The Impact of Augmentative and Alternative Communication Intervention on the Speech Production of Individuals With Developmental Disabilities: A Research Review

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Purpose: This article presents the results of a meta-analysis to determine the effect of augmentative and alternative communication (AAC) on the speech production of individuals with developmental disabilities.
Method: A comprehensive search of the literature published between 1975 and 2003, which included data on speech production before, during, and after AAC intervention, was conducted using a combination of electronic and hand searches.
Results: The review identified 23 studies, involving 67 individuals. Seventeen of these studies did not establish experimental control, thereby limiting the certainty of evidence about speech outcomes. The remaining 6 studies, involving 27 cases, had sufficient methodological rigor for the "best evidence analysis" (cf. R. E. Slavin, 1986). Most of the participants (aged 2–60 years) had mental retardation or autism; the AAC interventions involved instruction in manual signs or nonelectronic aided systems. None of the 27 cases demonstrated decreases in speech production as a result of AAC intervention, 11% showed no change, and the majority (89%) demonstrated gains in speech. For the most part, the gains observed were modest, but these data may underestimate the effect of AAC intervention on speech production because there were ceiling effects.
Conclusions: Future research is needed to better delineate the relationship between AAC intervention and speech production across a wider range of participants and AAC interventions.

KEY WORDS: augmentative and alternative communication, speech production, developmental disabilities, effectiveness, meta-analysis, systematic review

Augmentative and alternative communication (AAC) interventions can benefit individuals with developmental disabilities who have significant speech and language impairments by enhancing their communicative competence (e.g., Light, Binger, Agate, & Ramsay, 1999) and facilitating the development of language skills (e.g., Romski & Sevcik, 1996). Despite these recognized benefits, some parents and professionals are hesitant to initiate AAC interventions because of concerns that AAC will inhibit speech production (e.g., Beukelman, 1987; Silverman, 1995). They worry that AAC may become a "crutch" for individuals with developmental disabilities, negatively impacting the emergence of speech (Dowden & Marriner, 1995), and argue that

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individuals with developmental disabilities may prefer to use AAC and may not be motivated to learn to use speech to communicate, because they perceive that AAC is an easier way to communicate compared with speech (Glennen & DeCoste, 1997).

Others (Romski & Sevcik, 1996) have proposed a counterargument, positing that AAC will actually facilitate the production of speech for individuals with developmental disabilities who have significant speech impairments. Those who support this counterargument outline a number of reasons why AAC would benefit speech production. First, AAC intervention may reduce the pressure on the individual for speech production, thereby reducing stress and indirectly facilitating speech (Lloyd & Kangas, 1994). Second, AAC intervention may allow individuals with significant speech impairments to bypass the motor and cognitive demands of speech production and focus on the goal of communication instead; after they establish basic communication and language skills, they may then be better able to reallocate resources to improve their speech productions (Romski & Sevcik, 1996). Proponents of this argument emphasize that speech is a much more efficient means of communication compared with AAC and believe that children will inevitably choose the easier, more efficient, and more accepted mode of communication (i.e., speech), provided it is a viable mode within their repertoire.

According to Mirenda (2003), the behavioral theory of automatic reinforcement may provide another potential explanation of the facilitative effects of AAC intervention on speech development. According to this theory, if AAC (e.g., the manual sign or graphic symbol for cookie) is presented along with the spoken word (as is typically the case in AAC intervention), and these are followed by a reinforcer (e.g., a chocolate chip cookie), both the AAC mode and speech production should increase in frequency.

Others have argued that AAC facilitates speech production because AAC provides a more immediate and consistent model for individuals with developmental disabilities; this is particularly the case when AAC involves speech output (synthesized or digitized) as a model for speech production (Blischak, 2003; Romski & Sevcik, 1996; M. Smith & Grove, 2003).

Professionals and parents urgently need empirical evidence about the impact of AAC on speech production to make informed decisions about AAC interventions. In 1995, Silverman published a review of the literature addressing the impact of AAC on speech production. This review is frequently quoted as evidence that AAC facilitates speech production. Silverman reported that he reviewed over 100 published and unpublished reports to determine the impact of AAC on speech production. He concluded that, "The use of augmentative and alternative communication seems to facilitate speech (i.e., increase verbal output) in some children and adults" (p. 34). Furthermore, he concluded that at least 40% of the individuals in the studies he reviewed demonstrated an increase in speech as a result of AAC interventions. However, examination of the primary sources included in Silverman's review reveals several critical limitations that make it difficult to draw reliable conclusions about the impact of AAC on speech production. First, there is no description of the selection criteria or search procedures used to identify studies for the review. Second, references are provided for less than a third of the 100 reports reviewed (Silverman, 1995). In addition, of the references provided, many of the sources are unpublished; others that are published do not report reliable data on the participants' speech productions before and after AAC intervention. Furthermore, analysis of the data from some of the published studies suggests some inaccuracies in the conclusions reported (e.g., conclusions that there was an increase in speech attempts for some participants were not valid). Last, most of the studies cited in Silverman's review were published prior to 1982. There have been many advances in AAC interventions since that time.

There is an urgent need for a systematic review of the current research on AAC intervention and natural speech production to guide evidence-based decision making in initiating AAC (Schlosser & Raghavendra, 2004). Our goal in this article is to report the results of a systematic research review designed to determine the relationship between AAC intervention and speech development in individuals with developmental disabilities.

Method

Inclusion Criteria

There were a number of criteria specified for the inclusion of studies in the review: (a) The studies were published between 1975 and 2003, (b) they involved individuals with developmental disabilities who had significant speech impairments (i.e., speech was not adequate to meet daily communication needs), (c) they included implementation of AAC (i.e., the compensation for spoken or written communication through unaided or aided AAC systems; Lloyd, Fuller, & Arvidson, 1997) and they included documentation of progress in the acquisition of the use of AAC, and (d) they included data on speech production for the participants before, during, and/or after AAC intervention (e.g., number of words spoken). *Speech production* was defined as the oral expression of language (Hulit & Howard, 2002) and included oral production of intelligible words or word approximations understood in context. Studies of individuals whose primary impairment was a hearing impairment were excluded from the review because these individuals are typically not considered within the population of individuals who require AAC (American Speech-Language-Hearing Association, 1991). Studies of individuals who had acquired disabilities were excluded; AAC interventions might be expected to impact the speech recovery of individuals with acquired disabilities in different ways than these interventions would impact the speech development of individuals with developmental disabilities who had no history of age-appropriate speech skills. Studies that included AAC interventions but did not document the participants' acquisition of AAC were also excluded (e.g., Yoder & Layton, 1988).

Search Procedures

A multifaceted search strategy was used to locate all studies that met the selection criteria and to avoid a biased yield, as would occur if only one source were consulted (White, 1994). First, electronic searches of various databases (i.e., *PsycINFO, ERIC, Medline*) were conducted using keywords (i.e., "nonspeaking," "nonvocal," "augmentative communication," "speech production," "speech development"). Next, hand searches or electronic searches of the tables of contents of 46 journals were performed (see Appendix A). A comprehensive list of journals was developed that had a history of including articles on AAC. The list of journals included in Schlosser and Lee's (2000) meta-analysis was also used as a guide to generate the list of journals for the current review. Last, ancestral searches of references cited in studies that met the selection criteria were conducted. These search procedures were designed to maximize the yield of relevant studies; however, as with any search, it is possible that a relevant study was missed.

Reliability of the search procedures. Five of the 46 journals (11%) were randomly selected and searched either by hand or electronically by a graduate student to determine the reliability of the search procedures. A total of 3,089 articles were reviewed using the inclusion criteria described above. The interjudge reliability was nearly 100% for the search procedures (i.e., 3,088 agreements out of 3,089 total articles). The single discrepancy was discussed and resolved.

Coding Procedures

Each study that met the selection criteria was reviewed and coded. The coding categories were based, in part, on the categories used by Schlosser and Lee (2000) in their meta-analysis of treatment effectiveness of AAC interventions. Additional categories specific to the objectives of the present review were added on the basis of a review of the related literature and input from experts in AAC. (See Appendix B for the final coding categories and their operational definitions.)

Each study was coded with respect to (a) the goals of the study, (b) the design, (c) the participants (i.e., gender, disability, chronological age), (d) the independent variable (i.e., type of AAC system, intervention procedures, number of sessions), (e) the percentage of nonoverlapping data (PND) of the speech production data in the case of single-participant experimental designs (Scruggs, Mastropieri, & Casto, 1987) or the effect size in the case of group designs (Kazdin, 2003), and (f) the speech outcomes (i.e., the change in speech production calculated as the amount of increase or decrease in speech productions during or after the AAC intervention compared with baseline preintervention). The PND and speech outcomes were coded for each participant in each single-participant experimental design separately according to the procedures established by Schlosser and Lee (2000). When participants were involved in more than one application of the same AAC intervention (e.g., as in a multiple-baseline-across-behaviors design where the same AAC intervention was applied across several sets of stimuli or in an ABAB withdrawal design), the researchers reported the mean PND of the AAC intervention across the applications according to the procedures suggested by Scruggs et al. (1987). If participants were involved in more than one treatment (as in an alternating treatments design), PND and speech outcomes for the individual treatments were coded as separate cases for each participant. This allowed for analysis of changes in speech productions with different interventions. In some of the alternating treatment designs (e.g., Conaghan, Singh, Moe, Landrum, & Ellis, 1992; Linton & Singh, 1984; Sisson & Barrett, 1984), after the more effective treatment was established, it was then applied to the less effective treatment condition in a new phase (C) of the study. The application of the more effective AAC treatment to the less effective condition was omitted from the analysis because the effects of AAC on speech production could not be reliably determined because of the confounding effects of the intervening, less effective treatment condition.

The increases or decreases in speech were quantified using the unit of measure adopted in each study (e.g., five spoken words) according to the following formula: maximum point during or following AAC intervention minus maximum point at baseline. The speech gains (or decreases) were reported separately for each application of an AAC intervention. Unfortunately, the studies did not use a common metric for measuring speech gains. Some studies measured intelligible words produced; others measured oral production of short, multiword phrases; and some used time-interval data and measured speech production as the percentage of opportunities with speech productions (e.g., Charlop-Christy, Carpenter, Loc, LeBlanc, & Kellet, 2002). As a result, it was not possible to aggregate speech gains precisely across studies.

Last, the methodological rigor of each study was evaluated on the basis of the level of experimental control, the reliability of the dependent variable, and the treatment integrity. Specifically, the methodological quality of each study was coded according to the certainty of evidence (cf. Simeonsson & Bailey, 1991; N. L. Smith, 1981) provided with respect to the effect of AAC intervention on speech production: (a) conclusive evidence (i.e., the design provided experimental control, the dependent variable was reliable, and treatment integrity was solid, allowing the conclusion that the speech outcomes for the participant were undoubtedly the result of the AAC intervention); (b) preponderant evidence (i.e., the study had minor flaws with respect to the design, reliability of the dependent variable, or treatment integrity, resulting in the conclusion that speech outcomes were more likely to have occurred as a result of the AAC intervention than not, but the evidence was not conclusive); (c) suggestive evidence (i.e., the study had several minor flaws, leading to the conclusion that it was plausible, but not certain, that speech outcomes were the result of the AAC intervention); and (d) inconclusive evidence (i.e., there were significant flaws in the design that precluded any conclusions regarding the impact of the AAC intervention on speech production). See Appendix B for operational definitions of the coding categories. This classification system provided a systematic method for documenting the level of certainty of evidence when evaluating the impact of interventions (Simeonsson & Bailey, 1991) and allowed us to determine which studies provided the best evidence.

Conclusive evidence may not always be available, particularly in the formative stages of evaluating specific phenomena. N. L. Smith (1981) argued that evidence at lower levels of certainty should be considered in these cases and concluded that such evidence is "certainly better than no informed conclusions at all" (p. 278), provided the intervention does not pose significant risk for the participants. In situations where conclusive evidence is not available, the best evidence available should be considered.

Best Evidence Analysis

In this research review, we applied a best evidence analysis (cf. Slavin, 1986) on the basis of the certainty of evidence provided by the studies. A best evidence approach combines the analysis of quantitative outcome measures with an evaluation of the quality of individual studies and the certainty of the evidence that the studies provide (Slavin, 1986). Greater weight is given to the best evidence available; that is, greater weight is given to those studies that use more rigorous designs and, thereby, provide greater certainty of evidence. Studies that are flawed methodologically are identified as such and given less weight in drawing summary conclusions (McNaughton, 1994). A best evidence analysis was especially relevant in the present research review because of the variability in methodological rigor across the studies reviewed. Many of the studies failed to establish experimental control with respect to the relationship of interest in this review—the effect of AAC intervention as an independent variable on speech production as a dependent variable. In most of these studies, the relationship between AAC intervention and speech production was not the primary research question in the studies; rather, data on speech outcomes were collected as secondary or collateral measures. As a result, the certainty of evidence in these studies was inconclusive and the effects of AAC intervention on speech productions could not be reliably determined. Greater weight was therefore accorded to those studies that established experimental control and allowed more reliable investigation of the relationship between AAC intervention and speech production.

Reliability of the coding. To ensure reliability of the coding, 20% of the studies were reviewed and coded independently by a second trained coder. Mean interrater reliability (number of agreements divided by number of agreements plus number of disagreements plus omissions) across the studies was 98% (range = 90%–100%). The mean interrater reliability for each variable was as follows: (a) goals, 100%; (b) design, 100%; (c) participants, 100%; (d) AAC intervention, 97%; (e) effect of AAC intervention, 100%; and (f) changes in speech production, 90%. Any discrepancies were resolved through discussion before the coding was finalized.

Results

The search resulted in the identification of 23 studies that met the inclusion criteria (see Table 1). Of the 23 studies, 8 were descriptive case studies; 6 were single-participant, alternating treatment designs; 6 were single-participant, multiple baseline designs; 1 was a single-participant, alternating treatment design within a multiple baseline; 1 was a single-participant withdrawal design; and 1 was a group pretest–posttest design. The studies involved a total of 67 participants: 40% had mental retardation, 31% had autism, and the rest had other disabilities (e.g., Klinefelter's syndrome, cerebral palsy). The goal of 70% of the studies was to teach expressive vocabulary, either in the form of single words (44%) or in short phrases (26%); the goal of the remaining studies (30%) was to teach the expression of various communicative functions (e.g., requests, comments). The majority (61%) of the studies investigated unaided AAC interventions (specifically, manual signs); 31% investigated nonelectronic-aided AAC systems;

Table 1. Studies, published between 1975 and 2003, involving AAC interventions with individuals with developmental disabilities that documented speech production before and during/after intervention.

Study/design	Goal	No. of participants and age[a,b]	AAC intervention	Authors' conclusions re. speech (no. of participants)
*Barrett & Sisson (1987) Alternating treatments within a multiple baseline	Teach two or more word combinations	2 participants with MR 5 & 13 years old	Unaided	Increase (2)
Benaroya, Wesley, Ogilvie, Klein, & Meaney (1977) Case study	Teach two or more word combinations	6 participants with autism 5–12 years old	Unaided	Increase (3) No change (3)
Bondy & Frost (1994) Case study	Teach function	1 participant with autism 3 years old	Aided with no speech output	Increase (1)
Blischak (1999) Pretest–posttest group design	Teach function	1 participant with Down syndrome, 2 with multiple disabilities, 1 with cerebral palsy, and 5 with dysarthria and/or apraxia (no definitive diagnoses) 4–7 years old	Aided with speech output and aided without speech output	Aided (with no speech output): increase (2), decrease (2) Aided (with speech output): increase (4), decrease (1)
Bonta & Watters (1983) Case study	Teach single words	1 participant with autism 11 years old	Unaided	Increase (1)
Casey (1978) Multiple baseline	Teach single words	4 participants with autism 6–7 years old	Unaided	Increase (4)
*Charlop-Christy et al. (2002) Multiple baseline	Teach function	3 participants with autism 3–12 years old	Aided with no speech output	Increase (3)
Clarke, Remington, & Light (1986) Alternating treatments	Teach single words	1 participant with MR 6 years old	Unaided	Increase (1)
Clarke, Remington, & Light (1988) Alternating treatments	Teach single words	2 participants with MR 6 & 7 years old	Unaided	Increase (2)
*Conaghan et al. (1992) Alternating treatments	Teach two or more word combinations	4 participants with MR and hearing impairments 18–60 years old	Unaided	Increase (3) No change (1)
Cregan (1993) Case study	Teach two or more word combinations	1 participant with MR 14 years old	Unaided and aided with no speech output	Increase (1)
DiCarlo, Stricklin, & Banajee (2001) Multiple baseline	Teach single words	6 participants with Down syndrome, autism, or cerebral palsy 1–3 years old	Unaided	Increase[c]
Fulwiler & Fouts (1976) Case study	Teach single words	1 participant with autism 5 years old	Unaided	Increase (1)

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Table 1 *Continued.* Studies, published between 1975 and 2003, involving AAC interventions with individuals with developmental disabilities that documented speech production before and during/after intervention.

Study/design	Goal	No. of participants and age[a,b]	AAC intervention	Authors' conclusions re. speech (no. of participants)
Garrison-Harrel, Kamps, & Kravits (1997) Multiple baseline	Teach function	3 participants with autism 6–7 years old	Aided with no speech output	Increase (3)
Gibbs & Carswell (1991) Case study	Teach single words	1 participant with MR 1 year old	Unaided	Increase (1)
Johnston, Nelson, Evans, & Palazolo (2003) Multiple baseline	Teach function	3 participants with MR 4–5 years old	Aided with no speech output	Increase (3)
*Kouri (1988) Withdrawal	Teach single words	1 participant with autism, 2 with Klinefelter's syndrome, 1 with Down syndrome, and 1 with an unknown diagnosis 2–4 years old	Unaided	Increase (3) Decrease (2)
Kravits, Kamps, Kemmerer, & Potucek (2002) Multiple baseline	Teach function	1 participant with autism 6 years old	Aided with no speech output	Increase (1)
*Linton & Singh (1984) Alternating treatments	Teach two or more word combinations	2 participants with MR and hearing impairments 18 & 59 years old	Unaided	Increase (2)
Pecyna (1988) Case study	Teach single words	1 participant with MR 4 years old	Aided with no speech output	Increase (1)
Remington & Clarke (1993) Alternating treatments	Teach single words	4 participants with MR 4–11 years old	Unaided	Increase (3) No change (1)
Romski, Sevcik, & Pate (1988) Case study	Teach function	3 participants with MR 17–19 years old	Aided with no speech output	Increase (1) No change (2)
*Sisson & Barrett (1984) Alternating treatments within a multiple baseline	Teach two or more word combinations	3 participants with MR and behavior disorders 4–8 years old	Unaided	Increase (3)

Note. All studies, except those marked with an asterisk, lacked the experimental control required to determine reliably the relationship between AAC intervention as an independent variable and natural speech production as a dependent variable; the evidence presented in these studies is inconclusive. AAC = augmentative and alternative communication; MR = mental retardation; HI = hearing impairment.

[a]Disability is reported per the studies cited. [b]Participants were included if there was some measure of speech production provided before and during or after AAC intervention. Participants were excluded if they demonstrated ceiling effects for the speech measures at baseline prior to AAC intervention. [c]Data regarding changes in speech production were not reported for individual participants but as a group. The authors concluded that the children demonstrated increases in speech production.

1 study (4%) investigated a combination of aided AAC systems with speech output and aided AAC systems without speech output; and 1 study (4%) investigated multimodal interventions combining unaided and aided AACs without speech output. The authors of the 23 studies reported the following conclusions regarding the effects of AAC intervention on speech production: (a) Speech increased for 55 of the 67 participants (82%),

(b) there was no change in speech for 7 participants (11%), and (c) speech decreased for 5 participants (7%).

However, many of the studies (17 of 23) did not establish experimental control with respect to the relationship between AAC intervention and natural speech production, making it difficult to draw reliable conclusions about this relationship from these studies. According to the certainty of evidence coding scale, these studies were considered "inconclusive." Six of the 23 studies used research designs that established experimental control with respect to the relationship between AAC intervention and speech production (at least for some of the participants) and established the reliability of the measures of speech production as the dependent variable. Unfortunately, none of these studies reported data on treatment integrity. As a result, the evidence that these studies provided is not "conclusive." However, these 6 studies provided strong evidence about the effects of AAC interventions on speech production. In this review, although none of the evidence was conclusive, these 6 studies used the most rigorous designs from the studies that met the selection criteria. Therefore, the 6 studies represent the best evidence available (see Table 2).

Participants

There were a total of 17 participants[1] with developmental disabilities in the six studies: 4 had autism, and 13 had mental retardation, Down syndrome, or developmental delay (with 6 of these participants having a hearing impairment as well). Of the 17 participants, 11 were children and 6 were adults (age range = 2;4–60;0).

Some of the 17 individuals participated in more than one treatment condition (e.g., introduction of two different AAC interventions, such as signs taught through positive practice compared with signs taught through positive practice plus positive reinforcement, in an alternating treatment design). Each individual's involvement in each treatment was considered as a separate case, resulting in a total of 27 cases across the six studies.

AAC Intervention

Five of the six studies investigated the effects of unaided AAC interventions, specifically instruction in manual signs; the remaining study considered the effects of aided AAC systems without speech output (i.e., Charlop-Christy et al., 2002). The mean length of the AAC interventions in these studies was 42 sessions, with a range of 4 to 206 sessions. In the majority of the cases (78%), the AAC interventions were highly structured and directed by the clinician; in only 22% of the cases were the AAC interventions implemented in child-centered play activities. The studies investigated a range of intervention procedures (e.g., directed rehearsal alone, directed rehearsal with positive reinforcement, positive practice, positive practice plus reinforcement).

Outcomes of the AAC Interventions

Of the 27 cases that provided the best evidence, increases in speech production were observed in 89% (24 of 27 cases). In the remaining 3 cases (11%), there was no change in speech production when baseline data were compared with data collected during and/or after AAC intervention. None of the 27 cases showed a decrease in speech production as a result of AAC intervention.

In 10 of the 27 cases (37%), the PND was at least 90. According to the classification system proposed by Scruggs et al. (1987), this level of PND suggests that the AAC interventions were "highly effective" in increasing speech production in these cases. As Kazdin (1978) explained, "If performance during an intervention phase does not overlap with performance during the baseline phase when these data points are plotted over time, the effects usually are regarded as reliable. The replication of non-overlapping distributions during different treatment phases strongly argues for the effects of treatment" (p. 637).

Most of the gains in natural speech in the 6 studies were measured in terms of the number of spoken words or word approximations produced by the participants (12 of the 24 cases where gains were observed); the mean gain across the AAC applications in these cases was 13 words (range = 1–52 words). In 6 of the 24 cases where gains were observed, speech production was reported in terms of the number of spoken two-word phrases produced by the participants; the mean gain across the AAC applications in these cases was 6 two-word phrases (range = 4–7 two-word phrases). In 6 cases, speech production was reported as the percentage of opportunities in which the participant produced words or word approximations; the mean gain was 77%, with a range of 40% to 100%. Ceiling effects were observed for 17 of the 27 cases in the measures of speech production after AAC intervention; these ceiling effects may have limited the gains observed.

In 79% of the cases where there were gains in speech production (19 of 24 cases), these gains were observed shortly after the AAC intervention was initiated (within

[1]Two of the participants in the study by Conaghan et al. (1992) and 2 of the participants from the study by Linton and Singh (1984) were excluded from the best evidence analysis because these participants demonstrated ceiling effects on the measures of speech production at baseline in both treatment conditions, leaving no room for gains on the speech production measures. One participant in the Linton and Singh study (J.) demonstrated ceiling effects for speech measures in one treatment (T1: signs taught through positive practice) but not in the other treatment (T2: signs taught through positive practice plus reinforcement); the former case was omitted from the analysis but the latter was included. Two participants from the study by Kouri (1988) were also excluded from the best evidence analysis because data were not reported from repeated measures of speech production within the withdrawal design for these participants.

Table 2. Participant information, AAC interventions, and speech outcomes for studies presenting the "best evidence" regarding the effects of AAC intervention on the speech production of individuals with developmental disabilities.

	Participant			AAC intervention			Speech outcomes	
Study/design	Participant ID and gender	Disability[a]	Age	Type of AAC	Treatment condition[b]	No. of sessions[c]	PND	Change in speech production during/after AAC intervention[d]
Barrett & Sisson (1987) Alternating treatments design within a multiple-baseline design	J. Male	Mod. MR; behavior disorder	5;3	Unaided manual signs	T1 (TC)	87 (2)	57	Increase; 3 words*, 1 word*
					T2 (MTC)	87 (2)	51	Increase; 2 words, 1 word
	M. Male	Mod. MR; behavior disorder	13		T1(TC)	67 (2)	38	Increase; 2 words, 1 word
					T2 (MTC)	67 (2)	72	Increase; 3 words*, 2 words
Charlop-Christy et al. (2002) Multiple baseline	A. Male	Autism	12	Aided with no speech output	T1 (PECS-Academic)	4	67	Increase; 60% of opportunities*[e]
					T2 (PECS-Play)	4	33	Increase; 40% of opportunities*
	J. Male	Autism	3;8		T1 (PECS-Academic)	5	82	Increase; 100% of opportunities*
					T2 (PECS-Play)	5	73	Increase; 80% of opportunities
	K. Male	Autism	5;9		T1 (PECS-Academic)	9	43	Increase; 80% of opportunities*
					T2 (PECS-Play)	9	50	Increase; 100% of opportunities*
Conaghan et al. (1992) Alternating treatments design	J. Male	Profound MR; mod. bilateral HI	18	Unaided manual signs	T1 (DR)	27	93	Increase; 6 two-word phrases*
					T2 (DR + PR)	56	98	Increase; 7 two-word phrases*
	T. Male	Severe MR; mild bilateral HI	36		T1 (DR)	23	0	No change
					T2 (DR + PR)	39	0	No change
	F. Male	Profound MR; bilateral high-freq. HI	60		T1 (DR)	16	94	Increase; 7 two-word phrases*
					T2 (DR + PR)	31	94	Increase; 7 two-word phrases*
	M. Female	Severe MR; mild HI in left, severe HI in right	18		T1 (DR)	11	100	Increase; 4 two-word phrases
					T2 (DR + PR)	25	100	Increase; 4 two-word phrases*
Kouri (1988) Withdrawal design	J.S. Male	Autism	3	Unaided manual signs	T1 (TC)	24 (2)	21	Increase; 0 words, 10 words

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Table 2 *Continued.* Participant information, AAC interventions, and speech outcomes for studies presenting the "best evidence" regarding the effects of AAC intervention on the speech production of individuals with developmental disabilities.

Study/design	Participant			AAC intervention			Speech outcomes	
	Participant ID and gender	Disability[a]	Age	Type of AAC	Treatment condition[b]	No. of sessions[c]	PND	Change in speech production during/after AAC intervention[d]
	T.A. Male	Dev. delay	2;4		T1 (TC)	17 (2)	45	Increase; 20 words, 20 words
	B.V. Female	Down syndrome	2;10		T1 (TC)	25 (2)	82	Increase; 5 words, 52 words
Linton & Singh (1984) Alternating treatments design	J. Male	Profound MR; mod. bilateral HI	18	Unaided manual signs	T2 (PP + R)	30	90	Increase; 2 words*
	F. Male	Severe MR; bilateral high-freq. HI	59		T1 (PP) T2 (PP + R)	9 19	0 63	No change Increase; 1 word*
Sisson & Barrett (1984) Alternating treatments design within a multiple-baseline design	E. Male	Mod. MR; Behavior disorder	7	Unaided manual signs	T1 (TC)	127 (3)	100	Increase; 4 words*, 2 words*, 2 words*
	M. Male	Mild MR; Behavior disorder	8;1		T1 (TC)	206 (3)	100	Increase; 4 words*, 4 words*, 4 words*
	T. Male	Mild MR; Behavior disorder	4;8		T1 (TC)	113 (3)	98	Increase; 4 words*, 3 words*, 3 words*

Note. PND = percentage of nonoverlapping data; mod. = moderate; MR = mental retardation; TC = total communication, MTC = modified total communication, PECS = picture exchange communication system; HI = hearing impairment; DR = directed rehearsal; DR + PR = directed rehearsal plus positive reinforcement; PP = positive practice; PP + R = positive practice plus reinforcement; DDdev. = developmental; freq. = frequency.

[a]Disability is reported per the studies cited. [b]The different intervention conditions in each study are designated by different numerals (e.g., in Conaghan et al., 1992, the treatment consisted of instruction in manual signs using directed rehearsal alone [Treatment 1 = T1] and in combination with positive reinforcement [Treatment 2 = T2]). The types of intervention are coded as described in the studies. [c]The total number of sessions is reported. If the sessions occurred in two or three sets (as in a multiple baseline across two or three sets of stimuli), the number of sets of sessions is indicated in parentheses (e.g., in the Barrett & Sisson study, there were a total of 87 sessions for J. in T1, grouped in two sets: one set of 75 sessions that targeted the first set of sentences and one set of 12 sessions that targeted the second set of sentences). [d]The gain scores represent approximate values because they were extrapolated from the graphic presentation of the data in the studies. Gain scores are reported separately for each application of the AAC intervention when the intervention was applied to more than one set of stimuli, as in a multiple-baseline-across-behaviors design, or when the treatment was replicated, as in an ABAB design. Gain scores are marked by an asterisk if there were ceiling effects. For example, in the Barrett & Sisson study, in T1 (TC), J. demonstrated an increase of 3 spoken words when the AAC intervention was applied to the first set of sentences and a gain of 1 spoken word when the AAC intervention was applied to the second set of sentences; ceiling effects were observed for both sets of sentences. [e]The percentage of structured opportunities with spontaneous speech was measured in each session with the participants. Gain scores are reported as a change in the percentage of opportunities with spontaneous speech, comparing the maximum point in baseline with the maximum point following AAC intervention.

the first 5 sessions). In the remaining 5 cases (21%), there was a lag between the initiation of AAC intervention and the observation of increases in speech production, ranging from 6 sessions to 25 or more sessions.

Discussion

The best evidence indicates that AAC interventions do not have a negative impact on speech production. All but 1 of the 17 participants (94%) in our review demonstrated increased speech production during or following at least one of the AAC interventions investigated. The remaining participant, a 36-year-old man with severe mental retardation and a mild bilateral hearing impairment ("T." in the study by Conaghan et al., 1992), showed no change in speech production in either of the two AAC interventions in which he participated (i.e., signs taught through directed rehearsal and signs taught through directed rehearsal plus positive reinforcement).

The positive effects of AAC intervention on speech production were observed across children and adults, ranging in age from 2 years to 60 years. These results are encouraging and suggest that speech gains may still be realized by individuals with developmental disabilities well past the critical early childhood years. Positive effects were also observed across a range of AAC intervention approaches, including highly structured, clinician-directed instruction grounded in behavioral theory and child-centered approaches implemented in play contexts. The facilitative effects on speech production were robust across different instructional approaches. The majority of the best evidence studies investigated the effects of unaided AAC (five of the six studies); only one study included aided AAC systems (without speech output). Future research is required to investigate the effects of aided AAC systems on speech production for children and adults with developmental disabilities. Given the limited number of participants in the studies, the wide variation in participant characteristics and AAC interventions, and the range of speech measures used, it is not possible to generalize the findings of the studies to the population of individuals who require AAC. Considerably more research is required to determine what factors may best predict gains in speech production as a result of AAC interventions.

Most of the speech gains observed were modest ones when considered in absolute terms. The mean gain for the studies that provided the best evidence was an increase of 13 words (range = 1–52 words) and an increase of 6 spoken two-word phrases (range = 4–7 two-word phrases). It is important to note that AAC interventions are typically implemented to build communication and language skills through a range of modalities (including signs and aided AAC systems as well as natural speech), rather than to increase speech production alone. To date, there is limited evidence to determine whether AAC interventions are the most effective means to increase speech production if this is the primary goal of intervention. Future research is needed to determine the comparative effectiveness and efficiency of interventions to promote speech production. There is evidence, however, to support the conclusion that AAC enhances communicative competence and language skills (Light et al., 1999) and has at least modest benefits for increases in speech production.

There are a number of possible factors that may account for the modest gains in speech production that were observed: (a) the characteristics of the participants (12 of the 17 participants were 5 years old or older, 6 had hearing impairments, and many had significant cognitive impairments); (b) the relatively short duration of the AAC interventions (mean of 42 sessions); (c) the limited corpus of words targeted in intervention; and/or (d) the ceiling effects observed in the speech measures after AAC intervention.

Although the speech gains were modest ones when considered in absolute terms, these gains should also be considered in relative terms, specifically in the context of the total number of words introduced through the AAC interventions as well as in the context of the number of words in the participants' repertoires prior to the AAC interventions. In four of the six studies, the data on speech production were collected exclusively within structured naming tasks; in these studies, only a limited number of words were introduced and gain scores were constrained by the number of trials (words or phrases targeted). Ceiling effects were observed in the speech production data collected during or after the AAC intervention in 17 of the 27 cases; in these cases, the participants learned 100% of the spoken words or phrases that were introduced through AAC intervention. When considered in this context, the gain scores are impressive. Given the ceiling effects observed, the gains reported might underrepresent the effects of AAC intervention on speech production. In fact, the largest gains in speech production were recorded in the study by Kouri (1988), in which data on speech production were collected during free-play interactions and were, thus, unconstrained by ceiling effects. In the 3 cases in this study, the gains in speech production after AAC intervention ranged from 10 words to greater than 50 words.

The speech gains should also be considered in light of the number of words in the repertoires of the participants at baseline prior to AAC intervention (Schlosser, 2003). For example, Kouri (1988) reported that the 3 participants in her study (J.S., T.A., and B.V.) had very limited speech repertoires prior to AAC intervention (0, 3–5, and 8 spoken words, respectively); their repertoires were 4 to 10 times greater after the AAC interventions (gains of 10, 20, and 52 spoken words, respectively). These gains are impressive, particularly given the relatively short duration of the AAC intervention (17–25 sessions). Unfortunately, most of the studies provide limited data on the participants' speech repertoires preintervention, limiting this type of analysis.

The best evidence analysis also suggests that, in some cases, the initial introduction of an AAC intervention may not have resulted in immediate gains in speech production; in 21% of the cases, there was a lag between the onset of AAC intervention and evidence of gains in speech production. It has been argued that AAC intervention may allow individuals with developmental disabilities to bypass the motor and cognitive demands of speech production and focus on building communication and language skills instead; after individuals establish basic communication and language skills, they may be better able to reallocate resources to improve their speech productions (Romski & Sevcik, 1996). This theory would predict a delay in speech gains following the initiation of AAC intervention, as was observed for some of the cases in the best evidence review. The lag in speech gains may also be explained by the initial learning demands imposed by the AAC systems. It may be that some individuals with developmental disabilities must focus on mastering the operational demands of AAC during the early stages of AAC intervention (e.g., producing the correct hand shape, position, orientation, and movement of the sign; selecting the correct graphic symbol; Blischak, 2003; Light, 1989, 2003); speech gains may only be realized after these operational skills are learned and resources can be reallocated to speech production. This latency effect is important to note because it causes an overlap in the data in baseline and treatment phases, decreasing the level of PND. The effectiveness of the AAC intervention in increasing speech production may be underestimated.

For most of the participants in the best evidence analysis, however, the gains in speech production were observed shortly after the introduction of the AAC intervention. These cases argue against resource allocation as a theoretical explanation of the facilitative effects of AAC. Instead, the data in these cases better support the theory of automatic reinforcement, which suggests that if AAC is presented along with speech and followed by a reinforcer, both AAC and natural speech should increase in frequency. Future research is needed to better delineate the theoretical mechanism(s) that account for the facilitative effects of AAC on speech production for individuals with developmental delay.

Implications for Practice

The results of the best evidence analysis should assuage the fears of parents and professionals about the potential negative impact of AAC intervention on speech production. Clinicians and parents should not hesitate to introduce AAC interventions to individuals with developmental disabilities whose speech is inadequate to meet their communication needs. AAC intervention has significant benefits in the development of communicative competence and language skills; the present best evidence analysis provides data that suggest AAC interventions can also have positive benefits for natural speech production. Too often, AAC is pursued as a last resort with individuals with developmental disabilities for fear that AAC will inhibit the development of speech. Frequently, clinicians perceive that they must make an "either–or" decision: either pursue the development of natural speech or introduce AAC (Beukelman, 1987). This review provides empirical evidence to support the counterargument that AAC intervention facilitates the production of natural speech. This evidence, coupled with the existing evidence that AAC interventions support the development of communicative competence and language skills, provides a strong case for implementing AAC with individuals with developmental disabilities who are unable to meet their communication needs through natural speech.

Results of the best evidence analysis also suggest that clinicians and parents should not be concerned if increases in speech production do not occur immediately after initiation of the AAC intervention; in 21% of the cases reviewed, speech gains were observed after a lag of 6–25 sessions. In keeping with evidence-based practices and outcomes measurement, clinicians should carefully monitor the effectiveness of AAC interventions with individual clients to determine the effects on communicative competence, social interaction, language skills, and speech production.

Limitations of the Research

The results of this best evidence analysis provide important preliminary empirically based evidence to guide parents and professionals in decision making regarding AAC interventions. However, there are a number of limitations to this best evidence analysis that must be considered in interpreting and applying the results.

None of the studies had the primary goal of determining the impact of AAC on speech development. As a result, some of the studies (outside the best evidence analysis) did not establish experimental control with respect to these variables and failed to establish the reliability of the speech measures and treatment integrity. It was not possible to draw reliable conclusions about the impact of AAC on natural speech for some of the studies; the certainty of evidence was inconclusive.

Six of the 23 studies had sufficient methodological rigor to support conclusions regarding the effect of AAC on speech production. These studies involved a total of

17 participants, with a total of 27 treatment cases. Almost all of the participants in the studies had mental retardation, developmental delays, or autism; hence, they represented only one subset of the diverse population of individuals who require AAC. Furthermore, variation in the participants' speech production and intelligibility was not clearly defined in most studies. These limitations make it difficult to generalize results to others who require AAC.

The current review included studies published between 1975 and 2003; however, only 11 of the 23 studies that met the criteria for inclusion were published since 1990. Furthermore, only 2 of the 6 studies included in the best evidence analysis were published after 1990. There have been significant advances in AAC systems and practices since this time. Some of the studies included in the review used intervention approaches that would not be considered current best practices. Speech outcomes may differ when AAC interventions that use best practices are implemented.

Most of the studies in the best evidence analysis implemented unaided AAC systems (i.e., manual signs). Results may not generalize to interventions implementing aided systems (with speech output) because these systems impose different learning demands. Although all of the studies provided AAC interventions, they used different instructional procedures to teach AAC. Of the studies that provided the best evidence, only two investigated AAC that was taught through child-centered intervention in a play context. The other four studies used highly structured instruction that was based on behavioral theory; each of these four studies used different types of instructional procedures (e.g., positive practice alone or in combination with positive reinforcement [Linton & Singh, 1984], directed rehearsal with and without positive reinforcement [Conaghan et al., 1992]). Given the small number of studies analyzed and the diversity of instructional techniques used, it is not possible to draw precise conclusions regarding the relative effectiveness or efficiency of various approaches to instruction in AAC. Some instructional methods may be more advantageous for specific populations in enhancing communicative competence, language development, and speech production.

The speech gains reported in the best evidence analysis were based on visual inspection of the graphs provided in the studies and many of these graphs were small in scale. As a result, it was necessary to estimate the values of specific data points. Furthermore, in more than half the cases, ceiling effects were observed in the speech measures, making it difficult to draw reliable conclusions about the extent of the impact of AAC intervention on speech production. Most of the studies only collected data for a limited corpus of words or phrases within structured naming tasks; only the study by Kouri (1988) collected data within communicative interactions in play contexts but these were conducted within a clinic setting. None of the studies investigated the generalization of speech gains to functional use in the natural environment.

Future Directions

Future research is urgently needed to more clearly delineate the relationship between AAC intervention and natural speech production. To establish the certainty of the evidence, this research should be designed with sufficient methodological rigor to establish experimental control, ensure the reliability of the dependent measures of speech production, and ensure the integrity of the AAC interventions. Furthermore, the studies should clearly document participant characteristics (e.g., cognition, language comprehension, speech production, intelligibility) and AAC intervention procedures. Systematic research is needed to determine participant characteristics that may positively or negatively influence the development of natural speech; for example, individuals with severe hearing impairments or cognitive deficits may be limited in the development of speech. Specifically, research studies are needed (a) to investigate the effects of various types of AAC systems (i.e., unaided systems, nonelectronic aided systems, electronic systems with speech output) and various instructional approaches on speech production, (b) to determine the impact on individuals of various ages with a range of developmental disabilities, (c) to identify factors that may influence the effects of AAC intervention on speech production, (d) to evaluate the extent of generalization of speech gains to functional use in real-world situations, and (e) to document the long-term effects of AAC on speech production over an extended time period.

AAC offers significant benefits for individuals with developmental disabilities in terms of enhancing communicative competence and promoting language development. The present research review provides important preliminary evidence that AAC interventions do not inhibit speech production; instead, AAC may also support speech production.

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Appendix A. Journals searched.

Journal name
American Association for the Education of the Severely/Profoundly Handicapped
American Journal of Mental Deficiency
American Journal of Speech-Language Pathology
American Journal of Mental Retardation
Analysis and Intervention in Developmental Disabilities
Aphasiology
Applied Psycholinguistics
Applied Research in Mental Retardation
Assistive Technology
Augmentative and Alternative Communication
Australia and New Zealand Journal of Developmental Disabilities
Australia Journal of Human Communication Disorders
Behavior Modification
British Journal of Disorders of Communication
British Journal of Developmental Disabilities
British Journal of Mental Subnormality
Education and Training in Mental Retardation
Education and Training of the Mentally Retarded
Education and Treatment of Children
European Journal of Communication
European Journal of Disorders of Communication
Exceptional Children
Exceptionality
International Journal of Language and Communication Disorders
Journal of Applied Behavior Analysis
Journal of the Association for Persons with Severe Handicaps
Journal of the Association for the Severely Handicapped
Journal of Autism and Childhood Schizophrenia
Journal of Autism and Developmental Disorders
Journal of Behavioral Education
Journal of Childhood Communication Disorders
Journal of Communication Disorders
Journal of Experimental Child Psychology
Journal of Intellectual Disability Research
Journal of Mental Deficiency Research
Journal of Psycholinguistic Research
Journal of Special Education
Journal of Special Education Technology
Journal of Speech and Hearing Disorders
Journal of Speech and Hearing Research
Journal of Speech, Language, and Hearing Research
Language, Speech, and Hearing Services in Schools
Mental Handicap Research
Mental Retardation
Remedial and Special Education
Research in Developmental Disabilities
Sign Language Studies
Topics in Early Childhood Special Education

Appendix B. Operational definitions for coding the studies.

Coding category	Operational definition
Study identification	Record the authors of the study and the year that the study was published.
Goal of the study	Record the goals of the study according to the following categories: (a) teach single-word vocabulary; (b) teach two or more word combinations; (c) teach specific communicative function or intent (e.g., request, comment); (d) other (i.e., the goal of the study was other than those listed).
Design of the study	For single-participant designs, record the design of the study according to the descriptions by Barlow and Hersen (1984) and Kearns (1986): (a) single-participant, alternating treatments design; (b) single-participant, multiple-probe or multiple-baseline design (across participants, behaviors, stimuli, or settings); (c) single-participant withdrawal design; (d) descriptive case study; (e) other (i.e., a design other than those listed; if so, specify the design). For group designs, record the design of the study according to the descriptions by Ventry and Schiavetti (1986): (a) one group pretest–posttest; (b) randomized pretest–posttest control group; (c) Solomon randomized four-group design; (d) static-group comparison; (e) nonequivalent control group; (f) time series; (g) other (i.e., a design other than those listed; if so, specify the design).
Participants	
Identification	Record the letter(s) or numbers used in the study to identify each participant.
Gender	Record the participant's gender as reported by the authors.
Disability	Record the primary disability reported for each participant separately, using the terminology of the authors: mental retardation, autism, developmental delay, cerebral palsy, developmental apraxia, or other. List any associated impairments listed by the authors: hearing impairment, visual impairment, behavior disorder.
Age	Record the chronological age of each participant in years (and months) as reported by the authors.
AAC intervention	
AAC systems	Record all of the types of AAC system(s) used in the intervention according to the following categories: (a) unaided AAC systems (i.e., communication modes that use only the communicator's body, such as manual signs); (b) aided AAC systems with speech output (i.e., electronic AAC systems that produce either digitized or synthesized speech output); and/or (c) aided AAC systems without speech output (i.e., nonelectronic AAC systems such as communication boards, communication books, or other forms of graphic symbols).
Treatment condition	Record the treatment condition as described by the authors. Code if the intervention involves: (a) structured, clinician-directed trials; (b) client-centered play or other daily activities; (c) other (if so, specify).
Sessions	Record the number of sessions as reported by the authors or illustrated on the graphs provided. If the sessions occurred in two or three sets (as in a multiple baseline across two or three sets of stimuli), the number of sets of sessions is indicated in parentheses.
Outcomes	
Effect of AAC intervention	Calculate the effect of AAC intervention on speech production using the data provided in the study. For single-participant experimental designs, report the percentage of nonoverlapping data (PND; Scruggs et al., 1987). Calculate the PND by dividing the total number of data points in intervention that do not overlap the data points in baseline by the total number of data points in intervention and multiplying by 100. Code the PND for each participant in each single-participant design separately according to the procedures established by Schlosser and Lee (2000). If participants were involved in more than one treatment (as in an alternating treatments design), code the PND for the individual treatments as separate cases for each participant. When participants were involved in more than one application of the same AAC intervention (e.g., as in a multiple baseline across behaviors design where the same AAC intervention was applied across several sets of stimuli or in an ABAB withdrawal design), the researchers reported the mean PND of the AAC intervention across the applications according to the procedures suggested by Scruggs et al. (1987). Do not calculate PND in an alternating treatment design when the ''more effective'' treatment is applied to the "less effective" treatment condition in a C phase because the effects of AAC on speech production cannot be reliably determined for this C phase because of the confounding effects of the intervening, less effective treatment condition. For group designs, calculate the effect size. This is determined by calculating the difference between the two group means (the control group and the experimental group) and dividing by the control group's standard deviation (Kazdin, 2003). Report "not possible to calculate" if there are not sufficient data available to calculate the effect of AAC intervention on speech production.
Changes in speech production	Calculate the increases, decreases, or lack of change in speech production based on the data provided in the study using the following formula: subtract the maximum point at baseline (prior to AAC intervention) from the maximum point during or following AAC intervention. Quantify the change in speech production using the unit of measure observed in each study (e.g., 5 spoken words). Report the changes in speech production separately for each application of an AAC intervention. Indicate that it is not possible to calculate changes in speech production reliably if the study is so flawed methodologically that the evidence is inconclusive.

Appendix B (p. 2 of 3). Operational definitions for coding the studies.

Coding category	Operational definition
Certainty of evidence	Code each study as to the certainty of evidence that it provides with respect to the relationship between AAC intervention (as the independent variable) and speech production (as a dependent variable). Use the following coding categories based on N. L. Smith (1991) and Simeonsson & Bailey (1995): (a) conclusive evidence (i.e., the study has a strong design with adequate or better procedural reliability and reliability of the speech measures; the speech outcomes observed are undoubtedly the result of the AAC intervention); (b) preponderant evidence (i.e., the study has only minor flaws in the design with adequate or better procedural reliability and reliability of the speech measures; speech outcomes are not only possible but they are more likely to have occurred as a result of the AAC intervention than not); (c) suggestive evidence (i.e., the study has minor design flaws and inadequate procedural reliability or inadequate reliability of the speech measures; the speech outcomes are plausible as the result of the AAC intervention); or (d) inconclusive evidence (i.e., the study exhibits major design flaws and fails to establish experimental control; the study's flaws preclude any conclusions that speech outcomes are the result of AAC intervention).