

Examining the Effects of AAC Intervention on Oral Language in Children with Autism
Spectrum Disorders: A Systematic Review

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Abstract

This systematic review researched the efficacy of augmentative and alternative communication (AAC) in increasing oral communication in children with Autism Spectrum Disorder (ASD). It may be used to inform best practice when working with children with ASD. The search strategy reviewed medical, social science, and communication databases. Inclusionary criteria consisted of peer-reviewed, quantitative research published between 2007 and 2018 regarding children with ASD under the age of 18. The included studies used AAC interventions and measured spoken language outcomes. Exclusionary criteria consisted of research that studied only receptive language, only included participants without ASD, and publications in languages other than English. After conducting an initial database search with these criteria, a manual search was performed using references from the found articles. Results varied across studies. Although the trend demonstrates increases in verbal* language with AAC intervention, few studies show significance with statistical analysis. The studies indicate that additional factors, such as verbal communication at baseline, may affect outcomes. AAC use did not decrease verbal language. In terms of limitations, there were few randomized control trial designs, few study replications, and varied outcome measures. Based on the studies analyzed, implementation of AAC may increase the number of communicative acts, but may not reliably increase verbal language. The research to date on this subject is preliminary and does not account for extraneous factors. Therefore, further research is needed to understand the most effective implementation of AAC intervention to increase verbal language. Higher quality research in the form of randomized control trials, and the replication of studies to confirm results is necessary to inform evidence-based practice. The findings are consistent with those of previous systematic

* It must be noted that the term *verbal* is used interchangeably in the literature with *oral* or *spoken* language, therefore the authors of the current systematic review will do the same.

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reviews and meta analyses. Future considerations should include type of AAC, communicative act being measured, longitudinal studies, and increased use of formal measures.

Keywords: autism spectrum disorder, autism, ASD, augmentative and alternative communication, augmentative communication, assistive technology, verbal communication, speech development, verbal language development

Introduction

Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a disorder that affects communication and social skills in children and adults. ASD is a 'spectrum' because each individual presents differently with varying severities, making it difficult to diagnose and treat. Today, ASD encompasses autistic disorder, pervasive developmental disorder not otherwise specified (PDD-NOS), and Asperger syndrome (CDC, 2017b). The American Speech-Language-Hearing Association (ASHA, 2017c) has published a list of potential communicative signs of autism. They may include difficulty using gestures, following directions, having conversations, using appropriate social language and reasoning, reading, writing, and reduced receptive and expressive language. Resulting communication breakdowns may lead to negative outbursts or other challenging behaviors. Difficulty exhibiting appropriate social skills manifests in trouble playing with others, understanding others' feelings, and making friends. Additionally, children with autism may have difficulty transitioning between activities, be more sensitive to sounds or food, or become fixated on a particular topic or object (ASHA, 2017c). The National Autism Association (2017) reports that around 40% of children with ASD are nonverbal. The cause of autism is not definite, but could be related to genetic problems, severe infections (e.g., meningitis, encephalitis), or problems related to the pregnancy (ASHA, 2017c).

Diagnosis. Autism may be diagnosed by a team of professionals, such as an occupational therapist, physical therapist, speech-language pathologist, developmental specialist, and a doctor (ASHA, 2017b). Children should receive developmental screenings during routine doctor visits, which is an observation of behavioral and developmental skills. If any signs are present, the doctor may recommend a comprehensive diagnostic evaluation, and the child may be referred to

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a professional who specializes in ASD, such as a developmental pediatrician, child neurologist, or child psychologist or psychiatrist (CDC, 2017c). Screening tools may include the Ages and Stages Questionnaire (ASQ), the Communication and Symbolic Behavior Scales (CSBS), the Parents' Evaluation of Developmental Status (PEDS), the Modified Checklist for Autism in Toddlers (MCHAT), or the Screening Tool for Autism in Toddlers and Young Children (STAT). Diagnostic tools include the Autism Diagnosis Interview – Revised (ADI-R), the Autism Diagnostic Observation Schedule – Generic (ADOS-G), the Childhood Autism Rating Scale (CARS), or the Gilliam Autism Rating Scale – Second Edition (GARS-2; CDC, 2017d). The Centers for Disease Control and Prevention (CDC; 2017a) reports that about one out of 68 children have ASD, based on a survey conducted in 2012. This is a 123% increase since 2002, in which one out of 110 children were reported to have ASD. Additionally, the CDC found that ASD is 4.5 times more prevalent among boys than girls, and that there is a higher prevalence among white children in comparison to black or Hispanic children. However, this finding may be related to black and Hispanic children being less likely to receive an evaluation for developmental concerns. Most children are diagnosed after the age of 4, although it is possible to diagnose at age two (CDC, 2017a).

Interventions. Various interventions have been discussed regarding the enhancement of communication in children with ASD. Many researchers agree that early intervention from ages birth to three years old is vital to success (National Autism Association, 2017; ASHA, 2017b; CDC, 2017b). Brunner and Seung (2009) conducted a literature review discussing the efficacy of the available treatments. Applied behavior analysis (ABA) is one method, in which children are taught to engage in positive behaviors rather than negative ones (Brunner & Seung, 2009). ABA includes discrete trial training, which systematically analyzes a clear antecedent and its following

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consequence (ASHA, 2017b). Additional approaches include naturalistic behavioral methods, such as milieu teaching, functional communication training (FCT), and pivotal response training (PRT). Brunner and Seung (2009) describe these approaches as having been developed due to “limitations of ABA and discrete trial training” (p. 17). Milieu teaching includes incidental teaching in natural contexts, the mand model, which models a request for the child, and time delay, which inserts time between presenting a desirable stimulus and adult prompting, so that the child has time to request independently. Functional communication training targets behaviors such as tantrums or aggression by teaching behaviors to replace these (Brunner & Seung 2009). Pivotal Response Training uses play-based natural reinforcement to “teach language, decrease disruptive behaviors, and increase social, communication, and academic skills” (ASHA, 2017b, Behavioral Interventions/Techniques section, para. 9).

Developmental Interventions. Developmental interventions have also been used with children with ASD. These include floortime techniques, the Hanen approach, and the social communication, emotional regulation, and Transactional Support (SCERTS) model. Parent training is a key piece of developmental interventions. All forms of child communicative attempts are seen as purposeful (Brunner & Seung, 2009). The floortime technique utilizes a child’s senses and emotions while encouraging parent-child interaction in play while following the child’s lead. The Hanen approach includes *More Than Words* and *Talkability*, both of which are parent-directed and assist with social skills. Transactional Support targets goals based on the child’s social, emotional and communication development (ASHA, 2017b).

Classroom-Based Interventions. Classroom-based interventions are also utilized in communication intervention of children with autism. These include Project DATA (Developmentally Appropriate Treatment for Autism) and TEACCH (Treatment and Education

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of Autistic and Related Communication-Handicapped Children). Project DATA is used with young children, and incorporates elements from both behavioral and developmental models, including ABA. Children are given the intervention they need while being part of an inclusive classroom (Schwartz, Sandall, McBride, & Boulware, 2004 as cited in Brunner & Seung, 2009). The TEACCH model emphasizes visual aids, and incorporates functional communication and augmentative and alternative approaches (Brunner & Seung, 2009).

Video modeling is another intervention approach that models desired behaviors in a video to reduce anxieties and distractions that may be prevalent in an in-person modeling scenario. Other interventions target social skills, which include social skills training, social stories, and peer/sibling training. Social skills training includes “perspective taking, conversational skills, problem solving, emotional awareness and regulation, and the unwritten rules of social engagement” (Barnhill, 2002 as cited in Brunner & Seung, 2009). Social stories are written stories to help children with ASD navigate specific situations in their lives. Peer/sibling training involves the teaching of peers to support social interactions with children with autism (Brunner & Seung, 2009).

Augmentative and Alternative Communication. For individuals with complex communication needs (CCNs), including those with ASD, devising an effective communication system is essential for them to develop and interact with the world around them. Augmentative and alternative communication (AAC) is a non-verbal method for individuals with CCNs to access communication. According to Beukelman and Mirenda (2013), the goal of AAC is to facilitate participation in preferred activities. According to Light (1989), AAC strives to increase participation by supporting language development and communicative competence in four domains of communicative competence: linguistic, operational, social, and strategic (as cited in

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Light, Binger, Agate, & Ramsay, 1999). The linguistic domain refers to the semantic and syntactic systems of the language that is being communicated, as well as the linguistic organization of the AAC system itself. The operational domain is the ability to navigate the AAC system using technical skills. The social domain encompasses social communication and the knowledge of the unwritten rules that communicators follow when interacting with each other in various situations. Finally, the strategic domain includes the skills to compensate for areas of weakness in the other three domains.

For individuals with CCNs, the AAC system must be highly individualized to the person's needs and lifestyle. There are two broad classes of AAC: unaided and aided. Unaided AAC systems do not rely on external materials. An individual may use gesture, facial expressions, body language, manual signs, and sign language (ASHA, 2017a). Aided AAC relies on an external tool or device to facilitate communication. This may be as simple as a pen and paper, or as complex as a computer device with specifically designed language software. According to Brunner and Seung (2008) and van der Meer & Rispoli (2010), AAC as an effective intervention for individuals with autism.

The Picture Exchange Communication System (PECS) is one form of aided AAC that has been widely discussed by researchers and interventionists. PECS involves the exchange of picture cards for desired outcomes. This highly structured intervention is taught in phases which increase in complexity and are mastered step-by-step.

Another widely used aided AAC system is an electronic device. Electronic AAC systems may be referred to as either a voice output communication aid (VOCA) or a speech generating device (SGD). The term SGD has been used with increasing frequency over the past 10 years, and will therefore be the term that is used throughout the duration of this systematic review.

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SGDs come in a variety of formats, ranging from simple static pages with buttons that emit a personalized recording when activated, to high-tech dynamic screens with expansive core vocabularies that can be used to create flexible phrases. SGDs have been utilized in communication interventions for people with ASD since the 1980s (van der Meer & Rispoli, 2010). A variety of communication skills have been targeted with these interventions, including increasing the amount of verbal speech produced, requesting, and commenting (van der Meer & Rispoli, 2010).

Concerns

There is a widely-believed concern among parents, educators, and health care professionals that AAC may hinder the speech and language development of individuals with CCNs. The belief is that individuals who are exposed to and taught AAC may no longer be motivated to communicate verbally. However, studies have continuously indicated that the implementation of an AAC system does not negatively impact language development (van der Meer & Rispoli, 2010; Schlosser & Wendt, 2008). Even so, there has been limited evidence up until this point that suggests that using AAC will improve language development.

Objective

Although there have been research reviews that report on AAC intervention to improve verbal language, there are few systematic reviews conducted after the release of the Apple iPad, when high-tech AAC systems became more available. Therefore, a systematic review to consolidate research that is more current and relevant to this technological era was needed. That being said, other aided forms of AAC (such as the lite-tech PECS) were not excluded from this paper, as the authors looked to compare various forms of aided AAC. This systematic review was conducted with the hopes of synthesizing peer-reviewed research regarding the verbal

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language development of children with ASD who use aided AAC systems. The authors aimed to find evidence to support that verbal language development may increase with the implementation of an AAC system. Furthermore, they aimed to discover which aided AAC system was most effective in increasing verbal language output.

This systematic review focuses specifically on the effectiveness of the aided AAC systems PECS and SGDs. This decision was based on the desire to study SGDs due to the relatively recent widespread availability of technological devices, such as iPads and tablets. Additionally, the authors discovered in their review that much of the research conducted to date consisted of an analysis of PECS.

Methods

Sources

The authors searched the databases PsychInfo, ComDisDome, Campbell, Cochrane, CINAHL, Google Scholar, Linguistics and Language Behavior, Ovid Medline, PubMed, TRIP and Web of Science. The year of publication for selected research ranged from 2006-2016. The search dates ranged between October 30th, 2017 through November 13th, 2017. Source restrictions included articles published within the past 10 years, articles written in English, and articles published in peer reviewed journals. Terms used in the literature search included keywords relating to Autism Spectrum Disorder, verbal language development, and alternative and augmentative communication intervention. See Table 1 on the following page for a detailed list of search terms and Table 2 for an example of the authors' search strategy using the database PsychInfo.

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Table 1

Search Terms Utilized According to Key Concepts

Children with Autism Spectrum Disorder	Augmentative and Alternative Communication	Verbal Language Development
Autis* Spectrum Disorder	Augmentative and Alternative Communication	Verbal Communication
Autis*	Augmentative Communication	Speech Development
ASD	Assistive Technology	Verbal Language Development

Table 2

Search Strategy Protocol Example

PsychInfo Search Strategy

Steps	Search Terms	Results
Used search terms to create boolean sentence	(Autis* Spectrum Disorder OR ASD OR Autis*) AND (Verbal Communication OR Speech Development OR Verbal Language Development OR Verbal Development) AND (Augmentative Communication OR Augmentative AND Alternative Communication OR Assistive Technology)	188
Applied inclusionary and exclusionary criteria	Date Range: 2007-2017 Age Group: Childhood (birth-12); School Age (6-12); Preschool (2-5); Adolescence (13-17) Infancy (2-23 months) Peer Reviewed Articles EXCLUDE "Interview, Qualitative Study" EXCLUDE "German, French"	46

After the initial database search, authors combed through reference lists from selected articles to conduct a manual search in March 2018.

Selection

A study had to contain the following inclusion criteria to be included in this systematic review: Intervention targeting expressive verbal language with children ages birth – 17 years and 11 months, with an official diagnosis of Autism Spectrum Disorder made by a medical professional. A study was excluded from this systematic review if it included participants who were over 18 years old, was a qualitative study, or used interventions which targeted receptive language only. See Table 3 on page 14 for detailed inclusionary and exclusionary criteria.

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Table 3

Inclusionary and Exclusionary Criteria

Criteria	Date Range	Age Group	Population	Language	Types of study	Intervention	Outcomes
Inclusionary	2007-2018	0-17 years old	Autism Spectrum Disorder (ASD)	English	Peer-reviewed, Quantitative	Aided AAC	Verbal Expressive Communication
Exclusionary	Dates prior to 2007	Adults (18+)	No diagnosis of ASD	Languages other than English	Qualitative Studies	Unaided AAC (e.g., sign language), no AAC	Non-verbal communication, receptive language

Assessment of Articles

For each study included, one author proofread the abstract for measurements matching inclusion and exclusion criteria. If the inclusion and exclusion criteria were met by the abstract, the article was read by another author. Information in the article was coded according to population, outcome measures, and intervention. Questions about article inclusion arose from targeting an inappropriate population (i.e., children and adults), inappropriate outcome measures (i.e., receptive language, or expressive communication which was non-verbal) or usage of an inappropriate AAC system (i.e., unaided systems, such as sign language or gestural communication). While randomized control trial experiments are the most methodologically rigorous design, the authors included all types of experimental studies to gain a thorough overview of the literature. The data abstraction followed the same process. Interventions, outcome measurements, sample characteristics, and significance were identified. Any articles deemed inappropriate were not included in the review. Questions about article inclusion were resolved with unanimous agreement among the authors.

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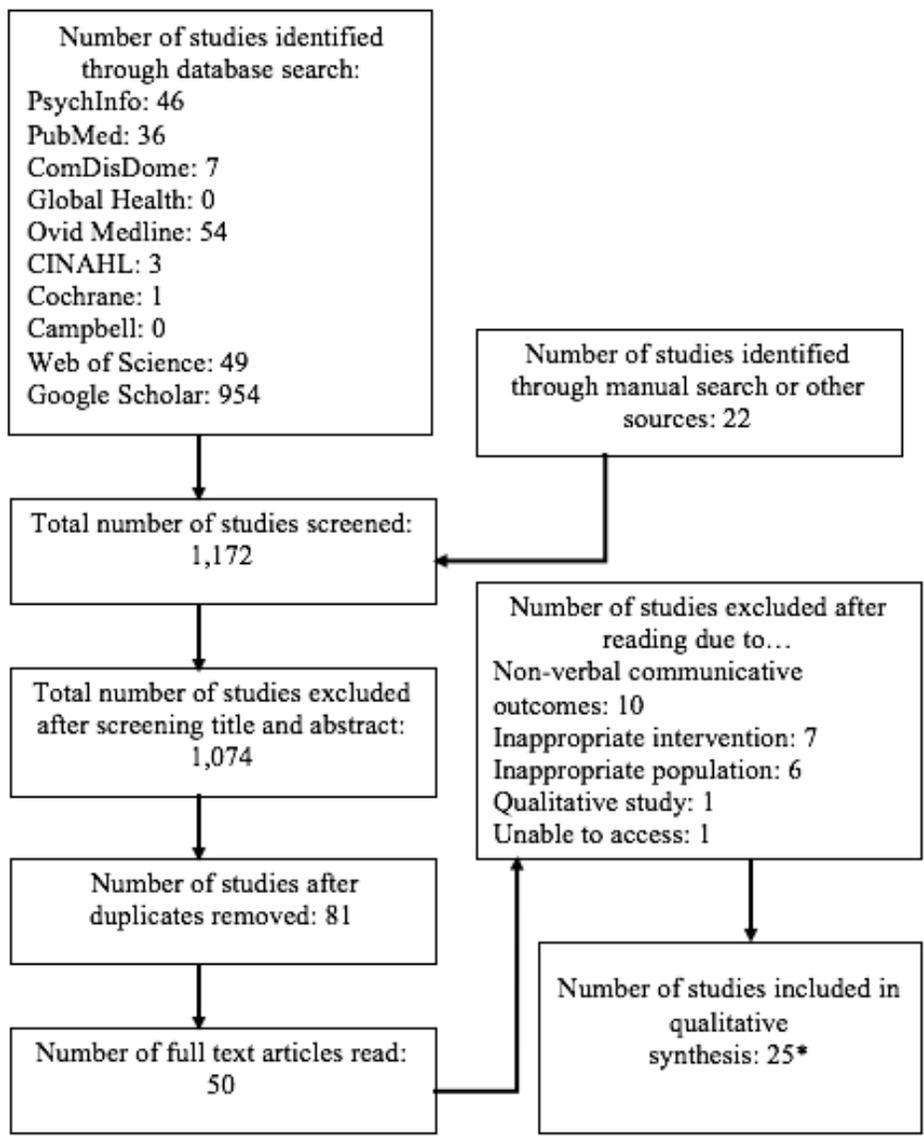
The authors then performed a quality analysis on all studies that met the inclusion criteria. The quality analysis was conducted using a protocol that rates studies based on rigor of methodology, interrater reliability, quality of outcome measures, and fidelity of intervention. Refer to Appendix A for the quality assessment protocol. Studies were rated on a quality level based on their design type. First, design type of each study was identified. Then, the study was rated on criteria specific to the study design. The quality level ranged from low (meeting 40% of criteria), to moderate (meeting 40% to 70% of criteria) to high (meeting 70% to 100% of criteria). Refer to Appendix B for the results of the quality of evidence.

Results

Summary of Included Research

After searching all identified databases, the authors found 1,150 research articles. An additional 22 articles were found through a manual search. All article titles and abstracts were screened for key terms and concepts to determine their relevance to the research question. Additionally, the titles and abstracts were scanned for inclusionary and exclusionary criteria. This screening resulted in 100 articles after 1074 were excluded. After the removal of 17 duplicates, the authors were left with 81 articles. 50 full-text articles were read, and additional studies were excluded due to non-verbal communicative outcomes (10), inappropriate intervention (7) or population (6), and a qualitative study (1). Examples of non-verbal outcomes were non-verbal expressive language or receptive language. Examples of inappropriate intervention included unaided AAC (such as sign language), social stories, or imitation therapy. Inappropriate populations included adults or children without ASD. Finally, there was one observational study that was not included due to its qualitative nature. Please refer to Figure 1 below for a diagram of this process and Appendix C for a descriptive list of the studies included.

Figure 1: Article Screening Flowchart



*Only 23 articles were analyzed as two of those found were literature reviews used exclusively for background information.

In addition to the studies listed in Appendix C, the authors included three meta analyses and two systematic reviews in their research. An overwhelming finding was that most studies conducted regarding AAC’s effectiveness in speech production for children with autism were single-subject designs. The research reviews analyzed these studies together and collect data

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such as mean weighted effect size, mean percentage of non-overlapping data (PND), and mean percentage exceeding median (PEM). A full list of meta analyses and systematic reviews can be found in Appendix D.

Appraisal of Outcome Measures

The research articles used a variety of outcome measures to quantitatively describe changes in the dependent variables. A description table of the outcome measures used in each study can be found in Appendix E. This table reports only on expressive and verbal language outcomes. It does not report on outcome measures quantifying additional information examined by research studies, such as social communication, general communicative behavior, and receptive language abilities. Both formal and informal means of collecting data were used.

Formal Outcome Measures. The formal outcome measures used by the studies were appraised for their validity and reliability. The Mullen Scales of Early Learning (MSEL) had an internal consistency above 0.80 for three subscales, while ‘visual reception’ had an internal consistency of 0.79 and ‘fine motor’ was 0.75. Test-retest reliability in two different instances was 0.80 and 0.70. The MSEL technical manual verified construct validity, concurrent validity, and criterion validity. Correlations of language scales with other tests were strong. Auditory comprehension yielded 0.85 for receptive language and 0.72 for expressive language. Verbal ability demonstrated a correlation of 0.72 for receptive language and 0.80 for expressive language (Statistics Solutions, 2017). When analyzing the reliability and validity of the MacArthur-Bates Communicative Development Inventory (CDI), The Brookes Publishing website states, “Numerous studies document the reliability and the validity of the instruments” (Paul H. Brookes Publishing Co., Inc., 2017, Is it valid and reliable section). Actual validity and reliability data was unable to be found. Vineland Adaptive Behavior Scale (VABS) was shown

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to have internal consistency of 0.83 to 0.90, test-retest reliability of 0.81 to 0.86, and interrater reliability of 0.62 to 0.78. VABS was described to have the following validity: intercorrelations, content, construct, and concurrent (compared to other adaptive behavior scales; Pearson Education, Inc., 2018b). Bessai (1997) indicates that the Expressive Vocabulary Test (EVT) has good content and construct validity. Additionally, median correlations with PPVT-III forms A and B of 0.79 and 0.77 demonstrate good discriminant and convergent validity. Test-retest reliability reported coefficients of .77 to .90, and split-half, corrected coefficients ranged from 0.83-0.97 (Bessai, 1997). The Expressive One-Word Picture Vocabulary Test, Revised (EOWPVT-R) was found to have high internal consistency reliability (median coefficient 0.90). Cizek (1995) discussed the issue that test-retest reliability information was missing. Criterion-related validity was calculated when comparing the EOWPVT-R to tests measuring similar skills, and moderate correlations were found (Cizek, 1995). The Receptive One-Word Picture Vocabulary Test (ROWPVT) was found to have a median reliability coefficient of 0.90 (range 0.81-0.93). Standard error of measurement (SEM) had a median of 3.33 (range 2.37-3.79). Validity data was unsupported, although the manual gave an average correlation coefficient of 0.42 when comparing the ROWPVT with related subtests of the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) and the Wechsler Intelligence Scale for Children, Revised (WISC-R; Dole, 1989). Scarborough (1990) analyzed Mean Length of Utterance (MLU) in an “Index of Productive Syntax” and found it to have high interscorer reliability, while content validity is questionable.

Informal Outcome Measures. Additionally, there were many informal outcome measures that assessed meaningful communicative acts across a variety of functions. Although there are no related reliability and validity data to these measures, they are important to mention

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as they were widely found across the research and often had face validity due to the relatedness of those communicative acts to the intervention targets. Measures included total number of spontaneous communicative utterances (TSCU); number of morphemes, verbalizations, vocalizations, words, word approximations, requests, comments, verbal mands, new words, communicative behaviors per minute. Additional measures included frequency of meaningful speech, imitated verbalizations, non-imitative spoken language, related speech, communicative turns, use of communication cards or gestures to communicate, and verbal initiations other than mands.

Interventions Delivered

All studies except one delivered either PECS intervention or SGD intervention. The remaining study used a picture communication system other than PECS. Additionally, two studies compared PECS and SGD interventions to each other. Other interventions included Joint Attention and Symbolic Play (JASP), Enhanced Milieu Teaching (EMT), Speech Generating Device (SGD), verbal modeling, peer mediated interventions, parent mediated interventions, Environmental Arrangement (EA), Mands, Mands/Comments using an AAC system (MAAC), models delivered by parents, models delivered by peers and Responsive Education and Prelinguistic Milieu Teaching (RPMT). A complete description of the interventions delivered in each study can be found in Appendix B.

Picture Exchange Communication System Intervention. Ten studies employing the PECS intervention were analyzed. These studies used both formal and informal outcome measures to quantify the development of verbal expression.

Formal outcome measures. Of the ten studies that explored PECS, one of them measured verbal language development with formal objective measurements. Schreibman and

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Stahmer (2014) compared PECS intervention with PRT and analyzed its effects on the use of verbal language with the MSEL, VABS, EOWPVT, and MacArthur Bates CDI. These standardized measures demonstrated statistically significant pre- to post-treatment improvement in language development among the participants. There was no statistical difference found between PECS and PRT, suggesting that both of these interventions are effective at improving verbal expression and that there is no clear advantage of using PECS over PRT.

Informal outcome measures. Many studies used event recording as a measurement system, a highly personalized and informal means of measuring changes in the dependent variables. Carson, Moosa, Theurer, and Cardy (2012) found mixed results with PECS intervention on increasing word approximations. One child increased word approximations only; the second child did not increase in word approximations or words; and the third child increased in sounds and words. Ganz, Heath, Rispoli, and Earles-Vollrath (2010) measured the frequency of imitated verbalizations and the frequency of related speech. Neither PECS nor the Verbal Modeling condition yielded increases in either of these measurements from pre- to post-test. Greenberg, Tomaino, and Charlop (2014) investigated the effects of PECS and PECS with verbal prompting on using vocalizations to request. With PECS training alone, three of four participants demonstrated increases in vocalizations from baseline. With the addition of verbal prompting, both of the subjects participating in this subsequent study increased the frequency of spontaneous vocalizations to request. Jurgens, Angelika, and Moore (2009) studied the effects of PECS on the frequency of verbal mands, verbal initiations other than mands, number of new words, and number of morphemes spoken. For all of these outcomes, verbal production increased with the PECS intervention, though statistical significance was not calculated. Nunes and Hanline (2007) studied the frequency of verbalizations/vocalizations as an effect of parent-implemented picture

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exchange intervention (not PECS) across various activities. No changes in vocal behavior were observed. Park, Alber-Morgan, and Cannella-Malone (2011) studied the frequency of words produced following PECS intervention when implemented by mothers. Only very slight increases in word production were noted in this study from baseline. Travis and Geiger (2010) examined PECS on multiple verbal outcomes which included frequency of word use for commenting and requesting, along with overall mean length of utterance (MLU). Increases were found in all three outcome measures, however, the statistical significance of these gains was not calculated. Finally, Yoder and Stone (2006) analyzed the effectiveness of RPMT versus PECS in the frequency of non-imitative verbalizations and the number of different non-imitative words. Results were analyzed immediately after treatment and at a 6-month follow-up. The Picture Exchange Communication System was shown to be significantly more effective for both outcome measures immediately after treatment, however there were no lasting effects at the 6-month follow-up, suggesting poor generalization and maintenance treatment effects.

Results summary. Generally, PECS has been shown to be effective at increasing verbalizations when analyzed by formal and informal measurements. However, these findings are inconsistent across the studies that were examined, regardless of whether a statistical analysis was performed. These inconsistencies are likely related to the small sample sizes and varying protocols used across studies. Additionally, the lack of statistical significance reporting decreases the validity of the conclusions made supporting the efficacy of PECS on increasing informal words and word approximation.

Speech Generating Device Intervention. Speech generating device intervention was studied in nine of the research articles. Among these studies, one used formal outcome measures

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and eight used informal observations to quantify the verbal development in children participating in the treatment protocol.

Formal outcome measures. Olive, Lang, and Davis (2008) analyzed the expressive language in children who received parent-implemented FCT using an SGD. This was measured with two standardized assessments: EOWPVT and the Expressive Vocabulary Test. Both of these measures indicated significant increases in expressive language due to intervention.

Informal outcome measures. Event recording was the more widely-used measurement tool among research studies. Almirall et al. (2016) measured the total number of spontaneous communicative utterances in children who had received JASP training, EMT, and SGD interventions. As compared to children who received JASP and EMT intervention without SGD, these interventions paired with the SGD demonstrated significant improvement in the number of spontaneous communicative utterances post-treatment. Gevarter et al. (2016) analyzed the effect of SGD intervention paired with verbal modeling on the frequency of vocalizations, initiations, vocal approximations, and full words. These behaviors were coded and analyzed among the individual participants. Three out of four children increased in their frequency of vocalizations. None of the participants increased initiations, and only one increased the frequency of vocal approximations and full words. King et al. (2014) observed the vocal requests made by children who were taught to use an SGD using the PECS protocol. From baseline, all three participants demonstrated increases in vocal requesting behavior. Olive et al. (2007), who studied the effects of SGD intervention combined with EMT on words and word approximations, found varied results, with only one of their three participants exhibiting an increase in these behaviors. Schlosser et al. (2007) studied the effects of SGD intervention with voice output versus without voice output. The total number of vocalizations increased from baseline in one out of five

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participants. Thunberg, Sandberg, and Ahlsen (2009) studied the use of an SGD in two different contexts in the home environment and its effects on the production of meaningful speech. The results varied among participants. The frequency of meaningful speech increased in both contexts for one participant, increased in one of the contexts and decreased in the other for the second participant, and decreased in both contexts for the third participant.

Results summary. Overall, the studies that were reviewed show highly varied results regarding SGD intervention on verbal language outcomes. Only two of the studies performed a statistical analysis to determine significance. Both of these found that SGD intervention was significantly effective in increasing verbal language compared to baseline and intervention without SGD. Of the remaining studies, six out of eight showed some language gains in their participants. However, the lack of data analysis makes it difficult to say whether these changes were significant and attributable to the SGD intervention.

Direct Comparisons of PECS and SGD Interventions. Two studies compared PECS and SGD interventions directly to determine whether there was a difference in language outcomes. Beck, Stoner, Bock, and Parton (2008) studied the effects of PECS versus SGD intervention on a variety of informal measures, including total number of utterances, percent intelligible utterances, percent spontaneous intelligible utterances, and total number of different words. Results varied for all outcome measures. There was no difference in total number of utterances between conditions, with two of four participants increasing utterances, and two of four decreasing utterances, in each condition. Percent intelligible utterances increased in two out of four participants (decreased in two) with PECS intervention, and increased in three out of four (decreased in one) for SGD intervention. The percent of spontaneous intelligible utterances increased in one participant and decreased in three with PECS intervention. For SGD

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intervention, three of four participants increased and one had the same percentage of intelligible utterances from baseline to post-test (100%). Finally, for total number of intelligible words, one of four increased (three decreased) with PECS intervention and three of four increased (one decreased) with SGD intervention.

Boesch, Wendt, Subramanian, and Hsu (2013) measured intentional communicative verbalizations of three children who had been exposed to SGD and PECS interventions. At post-test, there was no change in verbal language for either of the conditions. Statistical significance was not calculated between pre and post-intervention or between conditions. In addition to informal observations, the researchers also used a standardized measurement tool to assess language development. The MacArthur Bates Words and Gestures CDI is a parent questionnaire that was used to assess language development. The findings stated were not conclusive as some parents did not complete the form before and after the treatment intervention. For the children whose parents did complete the questionnaire, no changes in vocalizations were observed from pre to post-intervention. There was no statistical analysis performed on the information obtained.

Meta Analyses and Systematic Reviews

Three meta analyses reported on the verbal language outcomes in children with ASD who had been exposed to AAC intervention. Flippin, Reszka, and Watson (2010) stated that verbal language outcomes for PECS were variable across studies and that the effectiveness of this intervention for improving verbal language was “questionable” (p. 187). Ganz et al. (2012) and a subsequent study, Ganz et al. (2014) both reported that PECS and SGD interventions do improve verbal language in children with ASD more so than other picture-based interventions, however the effects were small to moderate. While the 2012 meta analysis showed no significant difference between PECS and SGDs, the 2014 analysis did show better results with SGDs.

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Additionally, the 2014 study stated that SGD intervention was most effective in subjects without comorbid intellectual disabilities. They also found that children with some speech at baseline had more positive speech outcomes post-treatment.

Two systematic reviews were found, as well. Preston and Carter (2009) reported little-to-no changes in verbal language with PECS intervention across the 27 articles that were analyzed. Schlosser and Wendt (2008) confidently reported that PECS intervention did not impede verbal language production, though the evidence suggesting improvements in verbal expression was minimal.

Quality Analysis

The studies reviewed include three meta analyses, two systematic reviews, two randomized control trials, and 16 single-case studies. The quality analysis revealed that 16 out of the 23 studies met the Level 4 evidence criteria, being that they were single-subject designs.

Strengths of the reviewed literature include quality level of the individual studies. Upon completion of the quality of evidence table (Appendix B), seven articles met the Level I criteria, which consisted of two randomized control studies, three meta analyses, and two systematic reviews. Level 1 represents the highest quality and methodological rigor. Of the seven Level 1 articles, three had a 'moderate' quality level and four had a 'high' quality level. The remaining 16 studies met the Level 4 criteria and consisted of single-subject designs. Although this indicates that the type of design was not high, the qualities of all Level 4 articles were analyzed to be 'high.'

Discussion

The research that was conducted in this systematic review was consolidated and analyzed. There was a variety of literature on the use of both PECS and SGDs as interventions

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for children with ASD. However, throughout the research process it became apparent that the quality of the results was negatively affected by a variety of factors, which are discussed in detail below.

Limitations in Reviewed Research

The results of the included literature demonstrate lack of strong methodological and statistical rigor. There was also a lack of standardized protocols across studies. Together, these limitations resulted in reduced generalizability and validity of results.

Methodological Rigor. There are several weaknesses present in the methodology of the reviewed studies. For example, there is a lack of statistical significance values which provide information on whether the null hypothesis is rejected or not rejected. This decreases the validity of the results and conclusions of many of the articles included in this review. Studies without significance values do not contribute strongly to evidence based practice and make information of treatment from empirical evidence difficult to achieve. One weakness is the use of mostly single-subject designs in the research. These do not permit researchers to make statements about the intervention being likely to have an effect on the outcomes. This decreases the validity of the results observed in these studies, and this review. An additional methodological weakness is the frequent use of informal measures. While informal measures such as event recording procedure have face validity because of the assigned operative definitions of measurement are valid, they lack other types of validity and reliability, which decreases the reliability and validity of the results of the studies.

Few studies discuss the role that the characteristics of participants, intervention, and environment might play on the measured outcomes. This may be due to the widely heterogeneous nature of the population that was being studied and the need to accommodate

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specific characteristics when providing intervention. It is well known that individuals with ASD may present with a huge variety of abilities. It is therefore necessary to relate subject characteristics to intervention outcomes in order to understand the effects that these characteristics have on intervention results.

Protocol Standardization. While study protocols were described with enough detail to be replicated, there are no standardized protocols for delivering SGD intervention, even when the same types of SGD were utilized. The lack of standardization in protocol decreases the generalizability of results and makes comparison of results across studies futile. When intervention protocols are different, determining success of an intervention or best practice is difficult.

Recommendations for Future Research

Experimental Design. There was only one longitudinal study conducted (Almirall et al., 2016) to examine the effects of AAC intervention, which included 24 weeks of intervention and a follow-up at 36 weeks. It is still unknown what the effects of time are on treatment outcomes. This supports the need for more communication among researchers to develop consistent goals for research studies (i.e., to examine the effects of length of treatment). While participants in some PECS intervention studies were given time to master all of the PECS levels being examined, many had a set timeline for their data recording of just a few months. Participants in the SGD intervention studies were also given a limited amount of time with their AAC device. The relatively short length of the studies may not have been substantial in providing treatment, or for examining language outcomes once AAC systems were mastered

Due to the lack of methodologically rigorous designs, it would be beneficial for future studies to include randomized controlled trials (RCTs) to provide more substantial evidence and

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significance data of the efficacy of aided AAC when working with verbal communication of children with autism. Additionally, this would allow for further systematic reviews to assist in guidance of treatment. Replication of methodologically strong studies would also increase the validity and reliability of the observed results and provide more information about treatment efficacy.

Protocol Standardization. The collection of studies in this systematic review indicate the need for more standardized protocols of intervention. While the individual articles adequately describe intervention protocols and generally are of good methodological quality, there are few commonalities between studies that build off previous research. By building off of previous research designs, researchers might be able to develop a more standardized protocol for administering AAC interventions. Furthermore, by studying the effects of intervention on specific subject characteristics, researchers may advance the knowledge base of how specific intervention approaches may develop the language skills in children who present with a variety of abilities.

Analysis of Subject Characteristics. Additionally, children in each study had varied characteristics at the baseline, such as severity of ASD, communication environment, whether the participants had already acquired the communicative function being studied in some other non-verbal form, the familiarity of the examiner or communication partner, joint attention level, and level of verbal output. A discussion of the relationship between these characteristics and their potential effects on the outcomes was rarely addressed in the studies. However, it is necessary to identify these characteristics in the context of methodologically rigorous studies in order to determine whether or not these characteristics interact with the intervention and affect the outcomes.

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Clinical Implications. The studies were varied in their methods, did not demonstrate reliable change post-intervention, and results were minimally valid and generalizable. These factors are too variable for the authors to determine in which way they may have affected the study outcomes. Therefore, it would be difficult to conclude which intervention would be most successful when working with children with autism to support their verbal communication. Because these studies provide limited evidence as to the efficacy of using AAC to enhance verbal communication in children with autism, it is difficult to draw any clinical inferences when working with children with autism. The only consistent finding in the current review is that the use of AAC consistently did not negatively impact verbal communication as compared with baseline. This, however, does not provide clinical significance to the use of the intervention to positively impact verbal communication.

Strengths and Limitations of the Current Study

This systematic review had a number of strengths. First, the authors began with a broad search strategy to capture all related studies before narrowing down the scope of the review. This strategy was inclusive of all diagnoses of ASD and broad communication criteria to examine all types of verbal communication. It also included a broad definition of AAC to acquire as much information as possible, which originally incorporated both aided and unaided AAC (such as sign language and gestures). Eventually, the authors narrowed the criteria when screening the articles found, to only discuss aided AAC and expressive verbal outcomes. A weakness of this systematic review was the narrowed population. Since the authors looked solely at ASD, this prevented a wider discussion of other populations' outcomes whose verbal expression could also benefit from AAC.

Conclusion

Lack of clinical and statistical significance in the studies conducted up until this point indicate that there is not enough evidence to support the implementation of AAC for improvement of oral language development in children with Autism Spectrum Disorder. At this time, no definitive recommendation for use of this intervention can be made based on available evidence. However, this is largely due to the lack of standardized protocol, the ways in which subject characteristics could affect outcomes, and limited RCTs. Despite the lack of statistically significant evidence, the studies do demonstrate an overall trend of increased verbal communication from baseline to posttest. At this time, no conclusions can be made stating whether high or lite tech AAC options result in better outcomes.

References

- Almirall, D., DiStefano, C., Chang, Y.-C., Shire, S., Kaiser, A., Lu, X., ... Kasari, C. (2016). Longitudinal effects of adaptive interventions with a speech-generating device in minimally verbal children With ASD. *Journal of Clinical Child and Adolescent Psychology*, 45(4), 442–456. <https://doi.org/10.1080/15374416.2016.1138407>
- American Speech-Language-Hearing Association (2017a). *Augmentative and alternative communication*. Retrieved from <https://www.asha.org/public/speech/disorders/AAC/>
- American Speech-Language-Hearing Association. (2017b). *Autism*. Retrieved from <https://www.asha.org/PRPSpecificTopic.aspx?folderid=8589935303§ion=Treatment>
- American Speech-Language-Hearing Association. (2017c). *Autism (autism spectrum disorder)*. Retrieved from <https://www.asha.org/public/speech/disorders/Autism/>
- Beck, A. R., Stoner, J. B., Bock, S. J., & Parton, T. (2008). Comparison of PECS and the use of a VOCA: A replication. *Education and Training in Developmental Disabilities*, 198–216.
- Bessai, F. (1997) [Review of *Expressive vocabulary test*. IN: Plake, B. S., & Impara, J. C., eds. The fourteenth mental measurements yearbook. Lincoln, NE: Buros Center for Testing]. Retrieved from EBSCO mental measurements yearbook with tests in print [database]<http://web.b.ebscohost.com.ezproxy.uvm.edu/ehost/detail/detail?vid=4&sid=d2a82b6e-10d6-4c6d-8c80-3aa4c491397e%40sessionmgr102&bdata=JnNpdGU9ZWlhvc3QtbG12ZQ%3d%3d#AN=t est.488&db=mmt>
- Beukelman, D. R. & Miranda, P. (2013). *Augmentative & alternative communication: Supporting children & adults with complex communication needs*. Baltimore, MD: Paul H. Brookes.

AAC INTERVENTION ON ORAL LANGUAGE IN ASD

Boesch, M. C., Wendt, O., Subramanian, A., & Hsu, N. (2013). Comparative efficacy of the Picture Exchange Communication System (PECS) versus a speech-generating device: Effects on social-communicative skills and speech development. *Augmentative and Alternative Communication, 29*(3), 197–209.

Brookes Publishing Co., Inc. (2017). CDI: Capture parents' knowledge of their child's emerging language skills. *Screening, Assessment, and Curricula*. Retrieved from <http://www.brookespublishing.com/resource-center/screening-and-assessment/cdi/>

Brunner, D. L., & Seung, H. (2009). Evaluation of the efficacy of communication-based treatments for autism spectrum disorders: A literature review. *Communication Disorders Quarterly, 31*(1), 15–41.
<https://doi.org/http://dx.doi.org.ezproxy.uvm.edu/10.1177/1525740108324097>

Carson, L., Moosa, T., Theurer, J., & Oram Cardy, J. (2012). The collateral effects of PECS training on speech development in children with autism. *Canadian Journal of Speech-Language Pathology & Audiology, 36*(3), 182–195.

Centers for Disease Control and Prevention. (2017a). *Autism and developmental disabilities monitoring (ADDM) network*. Retrieved from <https://www.cdc.gov/ncbddd/autism/addm.html>

Centers for Disease Control and Prevention. (2017b). *Facts about ASD*. Retrieved from <https://www.cdc.gov/ncbddd/autism/facts.html>

Centers for Disease Control and Prevention. (2017c). *Screening and diagnosis*. Retrieved from <https://www.cdc.gov/ncbddd/autism/screening.html>

Centers for Disease Control and Prevention. (2017d). *Screening and diagnosis for healthcare providers*. Retrieved from <https://www.cdc.gov/ncbddd/autism/hcp.html>

AAC INTERVENTION ON ORAL LANGUAGE IN ASD

- Cizek, R. J. (1995) [Review of *Expressive one-word picture vocabulary test, revised*. IN: Conoley, J. C., & Impara, J. C., eds. The twelfth mental measurements yearbook. Lincoln, NE: Buros Center for Testing]. Retrieved from EBSCO mental measurements yearbook with tests in print [database]<http://web.b.ebscohost.com.ezproxy.uvm.edu/ehost/detail/detail?vid=17&sid=a372a392-3628-45c9-8cca-7d8580fdf884%40sessionmgr120&bdata=JnNpdGU9ZWZWhvc3QtbGl2ZQ%3d%3d#AN=test.22&db=mmt>
- Dole, J. A. (1989) [Review of *Receptive one-word picture vocabulary test*. IN: Conoley, J. C., & Kramer, J. J., eds. The tenth mental measurements yearbook. Lincoln, NE: Buros Center for Testing]. Retrieved from EBSCO mental measurements yearbook with tests in print [database]<http://web.b.ebscohost.com.ezproxy.uvm.edu/ehost/detail/detail?vid=19&sid=a372a392-3628-45c9-8cca-7d8580fdf884%40sessionmgr120&bdata=JnNpdGU9ZWZWhvc3QtbGl2ZQ%3d%3d#AN=test.10849&db=mmt>
- Flippin, M., Reszka, S., & Watson, L. R. (2010). Effectiveness of the Picture Exchange Communication System (PECS) on communication and speech for children with autism spectrum disorders: A meta-analysis. *American Journal of Speech-Language Pathology*, *19*(2), 178–195.
- Ganz, J. B., Earles-Vollrath, T. L., Heath, A. K., Parker, R. I., Rispoli, M. J., & Duran, J. B. (2012). A meta-analysis of single case research studies on aided augmentative and alternative communication systems with individuals with autism spectrum disorders.

AAC INTERVENTION ON ORAL LANGUAGE IN ASD

- Journal of Autism and Developmental Disorders*, 42(1), 60–74.
<https://doi.org/10.1007/s10803-011-1212-2>
- Ganz, J. B., Heath, A. K., Rispoli, M. J., & Earles-Vollrath, T. L. (2010). Impact of AAC versus verbal modeling on verbal imitation, picture discrimination, and related speech: A pilot investigation. *Journal of Developmental and Physical Disabilities*, 22(2), 179–196.
<https://doi.org/10.1007/s10882-009-9176-2>
- Ganz, J. B., Mason, R. A., Goodwyn, F. D., Boles, M. B., Heath, A. K., & Davis, J. L. (2014). Interaction of participant characteristics and type of AAC with individuals with ASD: A meta-analysis. *American Journal on Intellectual and Developmental Disabilities*, 119(6), 516–535. <http://dx.doi.org/10.1352/1944-7558-119.6.516>
- Gevarter, C., O'Reilly, M. F., Kuhn, M., Mills, K., Ferguson, R., Watkins, L., ... Lancioni, G. E. (2016). Increasing the vocalizations of individuals with autism during intervention with a speech-generating device. *Journal of Applied Behavior Analysis*, 49(1), 17–33.
<https://doi.org/10.1002/jaba.270>
- Greenberg, A. L., Tomaino, M. E., & Charlop, M. H. (2014). Adapting the Picture Exchange Communication System to elicit vocalizations in children with autism. *Journal of Developmental and Physical Disabilities*, 26(1), 35–51.
- Jurgens, A., Anderson, A., & Moore, D. (2009). The effect of teaching PECS to a child with autism on verbal behaviour, play, and social functioning. *Behaviour Change*, 26(1), 66–81.
- King, M. L., Takeguchi, K., Barry, S. E., Rehfeldt, R. A., Boyer, V. E., & Mathews, T. L. (2014). Evaluation of the iPad in the acquisition of requesting skills for children with

AAC INTERVENTION ON ORAL LANGUAGE IN ASD

- autism spectrum disorder. *Research in Autism Spectrum Disorders*, 8(9), 1107–1120.
<https://doi.org/10.1016/j.rasd.2014.05.011>
- Light, J., Binger, C., Agate, T. L., & Ramsay, K. N. (1999). Teaching partner-focused questions to individuals who use augmentative and alternative communication to enhance their communicative competence. *Journal of Speech, Language, and Hearing Research*, 42, 241-255.
- National Autism Association. (2017). *Autism fact sheet*. Retrieved from
<http://nationalautismassociation.org/resources/autism-fact-sheet/>
- Nunes, D., & Hanline, M. F. (2007). Enhancing the alternative and augmentative communication use of a child with autism through a parent-implemented naturalistic intervention. *International Journal of Disability, Development and Education*, 54(2), 177–197.
<https://doi.org/10.1080/10349120701330495>
- Olive, M. L., de la Cruz, B., Davis, T. N., Chan, J. M., Lang, R. B., O'Reilly, M. F., & Dickson, S. M. (2007). The effects of Enhanced Milieu Teaching and a Voice Output Communication Aid on the requesting of three children with autism. *Journal of Autism and Developmental Disorders*, 37(8), 1505–1513.
- Olive, M. L., Lang, R. B., & Davis, T. N. (2008). An analysis of the effects of functional communication and a Voice Output Communication Aid for a child with autism spectrum disorder. *Research in Autism Spectrum Disorders*, 2(2), 223–236.
<https://doi.org/10.1016/j.rasd.2007.06.002>
- Park, J. H., Alber-Morgan, S. R., & Cannella-Malone, H. (2011). Effects of mother-implemented Picture Exchange Communication System (PECS) training on independent communicative behaviors of young children with autism spectrum disorders. *Topics in*

AAC INTERVENTION ON ORAL LANGUAGE IN ASD

Early Childhood Special Education, 31(1), 37–47.

<https://doi.org/10.1177/0271121410393750>

Pearson Education, Inc. (2018b). *Vineland technical information*. Retrieved from

<https://www.pearsonclinical.com/psychology/support/technical-support/Vineland-Technical-Information.html>

Preston, D., & Carter, M. (2009). A review of the efficacy of the Picture Exchange

Communication System intervention. *Journal of Autism and Developmental Disorders*, 39(10), 1471–1486. <https://doi.org/http://dx.doi.org.ezproxy.uvm.edu/10.1007/s10803-009-0763-y>

Schlosser, R. W., Sigafoos, J., Luiselli, J. K., Angermeier, K., Harasymowycz, U., Schooley, K.,

& Belfiore, P. J. (2007). Effects of synthetic speech output on requesting and natural speech production in children with autism: A preliminary study. *Research in Autism Spectrum Disorders*, 1(2), 139–163. <https://doi.org/10.1016/j.rasd.2006.10.001>

Schlosser, R. W., & Wendt, O. (2008). Effects of augmentative and alternative communication

intervention on speech production in children with autism: A systematic review. *American Journal of Speech-Language Pathology*, 17(3), 212–230.

Schreibman, L., & Stahmer, A. C. (2014). A randomized trial comparison of the effects of verbal

and pictorial naturalistic communication strategies on spoken language for young children with autism. *Journal of Autism and Developmental Disorders*, 44(5), 1244–1251. <https://doi.org/10.1007/s10803-013-1972-y>

Statistics Solutions. (2017). *Mullen scales of early learning (MSEL)*. Retrieved from

<http://www.statisticssolutions.com/mullen-scales-of-early-learning-msel/>

AAC INTERVENTION ON ORAL LANGUAGE IN ASD

- Thunberg, G., Sandberg, A. D., & Ahlsén, E. (2009). Speech-generating devices used at home by children with autism spectrum disorders: A preliminary assessment. *Focus on Autism and Other Developmental Disabilities, 24*(2), 104–114.
<http://dx.doi.org.ezproxy.uvm.edu/10.1177/1088357608329228>
- Travis, J., & Geiger, M. (2010). The effectiveness of the Picture Exchange Communication System (PECS) for children with autism spectrum disorder (ASD): A South African pilot study. *Child Language Teaching & Therapy, 26*(1), 39–59.
<https://doi.org/10.1177/0265659009349971>
- van der Meer, L. A. J., & Rispoli, M. (2010). Communication interventions involving speech-generating devices for children with autism: A review of the literature. *Developmental Neurorehabilitation, 13*(4), 294–306. <https://doi.org/10.3109/17518421003671494>
- Yoder, P., & Stone, W. L. (2006). A randomized comparison of the effect of two prelinguistic communication interventions on the acquisition of spoken communication in preschoolers with ASD. *Journal of Speech, Language, and Hearing Research, 49*(4), 698–711.

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Appendix A: Quality Analysis Protocol and Description

Quality of Evidence Protocol

[Portney, L. G., & Watkins, M. P. (2009). *Foundations of clinical research: Applications to practice* (3rd ed.). Upper Saddle River, NJ: Prentice Hall]

		Criteria of Quality										Quality Level	Evidence Level
Study	Type of design	1	2	3	4	5	6	7	8	9	10		

Instructions

Use 1 row per study. Complete each column in the table for each study. The first column identifies the study (per instructions below). In the second column write the number that correspond to the type of design of the study. The Quality of Evidence of Included Studies follows. Place a 1 in the box if study meets criterion for its type of design (see 'Criteria Description by Type of Design' below) and a 0 if it does not meet the criterion. Place N/A if the criterion is not applicable to the particular study.

Study (First column): First author's last name et al. (YEAR); if two studies have the same first author and year, use the 1st two authors' last names.

Type of design (Second column): Place the number from the list below that corresponds to the study design in the second column of the table. If you believe the study uses a different design, please contact your course instructor.

1 = Meta-analysis (aka quantitative systematic review)

2 = Large (n>100) randomized clinical trial (RCT; aka Pretest-Posttest Control Group Design p.196 of Portney & Watkins, 2009)

3 = Small (n<100) RCT (Pretest-Posttest Control Group Design p.196 of Portney & Watkins, 2009)

4 = Qualitative systematic review

5 = Nonequivalent pretest-posttest control group design (p.228) OR **Nonequivalent Posttest-only control group design** (p.231) (i.e., RCT with inadequate approach to key elements)

6 = One-Group pretest-posttest design (p. 223) OR **Time Series Design** (p. 225)

7 = Single-case design; specify type: _____

8 = cohort study

9 = Case-control study

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Criteria of Quality: Criteria Description by Type of Design

Find the type of design of the study in the list below. Read each criterion (labeled by a number from 1 to 11) and decides whether the study meets it or not. Place a 1 in the box if study meets criterion and a 0 if it does not. Place N/A if the criterion is not applicable to the particular study or if there is no corresponding criteria for this type of design.

1 and 4 = Systematic Reviews and Meta-analyses

1. Are the inclusion/exclusion criteria for the selection of the studies clearly identified? Yes, if stated in terms of the following:
 - a. Population: The specific characteristics of the patients in whom the intervention will be evaluated.
 - b. Intervention: When the intervention concerns a form of treatment, the form of administration, dosing and duration of therapy is specified so the reader can reliably determine the treatment that is being evaluated
 - c. Outcomes: The outcome variables by which the effect of the intervention is measured is specified.
 - d. Methodological design: The type of studies to be included is specified
2. Does the review include only randomized control trials?
3. Is the literature search method systematic and exhaustive, minimizing the likelihood that relevant research has been omitted? Yes, if
 - a. All large, relevant electronic databases were searched
 - b. The authors reviewed the cited papers in the retrieved articles to look for further eligible articles
 - c. The authors hand-search publications specific to the question and perhaps not indexed in electronic databases
 - d. Conducted personal communications with researchers or experts on the subject to identify unpublished articles, or to obtain data not included in the original publications
4. Were the identified studies been evaluated for quality using established quality criteria?
5. If studies were excluded because of important methodological shortcomings, did the author explain the reasons?
6. Was quality evaluation carried out, by more than one person independently, using pre-established criteria?
7. Was the degree of agreement between those reviewing study quality reported?

Include the following criteria for meta-analysis only

8. Did the methods used to statistically combine the findings of the relevant studies (to reach a conclusion) go beyond simple averaging of results?
9. Was the analysis of the results (re)done excluding those studies of poor methodological quality to determine how they influence the overall results?
10. Are point estimates of effect reported with their confidence intervals?

2 and 3 = RCTs

1. Was the assignment to the treatment groups really random?
 - a. Computer-generated random numbers

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- b. Random numbers tables
- 2. Was the treatment allocation concealed?
 - a. Adequate approaches to concealment of randomization
 - b. Centralized or pharmacy-controlled randomization
 - c. Serially-numbered identical containers
 - d. On-site computer based system with a randomization sequence that is not readable until allocation
 - e. Other approaches with robust methods to prevent foreknowledge of the allocation sequence to clinicians and patients
 - f. Inadequate approaches to concealment of randomization
 - i. Use of alternation, case record numbers, birth dates or week days
 - ii. Open random numbers lists
 - iii. Serially numbered envelopes (even sealed opaque envelopes can be subject to manipulation)
- 3. Were the groups similar at baseline on key characteristics? (selection/confounding bias)
- 4. Were the eligibility criteria specified and were they logical in terms of the intervention under study?
- 5. Were outcome assessors blinded to the treatment allocation? (detection bias)
- 6. Was (were) the outcome measure(s) valid and reliable?
- 7. Was the care provider blinded to the study purpose?
- 8. Were drop-outs and loss to follow-up reported? If so was it less than 20% and balanced between groups? (attrition bias)
- 9. Was the intervention based on reasonable, physiological plausibility?
- 10. Was fidelity of intervention explicitly addressed in the study?

5 = Nonequivalent pretest-posttest control group design OR Nonequivalent Posttest-only control group design

- 1. Is the study based on a representative sample of the population?
- 2. Were the eligibility criteria specified and logical in relation to the population and the intervention under study?
- 3. Were the groups similar at baseline? (selection/confounding bias)
- 4. Was attention bias addressed?
- 5. Were assessors blinded to the treatment allocation? (detection bias)
- 6. Was/were the care provider or subject blinded to the study purpose? (performance or attention bias)
- 7. Was (were) the outcome measure(s) valid and reliable?
- 8. Were drop-outs and loss to follow-up reported and balanced between groups? (attrition bias)
- 9. Was the intervention based on reasonable, physiological plausibility?
- 10. Was fidelity of intervention explicitly addressed in the study?

6 = One-Group pretest-posttest design OR Time Series Design

- 1. Is the study based on a representative sample of the population?
- 2. Were the eligibility criteria specified and logical in relation to the population and the intervention under study?
- 3. Were assessors blinded? (detection bias)

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4. Was/were the care provider or subject blinded to the study purpose? (performance or attention bias)
5. Was (were) the outcome measure(s) valid and reliable?
6. Were drop-outs and loss to follow-up reported, and explained? (attrition bias)
7. Was the intervention based on reasonable, physiological plausibility?
8. Was fidelity of intervention explicitly addressed in the study?

7 = Single-case design

1. Did the type of design allow us to attribute change to the intervention (e.g., stable baseline, withdrawal/extinction phase, alternate treatment, follow-up)?
2. Were the subject eligibility criteria logical in relation to the population and the intervention under study?
3. Were the children's characteristics well described permitting determination who the results might apply to?
4. Was the intervention sufficiently described that it could be replicated?
5. Was fidelity of intervention addressed?
6. Was (were) the outcome measure(s) valid and reliable?
7. Was the assessor blinded to phases of the study (baseline vs. intervention)?
8. Was the intervention based on reasonable, physiological plausibility?

8 = Cohort studies

1. Is there sufficient description of the groups and the distribution of prognostic factors?
2. Is the intervention/treatment reliably ascertained?
3. Were the groups comparable on all important confounding factors?
4. Was there adequate adjustment for the effects of these confounding variables?
5. Was a dose-response relationship between intervention and outcome demonstrated?
6. Was outcome assessment blind to intervention status?
7. Was (were) the outcome measure(s) valid and reliable?
8. Was follow-up long enough for the outcomes to occur?
9. Were drop-out rates and reasons for drop-out similar for each group?

9 = Case-control studies

1. Is the case definition explicit?
2. Has the disease state of the cases been reliably assessed and validated?
3. Were the controls randomly selected from the source of population of the cases?
4. Are the cases and controls comparable with respect to potential confounding factors?
5. Does the study control adequately for confounding with design or statistics?
6. Were interventions and other exposures assessed in the same way for cases and controls?
7. Was the measurement of exposure or intervention kept blinded to the case or control group status?
8. Was (were) the outcome measure(s) valid and reliable?
9. Were the non-response rates and reasons for non-response the same in both groups?
10. Was an appropriate statistical analysis used (matched or unmatched)?

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Quality Levels – (second to last column)

High: A study that meets 70% or more of design-specific criteria well.

Moderate: A study that meets at least 40% but than 70% of design-specific criteria and has no known "fatal flaw".

Low: A study that meets less than 40% of design-specific criteria OR has at least one design-specific "fatal flaw". These studies' results should be interpreted with great caution as these studies are deemed to have limited ability to inform practice recommendations.

Level of Evidence (last column) Levels of Evidence (adapted from Sackett, D.L., Rosenberg, W.M., Muir Gray, J.A., Haynes, R.B. & Richardson, W.S. (1996). Evidence-based medicine: What it is and what it isn't. British Medical Journal, 312, 71-72).

Level I - Systematic reviews, meta-analyses, randomized controlled trials

Level II - Two groups, nonrandomized studies

Level III - One group, nonrandomized

Level IV - Descriptive studies that include analysis of outcomes (e.g., single subject design)

Level V - Case reports and expert opinion that include narrative literature reviews and consensus statements

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Appendix B: Quality of Evidence Assessment Results

Quality Criteria

Study	Type of design	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Quality Level	Evidence Level
Almirall et al. (2016)	3: Sequential multiple assignment randomized trial (SMART)	1	1	1	0	1	1	1	1	1	1	9/10 - High	I
Flippin, Reszka, & Watson (2010)	1: Meta Analysis	1	0	1	1	-	1	1	1	1	1	8/9 - High	I
Ganz et al. (2014)	1: Meta Analysis	1	0	1	0	1	-	-	1	1	1	6/8 - High	I
Schreibman & Stahmer (2014)	3: Randomized control trial	1	0	1	1	0	1	0	1	1	1	7/10 - High	I
Ganz et al. (2012)	1: Meta Analysis	1	0	1	1	1	0	-	1	0	1	6/9 - Moderate	I
Preston & Carter (2009)	4: Systematic Review	1	0	1	1	-	1	0	-	-	-	4/6 - Moderate	I
Schlosser & Wendt (2008)	4: Systematic Review	1	0	1	0	-	-	-	-	-	-	2/4 - Moderate	I
Beck, Stoner, Bock, & Parton (2008)	7: Alternating treatment single subject design	1	1	1	1	1	1	0	1	-	-	7/8 - High	IV
Boesch, Wendt, Subramanian, & Hsu (2013)	7: Single subject multiple baseline	1	1	1	1	1	1	1	0	-	-	7/8 - High	IV

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Carson, Moosa, Theurer, & Oram Cardy (2012)	7: Single-subject, changing criterion	1	1	1	1	0	1	0	1	-	-	6/8 - High	IV
Ganz, Heath, Rispoli, & Earles-Vollrath (2010)	7: Multi-treatment/multi-measure single-case design	1	1	1	1	1	1	0	1	-	-	7/8 - High	IV
Gevarter et al. (2016)	7: Nonconcurrent multiple baseline design	1	1	1	1	0	1	0	1	-	-	6/8 - High	IV
Greenberg, Tomaino, & Charlop (2013)	7: Single subject multiple baseline	1	1	1	1	0	1	0	1	-	-	6/8 - High	IV
Jurgens, Angelika, & Moore (2009)	7: Single subject changing criterion design	1	1	1	1	1	1	0	1	-	-	7/8 - High	IV
King et al. (2014)	7: Single subject multiple baseline	1	1	1	1	1	1	0	1	-	-	7/8 - High	IV
Nunes & Hanline (2007)	7: Single subject multiple baseline	1	1	1	1	1	1	0	1	-	-	7/8 - High	IV
Olive, Lang, & Davis (2008)	7: Single case multiple probe design	1	1	1	1	1	1	0	1	-	-	7/8 - High	IV

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Olive et al. (2007)	7: Single subject multiple probe	1	1	1	1	0	1	1	0	-	-	7/9 – High	IV
Park, Alber-Morgan, & Cannella-Malone (2011)	7: Single subject changing criterion design	1	1	1	1	1	1	0	1	-	-	7/8 - High	IV
Schlosser et al. (2007)	7: Single case adapted alternating treatments	1	1	1	1	1	1	0	1	-	-	7/8 - High	IV
Thunberg, Sandberg, & Ahlsen (2009)	7: Single subject AB alternating	1	1	1	0	1	1	0	1	-	-	6/8 - High	IV
Travis & Geiger (2010)	7: Mixed research design: quantitative was single-subject multiple-baseline (MBD) looking at requesting, commenting, and length of verbal utterance	1	1	1	1	0	1	0	1	-	-	6/8 - High	IV
Yoder & Stone (2006)	6: Randomized group experiment	1	1	0	0	1	1	1	1	-	-	6/8 - High	IV

*Note: Q followed by a number is used to indicate the criteria question number in the protocol.
Key: A “-“ indicates a non-applicable criteria question*

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Appendix C: Interventions Table

Studies and Interventions Utilized

Authors	Study Design	Sample Size	Ages	Intervention
Almirall et al. (2016)	Sequential multiple assignment randomized trial (SMART)	61	5-8 years	JASP with EMT versus JASP + EMT + a speech-generating device SGD
Beck, Stoner, Bock, & Parton (2008)	Alternating treatment single subject	4	“preschool-aged”	PECS versus VOCA
Boesch, Wendt, Subramanian, & Hsu (2013)	Single-subject, multiple baseline with embedded alternating treatment	3	6-10 years	PECS versus SGD
Carson, Moosa, Theurer, & Oram Cardy (2012)	Single-subject, changing criterion	3	2-3 years	PECS
Ganz, Heath, Rispoli, & Earles-Vollrath (2010)	Multi-treatment/multi-measure single case	1	3 years	PECS and Verbal Modeling
Gevarter et al. (2016)	Nonconcurrent multiple baseline	4	4;0-7;9	SGD with Verbal Modeling
Greenberg, Tomaino, & Charlop (2013)	Single case multiple baseline	4	4;2-8;4 years	PECS (second study with time-delay and prompt fading) PECS alone and PECS with time delay and verbal prompting
Jurgens, Angelika, & Moore (2009)	Single subject changing criterion	1	3;7 years	PECS
King et al. (2014)	Multiple probe design	3	3-5 years	SGD (iPad with Proloquo2Go) using PECS protocol phases
Nunes & Hanline (2007)	Multiple baseline	1	4;7 years	EA, MAAC, and Model (all delivered by parent)
Olive et al. (2007)	Single case multiple baseline	3	3;8-5;6 years	SGD with EMT

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Olive, Lang, & Davis (2008)	Single case multiple probe	1	4 years	FCT and VOCA
Park, Alber-Morgan, & Cannella-Malone (2011)	Changing criterion	3	2-3 years	Parent-implemented PECS
Schlosser et al. (2007)	Adapted alternating treatments	5	8-10 years	SGD with voice output versus SGD without voice output
Schreibman & Stahmer (2014)	Randomized control trial (RCT)	39	2-4 years	PECS versus PRT
Thunberg, Sandberg, & Ahlsen (2009)	AB multiple probe	3	5-7 years	SGD in different contexts
Travis & Geiger (2010)	Mixed quantitative-qualitative	2	9;6-9;10 years	PECS
Yoder & Stone (2006)	Randomized group experiment	36	1;6-5 years	RPMT vs. PECS

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Appendix D: Meta Analyses & Systematic Reviews

Descriptions of Meta-Analyses and Systematic Review Included in the Study

Author	Type of study	Studies Included	Interventions	Results	Statistical Significance
Flippin, Reszka, & Watson (2010)	Meta analysis	Single subject: 8	PECS	“questionable effectiveness...for increasing speech for young children with autism across the single-subject literature” (p. 187);	Mean weighted effect size: 0.17 Mean PND: 44.7%
		Group design: 3	PECS	“variable effects in speech outcomes” across group studies (p. 187)	Mean effect size not calculated
Ganz et al. (2012)	Meta analysis	Single subject: 24	PECS, SGDs, voice output communication aids, picture-point systems	“aided AAC interventions had large effects on targeted behavioral outcomes in individuals with ASD...effects were greater for communication skills than other categories of skills” (p. 60); PECS and SGDs had larger effects than other picture-based systems (although they also had small effects)	IRD (Confidence Interval of 84%): Communication as behavioral outcome 0.99 (0.98-0.99) PECS 0.99 (0.98-0.99) SGD 0.99 (0.99-1.00) Other picture-based AAC 0.61 (0.57-0.64)
Ganz et al. (2014)	Meta analysis	35 studies (24 from Ganz et al. 2012, plus 11 studies published since)	PECS, SGDs, “other picture-based AAC” (p. 517)	“AAC has small to moderate effects on speech outcomes” (p. 516) “SGDS appear to be most effective...with individuals with ASD without comorbid intellectual/developmental disorders (IDD)” (p. 516)	IRD: Mean 0.71 Speech at outset 0.55 (0.50-0.59) No speech at outset 0.43 (0.37-0.49) PECS 0.68 (0.65-0.70) SGDs 0.74 (0.68-0.80) Other picture-based AAC 0.70 (0.67-0.72)

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Preston & Carter (2009)	Systematic review	Single subject: 14	PECS	Varied results: "The effect of PECS training on speech development remains unclear" (p. 1481)	Mean calculated PND: 49.8% Mean calculated PEM: 54.2% "non-effective or at best very mildly effective range" (p. 1478)
		Group design: 5	PECS		Mean effect size not calculated
		Pre-experimental: 8	PECS		Mean effect size not calculated
Schlosser & Wendt (2008)	Systematic review	Single subject: 9	PECS alone, PECS vs. Responsive Education and Prelinguistic Milieu Teaching, PECS vs. manual signing	"AAC interventions do not impede speech production" (p. 212) "most studies reported an increase in speech production" (p. 212)	PECS mean PND: 95.2 ("highly effective"; p. 223) Other studies had different dependent variables
		Group design: 2	PECS alone, PECS vs. Responsive Education and Prelinguistic Milieu Teaching, PECS vs. manual signing		

Note: PND = percent non-overlapping data; IRD = improvement rate difference; PEM = percentage exceeding median.

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Appendix E: Outcome Measures

Outcome Measure Descriptions and Results

Authors	Outcome Measures	Outcomes	Statistical Significance
Almirall et al. (2016)	TSCU	TSCU significantly better in (SGD, SGD) group	TSCU: $p < .01$
	NDWR	NDWR no statistical significance	NDWR: $p = .12$
Beck, Stoner, Bock, & Parton (2008)	Total number of utterances	No difference between PECS and VOCA (2/4 increased in each condition)	N/A
	Percent intelligible utterances	PECS: 2/4 increased VOCA: 3/4 increased	
	Percent spontaneous intelligible utterances	PECS: 1/3 increased VOCA: 3/4 increased (one stayed the same at 100%)	
	Total number of different words	PECS: 1/3 increased VOCA: 3/4 increased	
Boesch, Wendt, Subramanian, & Hsu (2013)	MacArthur Bates CDI	No change noted in words spoken	N/A
	Verbalizations to communicate a message	No change in verbal language for both conditions, with no significant differences between conditions	
Carson, Moosa, Theurer, & Oram Cardy (2012)	Words and word approximations used to request	Mixed: Increase in speech sound and/or words	N/A
Ganz, Heath, Rispoli, & Earles- Vollrath (2010)	Frequency of Imitated Verbalizations	No increased imitations for either PECS or Verbal Modeling	$p = 1.00$
	Frequency of Related Speech	No statistically significant increase in related speech utterances in either PECS or Verbal Modeling conditions	$p = 1.00$
Gevarter et al. (2016)	Frequency of vocalizations	Increased in 3 out of 4 subjects	N/A
	Frequency of vocal initiations	No increase	
	Frequency of vocal approximations and full words	Increased in 1 participant	
Greenberg, Tomaino, & Charlop (2013)	Vocalizations to request	3 out of 4 children produced more frequent vocalizations at follow-up	N/A
Jurgens, Angelika, & Moore (2009)	Frequency of verbal mands	Increased	N/A

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	Frequency of verbal initiations other than mands	Variable, though increased overall		
	Cumulative word count of new words	Increased from 17 to 44		
	Number of morphemes	Morpheme count increased		
King et al. (2014)	Frequency of vocal requests	Frequency of vocal requests increased for all 3 participants		N/A
Nunes & Hanline (2007)	Frequency of verbalizations/vocalizations	No change		N/A
Olive et al. (2007)	Words and word approximations	1 out of 3 subjects increased verbalizations		N/A
Olive, Lang, & Davis (2008)	Expressive vocabulary	Correct pronoun usage increased		Percent Change Index: EOWPVT: 0.45 EVT: 1.06
Park, Alber-Morgan, & Cannella-Malone (2011)	Frequency of word vocalizations	2 of the 3 subjects exhibited slight improvements in word vocalizations (from 0 to 2 words in one subject and from 0 to 1 word the other)		N/A
Schlosser et al. (2007)	Total number of vocalizations produced	1 out of the 5 participants increased number of vocalizations from baseline		N/A
Schreibman & Stahmer (2014)	Mullen Scales of Early Learning, MacArthur Bates CDI, Vineland Adaptive Behavior Scales, Expressive One Word Picture Vocabulary Test (EOWPVT)	Across conditions	Children in both groups showed increases in spoken language skills	Mullen: p=.000 MacArthur: p=.000 Vineland: p=.037 EOWPVT: p=.001
		Between conditions	No significant difference	Mullen: p=.91 MacArthur: p=.883 Vineland: p=.142 EOWPVT: p=.484
Thunberg, Sandberg, & Ahlsen (2009)	Frequency of meaningful speech	Frequency of meaningful speech improved in 2 of 2 contexts for 1 participant, 1 of 2 for another participant, and decreased in 2 of 2 contexts for the third participant		N/A
Travis & Geiger (2010)	Words for requesting and commenting, Mean Length of Utterance (MLU)	Increase in requesting, commenting, and MLU depending on phase of intervention		N/A
Yoder & Stone (2006)	Frequency of non-imitative spoken acts	End of treatment	PECS significantly higher frequency	ANCOVA p=0.03

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	6 months post treatment	No difference between conditions	p=0.96
Number of different non-imitative words	End of treatment	PECS significantly higher number	ANCOVA p=0.04
	6 months post treatment	No difference between conditions	p=0.93

Note: TSCU = total number of spontaneous communicative utterances; NDWR = number of different word roots.