S., & Pennell, D. (1996). Teaching children with Rett syndrome to request preferred objects using aided communication: Two preliminary studies. *Augmentative and Alternative Communication, 12*, 88–96.

Sigafoos, J., & Mirenda, P. (2002). Strengthening communicative behaviors for gaining access to desired items and activities. In J. Reichle, D. Beukelman, & J. Light (Eds.), *Exemplary practices for beginning communicators: Implications for AAC* (pp. 123–156). Baltimore: Paul H. Brookes.

Sigman, M., Dissandyke, C., Arbelle, S., & Ruskin, E. (1997). Cognition and emotion in children and adolescents with autism. In D. Cohen & F. Volkmar (Eds.), *Handbook of autism and pervasive developmental disorders* (2nd ed., pp. 249–265). New York: John Wiley & Sons.

Skinner, B. F. (1957). *Verbal behavior*. Englewood Cliffs, NJ: Prentice Hall.

Smith, R., Michael, J., Partington, J., & Sundberg, M. (1996). Automatic reinforcement and automatic punishment in infant vocal behavior. *The Analysis of Verbal Behavior, 13*, 39–48.

Speaking Dynamically [Computer software]. Solana Beach, CA: Mayer Johnson.

Stiebel, D. (1999). Promoting augmentative communication during

daily routines: A parent problem-solving intervention. *Journal of Positive Behavior Interventions, 1,* 159–169.

Sundberg, M. (1993). Selecting a response form for nonverbal persons: Facilitated communication, pointing systems, or sign language? *The Analysis of Verbal Behavior, 11,* 99–116.

Sundberg., M., & Michael, J. (2001). The benefits of Skinner's analysis of verbal behavior for children with autism. *Behavior Modification, 25,* 698–724.

Sundberg., M., Michael, J., Partington, J., & Sundberg, C. (1996). The role of automatic reinforcement in early language acquisition. *The Analysis of Verbal Behavior, 13,* 21–37.

Sundberg, M., & Partington, J. (1998). *Teaching language to children with autism or other developmental disabilities* (Version 7.1) [Computer manual]. Pleasant Hill, CA: Behavior Analysts.

Sundberg, C., & Sundberg, M. (1990). Comparing topography-based verbal behavior with stimulus selection-based verbal behavior. *The Analysis of Verbal Behavior, 8,* 31–41.

Van Acker, R., & Grant, S. (1995). An effective computer-based requesting system for persons with Rett syndrome. *Journal of Childhood Communication Disorders, 16,* 31–38.

Wraikat, R., Sundberg, C., & Michael, J. (1991). Topography-based and selection-based verbal behavior: A further comparison. *The Analysis of Verbal Behavior, 9,* 1–17.

Write:Outloud [Computer software]. Wauconda, IL: Don Johnston.

Yoder, P., & Layton, T. (1988). Speech following sign language training in autistic children with minimal verbal language. *Journal of Autism & Developmental Disorders, 18,* 217–229.

Yoon, S.-Y., & Bennett, G. (2000). Effects of stimulus-stimulus pairing procedure on conditioning vocal sounds as reinforcers. *The Analysis of Verbal Behavior, 17,* 75–88.

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