NeuroRegulation

ISNR INTERNATIONAL SOCIETY FOR NEUROREGULATION & RESEARCH

Clinical Effectiveness of AAC Intervention in Minimally Verbal Children With ASD: A Systematic Review

Atiya Aftab[1], Chhavi Arora Sehgal[1], Majumi M. Noohu[1], and Ghufran Jaleel[2]*

[1]Centre for Physiotherapy and Rehabilitation Sciences, Jamia Millia Islamia, New Delhi, India
[2]Integral Institute of Allied Health Sciences and Research, Integral University, Lucknow, India

Abstract

Background. Autism spectrum disorder is defined as neurodevelopmental disability by (DSM-5). One third to half of minimally verbal children could benefit from augmentative and alternative communication (AAC) intervention. In children and adults with developmental disabilities, AAC enhances social interaction and daily routines. **Objective**. Clinical effectiveness of AAC interventions is being studied in improving outcome variables like social communication, interaction, speech production behavior and expression and their implementation in clinical practice for children with autism spectrum disorder (ASD). **Method.** We searched electronic databases PubMed, Web of Science, and Scopus from inception to January 2022. Randomized controlled trials with multiple baselines and multiple probe designs were selected for this review. **Results**. Four hundred sixty-eight articles retrieved with recruitment criteria, eight studies selected, three with multiple baseline designs, two with multiple probe designs, one with both and two randomized controlled trials (RCT) selected. Tau-U analysis and improvement rate difference (IRD) were used for analyzing the data, ranging from 0.80 to 1.00 for single-case experimental design and 0.90 to 0.95 for RCTs. **Conclusions**. AAC aids are effective tools for increasing communication in ASD children, but high-tech aids were more effective in increasing social communication, interaction, and speech production than low technology. Children also prefer high tech.

Keywords: autism spectrum disorder; augmentative and alternative communication; manual sign; voice output communication aids; picture exchange communication system; visual scene display; speech-generating devices

Citation: Aftab, A., Sehgal, C. A., Noohu, M. M., & Jaleel, G. (2023). Clinical effectiveness of AAC intervention in minimally verbal children with ASD: A systematic review. *NeuroRegulation, 10*(4), 239–252. https://doi.org/10.15540/nr.10.4.239

***Address correspondence to**: Chhavi Arora Sehgal, Centre for Physiotherapy and Rehabilitation Sciences, Jamia Millia Islamia (A Central University), New Delhi-110025, India. Email: dr.chhaviarora@gmail.com

Edited by:
Rex L. Cannon, PhD, Currents, Knoxville, Tennessee, USA

Reviewed by:
Rex L. Cannon, PhD, Currents, Knoxville, Tennessee, USA
Tanya Morosoli, MSc: 1) Clínica de Neuropsicología Diagnóstica y Terapéutica, Mexico City, Mexico; 2) PPCR, ECPE, Harvard T. H. Chan School of Public Health, Boston, Massachussetts, USA

Introduction

Autism spectrum disorder (ASD) is defined as neurodevelopment disability according to the *Diagnostic and Statistical Manual of Mental Disorder* (5th ed.; DSM-5; American Psychiatric Association [APA], 2013). Prevalence of ASD in children is estimated to be approximately 1 in 68, and it has significantly heightened in the last 20 years (Baio et al., 2018). The cause is known to be idiopathic boys are more prone than girls. The core feature of ASD is deficit in social communication, social interaction, repetitive and restricted patterns of behavior and interest (e.g., repetitive body movement such as flapping of hand, sensory sensitivities, and circumscribed interest) along with the absence of eye contact or no response when their name is called (Mazurek et al., 2017). Speech is the most portable and ideal form of communication. In ASD, about 25% to 30% of children do not develop or fail to develop any language (functionally spoken) and remain minimally verbal (Norrelgen et al., 2015). In one of the studies, it was found that 25% of minimally verbal children have increased aggression level and social withdrawal during adolescence. Because of limited social interaction, adaptive behavioral skills, academic achievement, vocational accomplishment, and social relationships are also affected (Binger et al., 2010; Wodka et al., 2013).

Augmentative and alternative communication (AAC) techniques and strategies are used in social-

communication-deprived children (Ganz, 2015). There are two major groups of AAC intervention: high technology (speech-generating devices [SGD]) and low technology (e.g., gestures, body language, Picture Exchange Communication System [PECS], and manual sign). AAC is further classified as aided (requiring external supports) including PECS and SGD; whereas unaided included manual sign languages, KWS, and gestures (Mazurek et al., 2017).

Low Technology Devices

Picture Exchange Communication System (PECS). Originally developed for nonverbal children with ASD, PECS is used to teach various spontaneous functional communications through symbols and pictures that can be easily and inexpensively created and programmed into intervention. Two of PECS' reported merits are its required eye contact and oral motor skills, which are lacking in ASD children (Bondy & Frost, 1998).

Children use PECS to communicate by exchanging pictures with a partner in order to access preferred items and activities or to initiate social interaction. There are six phases in PECS that they progress through with training. The communications begin with exchanging a single picture card to request preferred items and then progresses through phases designed to increase vocabulary and mean length of utterance as well as to expand the function of the system, including commenting (Alzrayer et al., 2019).

Sign Language and Key Word Sign (KWS). ASD children have significantly impaired gestures, one of the predictors of language impairment (Dimitrova et al., 2016; Yoon & Bennett, 2000). Social, cognitive, and motor abilities are a few of the developmental skills required for successful gesture communication (Wray et al., 2016).

Body language, manual sign, and gestures help in teaching receptive and expressive vocabulary in children with speech impairments. Children here are taught to make a request or mand using photographs, symbols of real or partial objects, or lines. Manual signs require single stimulus whereas symbols requires multiple stimulus (Yoder & Layton, 1988; Yoder & Stone, 2006; Yoon & Bennett, 2000). Intervention including symbols with visual resemblance is likely to be learned more easily by people with language development difficulties than when symbols have weak visual relationship.

Sign language and key words are used to increase vocalization and speech production in people with speech impairment. Therefore, minimally verbal and nonverbal children require more sign language as it increases vocalization. For individuals who have difficulties in conditional discrimination, sign language is often recommended.

The goal of KWS is to support the development and use of functional communication, comprised of core vocabulary and fringe vocabulary. Fringe vocabulary contains specific words and messages individualized from person to person, whereas core vocabulary consists of words and phrases which are universal. KWS was specifically designed to provide support to children with complex communication needs like practicing social etiquette, exchanging information, and developing social closeness (Tan et al., 2014).

High Technology Devices

Speech-generating Devices (SGD). A frequently used AAC intervention and previously known as voice output communication devices, SGD are electronic devices which are portable and include features such as graphic symbols and written language along with digitized and synthesized speech output. (Mirenda, 2003). One of the merits of SGD is instantaneous speech production, which makes messages easier to understand, even for a communication partner not familiar with this device. This advantage facilitates greater participation in a natural setting (van der Meer et al., 2013; van der Meer & Rispoli, 2010). Nowadays, several tablet devices like iPhone, iPod, and iPad are designed in such a way that they can function as an SGD at a low price and with multifunctional abilities. SGD can save vocal messages and be given to children in a noisy environment or as a long distance intervention when implementing for those with communication disabilities (Alzrayer et al., 2019).

Quick speech production facilitates development of language, enhances pairing of graphics and spoken symbols, improves conversation, and builds independence in SGD users (Gilroy et al., 2018).

Vocabulary organization is one of the core features of SGD. Methods of grouping vocabulary on graphic mode AAC systems include taxonomic (i.e., by category), alphabetic, schematic (i.e., by event or activity), chronologic (i.e., by daily schedule sequence), and semantic-syntactic (i.e., by part of speech) apart from this frequency of use (Thistle et al., 2018).

Visual Scene Displays (VSD). The use of VSD with beginning communicators or those who are learning to communicate has been suggested as an alternative to traditional AAC approaches (Light et al., 2019). Here photos of different and meaningful events are present on either computer tablets or mobile phones with preprogrammed vocabulary hotspots. Upon touching the screen, the hotspot produces speech and plays a poem or song. It has been shown that there is a positive result when using VSD in children and adults with development disability in the context of number of turns (social communication) and production of different vocabulary items during social interaction routines (Holyfield, 2019).

The benefits for children are that the contextual support provided by the photographic image preserves or improves the functional and proportional relationships required for building communication in society and appears to play an important role in supporting the effective use of the AAC system (Light et al., 2019). For example, when the hotspot for an apple seen on a kitchen countertop on VSD is selected, the VSD produces the corresponding auditory output “apple” with a visual scene showing either the benefits of the apple or how to pronounce apple (Gevarter et al., 2014).

In a review of literature, researchers also found that implementing AAC as a mode of communication for children with ASD or other pervasive development disorders did not result in reduced speech production but rather an increase in vocalization (Cagliani et al., 2017). Similarly, another study reported beneficial effects of AAC on social interaction and daily routines in children and adults with developmental disability (Laubscher et al., 2019).

To date there is a lack of interventional studies examining the characteristics of exchanges between child and adult partners with respect to social context, such as the proportion of self-initiated exchanges or reciprocal communication (Thiemann-Bourque et al., 2016). Also, if not diagnosed in earlier stages ASD can result in social withdrawal, effecting quality of life and causing stress in adolescence (Chapin et al., 2022).

Thus, the purpose of this systematic review is to evaluate the clinical effectiveness of AAC in minimally verbal children with ASD and among all AAC intervention which is the most clinically effective in improving social communication and interaction, speech production, behavior and expression in these children.

Methods

Protocol and Registration

The review protocol was registered in PROSPERO (https://www.crd.york.ac.uk/PROSPERO, registration number CRD42021279344), which is an international database of prospectively registered systematic reviews.

Search Strategy

This systematic review is designed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement (Page et al., 2021).

A systematic search was done on electronic databases such as PubMed, Web of Science, and Scopus, starting from inception to January 2022. To retrieve relevant studies, in an advanced search using the drop-down menu under the “title/abstract” category, each phrase was combined with “autism spectrum disorder” OR “augmentative and alternative communication” using the Boolean operator “AND” with:

- Social communication
- Speech-generating devices
- Picture Exchange Communication System
- Multistep requesting
- Manual sign
- Low technology devices
- Visual scene display
- Voice output communication aids
- High technology devices

Inclusion Criteria

Our inclusion criteria were:

- Population: Children under 13 years of age with prediagnosed ASD who were minimally verbal, with utterance less than 20 or more than one spontaneous or functional word.
- Intervention: Given either in classroom, at school, or by researcher.
- Study Design: Randomized controlled trials (RCT), non–RCT, and single-case experimental designs (SCED).

Exclusion Criteria

The following exclusion criteria were followed for this study:

- Nonverbal children
- Uncontrolled seizures

- Diagnosed with any congenital or genetic anomalies like Fragile X syndrome or Down syndrome, with and without ASD
- Any motor impairment that could hinder the interventions given to children (cerebral palsy), as well any other factors affecting their social communication abilities
- Intervention given like peer-mediated approach, naturalistic teaching approach, or a computer-based intervention like Therapy Outcomes by You (TOBY).

A total of 468 articles were retrieved after applying the filter of recruitment criteria, and eight studies met the inclusion criteria.

Data Extraction

In this review process, four reviewers were involved; two reviewers (A. A., C. S.) searched various databases (PubMed, Web of Science, and Scopus) in order to retrieve all plausible studies. Any disagreements regarding the eligible studies were resolved either by discussion or by the involvement of other two reviewers (M. N., G. J.).

Data Collection

Characteristics for all included cases were according to study design; that is, multiple probe design (MPD), multiple baseline design (MBD) and RCT; participants characteristics (age, verbal status, and communication skills), intervention setting (clinical, school), type of intervention (PECS, SGD, VSD, manual sign, key words), dependent variable (object request, speech production, behavior, communication turn-social interaction), functional outcomes, and interobserver agreement. Also, the quality assessment of the included study was done by using PEDro (RCT) and single-case experimental design (SCED) for MPD, MBD design. The score for SCED ranged from 7/10 to 8/10, whereas for RCT it was 8/10.

Quality Synthesis

PEDro Scale and Scoring for RCT

The methodological quality assessment of each included trail is very important while conducting a systematic review. Many scales are there for assessing the quality of clinical trials; among them, the PEDro scale is most commonly used. This scale scores 11 items: random allocation, concealed allocation, similarity at the baseline, subject blinding, therapist blinding, assessor blinding, more than 85% follow-up for at least one key outcome, intention-to-treat analysis, between-group statistical comparison for at least one key outcome, as well as point and variability measures for at least one key outcome. Evaluation is done to determine the integrity of the steps involved in conducting a systematic review. Based on these criteria the PEDro score ranges from “fair” to “excellent” with interrater reliability (intraclass correlation coefficient [ICC] = 0.53 to 0.91) for clinical trials of physiotherapy-related interventions (Cashin & McAuley, 2020).

Single-Case Experimental Design (SCED) Scale

For multiple baseline design and multiple probe design, scoring is done based on a SCED scale that scientifically provides an alternative for RCT for clinically determining the effectiveness of an intervention. The strongest SCED includes more than one participant. When comparing SCED with RCT, SCED requires fewer sources and can be performed in setting as well as on studies that do not require large populations. When implemented properly, SCED can provide a strong internal validity to determine the casual relationship between the intervention and outcomes as well as also control external validity when generalizing the finding on larger setting and populations. It is an 11-item rating scale where item 1 assesses clinical history information and items 2–11 allow for the calculation of a quality score (higher score equates to higher quality). No study provided information on power calculation. However, in SCED it is stated that the higher the scoring, the better the quality of the study (Lobo et al., 2017).

Data Analysis

Quality Assessment

The quality assessment of the included study was done by using PEDro and SCED.

PEDro was used for two RCT and both reported a good scoring of 8/10 (McDuffie et al., 2012; Yoder & Stone, 2006). Discussing MPD and MBD, SCED was used and reported as 7/10 (Chapin et al., 2022; Laubscher et al., 2019) and 8/10 (Alzrayer et al., 2020; Ganz et al., 2009; Sigafoos et al., 2018; Tan et al., 2014).

Interpretation of Result

Improvement Rate Difference (IRD)

In SCED, some researchers use IRD to analyze their data. It is a new overlap effect size for two contrasted phases (like baseline versus intervention, including generalization and maintenance if included in that corresponded study). Parker et al. (2011) estimated that IRD scores around .50 to .70 indicate

a moderate effect, whereas scores ranging from .70 to .75 show higher effects (Lobo et al., 2017).

Tau-U Analysis

Some researchers analyzed their data by using Tau-U analysis. It is distributed as a free, nonparametric technique which is suitable for small sets of data that do not follow a normal distribution curve and is used to evaluate changes in the dependent variable. Tau-U analysis controls for monotonic trend and provides conservative effect size. According to Parker et al. (2011) the scores of Tau-U can be interpreted as 0.065 (weak effect), 0.66 to 0.92 (moderate effect), and 0.93 to 1.0 (strong effect; Lobo et al., 2017).

Along with this fidelity of treatment, in their study several researchers also assessed to what extend the treatment given by the primary practitioner is accurate. The analysis is either done by the same researcher involved in this study or by another person who is not part of the study, using a 5-point rating scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree*).

Result

Search Strategy and Systematic Review

A total of 1,292 articles were identified from various databases (PubMed, Web of Science, and Scopus). After removing duplicates, 468 articles were retained. Once title and abstract screenings were done, 31 articles were selected for full text review. Finally, eight articles met all of the inclusion criteria of this study: three MBD, two MPD, one MBD-MPD combination, and two RCT. Studies included in this review were performed on children with mean age between 18 months to 9 years. A total number of 88 participants with ASD who were minimally verbal with vocabulary ranging from one or more words, scripted phrases (Alzrayer, 2020; Chapin et al., 2022; Sigafoos et al., 2018; Tan et al., 2014) to less than 10 words (McDuffie et al., 2012; Yoder & Stone, 2006) were evaluated. Interventions were provided in schools, clinical settings (Alzrayer, 2020; Chapin et al., 2021; Ganz et al., 2009; Laubscher et al., 2019; Tan et al., 2014) and university-based clinical setting (McDuffie et al., 2012; Sigafoos et al., 2018; Yoder & Stone, 2006). Two out of six studies included VSD as their main intervention (Chapin et al., 2021; Laubscher et al., 2019), which were delivered to participants with mean duration of 3 to 4 months. SGD- and PECS-based intervention ranged between 4 to 6 months (Alzrayer, 2020; McDuffie et al., 2012; Sigafoos et al., 2018; Yoder & Stone, 2006). One study examined the effect of KWS and manual sign, where intervention lasted up to 3 weeks (Tan et al., 2014). Five out of eight articles focused on social communication and interaction either in the form of requesting, accepting, or rejecting items either desired or undesired, or of the participants with their partners. Speech production was included as an outcome variable in almost all the articles and delivered either through any modes of AAC, whereas behavior and expression were primarily focused in two articles.

Effect of AAC Intervention on Speech Production

Most of the selected articles either primarily or secondarily focused on speech production. Four out of eight articles showed significant improvement in speech production with AAC techniques like PECS, SGD, and KWS, while the remaining four were also on speech production in either form of requesting or rejecting.

A study done by Ganz and colleagues (2009) aimed at determining changes or improvement in speech production when PECS was used as a treatment aid. During baseline all three participants did not use any picture, whereas during intervention phases all three participants showed an increase in picture use ranging between 1 and 13, with an average of 6.6 picture exchanges. Two out of three participants showed a significant improvement in spoken words (0–100%). Data were analyzed using IRD for both baseline as well as intervention phases. IRD calculated in this study showed large effects for words used and speech production across all three participants. The treatment fidelity of this study was assessed by another observer for intervention phases, which ranged from 93 to 100% for all three participants (Ganz et al., 2009).

However, another study conducted by Alzrayer (2020) aimed at determining the proportional increase in speech production in children with limited requesting when they moved from PECS to SGD. All four participants showed a correct response using picture book across baseline, between 9 and 9.4 out of 10 responses. Whereas, for SGD-based requesting, none of the participants showed great vocalization during baseline, but after intervention phases all four participants and data showed a positive increase in vocalization value ranging between 7.4 and 9.3. Result gain from this study showed a significant improvement in speech production in children with limited requesting. This study used Tau-U analysis to analyze their data which ranged between 0.80 and 0.96, showing moderate to higher effects that were statistically significant, $p = .01$ (Alzrayer, 2020).

Figure 1. *PRISMA Flow Chart Diagram Depicting the Systematic Process Followed to Include Articles Captured in This Review*.

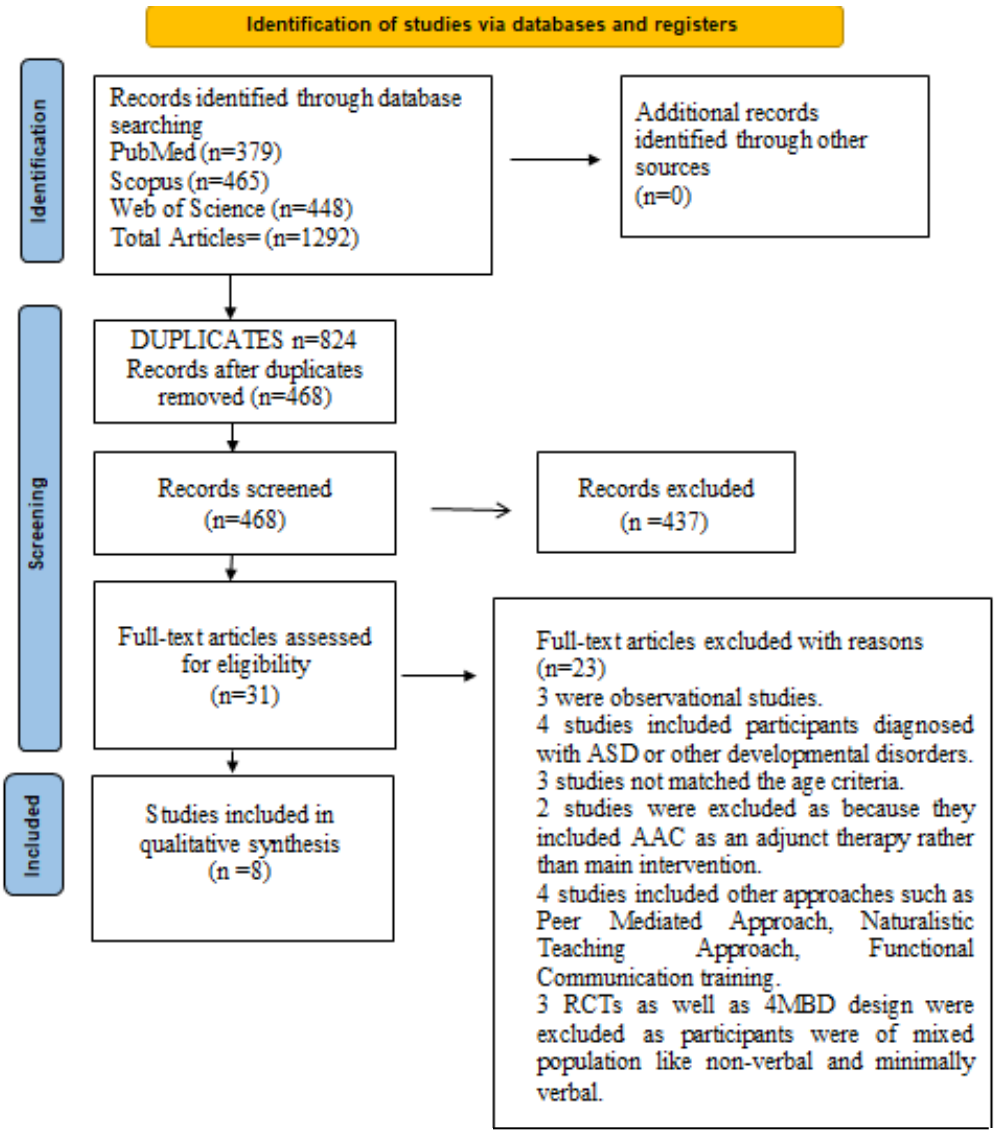

Table 1

Characteristics of the Included Randomized Controlled Trial Determining the Effect of Various AAC Interventions on Communication, Social Interaction, Speech Production, Behavior and Expression

Study	Design	Participants	Intervention setting	AAC intervention	Dependent variable	Outcomes	Interobserver agreement
Yoder & Stone, 2006	RCT	36 participants. 19 randomly allocated to PECS group and 16 to RPMT group.	Three 20-min individual therapy sessions over a period of 6 months.	PECS in comparison with RPMT.	Facilitating object exchange, turn taking, as well as requesting. ADOS and ESCS scales used for pre- and postassessment.	RPMT shows greater improvement as compared to PECS.	Mean interobserver agreement for PMRT was 99% and for PECS was 90%. Average ICC was 0.85 pretreatment and 0.95 posttreatment.
McDuffie et al., 2012	RCT	36 participants. 16 randomly allocated to PECS group and 16 to RPMT group.	Three 20-min individual therapy sessions over a period of 6 months.	PECS in comparison with RPMT.	Effect on object request. ADOS and ESCS scales used for pre- and postassessment.	Children in RPMT group showed greater increase in object request in comparison with PECS group.	Mean interobserver agreement for RPMT was 99% and for PECS was 90%. ICC for object interest was 0.90 at pre- and posttreatment.

Note. All participants met the criteria of having ASD unless otherwise indicated. This table is depicting two randomized controlled trials (RCT) included in the review, which fulfilled the criteria. ADOS: Autism Diagnostic Observational Schedule; ESCS: Early Social-Communication Scale; ICC: intraclass correlation coefficient; PECS: Picture Exchange Communication System; RPMT: Responsive Education and Prelinguistic Milieu Teaching.

Table 2

Characteristics of the Included Single Case Experimental Design (SCED) Determining the Effect of Various AAC Interventions on Communication, Social Interaction, Speech Production, Behavior and Expression

Study	Design	Participants	Intervention setting	AAC intervention	Dependent variable	Outcomes	Interobserver agreement
Ganz et al., 2009	MBD-MPD	Three children minimally verbal, age 3–6 years.	Clinical setting, ten 5-min sessions in each baseline and intervention phase, 3–5 times per week.	PECS with pictures.	Picture use. Words use. Maladaptive behavior.	Increase in picture exchange with increased request. Increase in word production with increased speech. Decrease in maladaptive behaviors.	Picture use during intervention was 100%, 94%, and 91%. Words use during intervention was 100%, 100%, and 67%. Maladaptive behavior was 97%, 100%, and 100%.

Table 2

Characteristics of the Included Single Case Experimental Design (SCED) Determining the Effect of Various AAC Interventions on Communication, Social Interaction, Speech Production, Behavior and Expression

Study	Design	Participants	Intervention setting	AAC intervention	Dependent variable	Outcomes	Interobserver agreement
Chapin et al., 2022	MPD	Three participants minimally verbal, age 3–5 years.	School setting, 5-min session, 2–3 times per week, in each baseline and intervention phase, over a period of 3 months for two children and 4 months for one child.	VSD with indiviualized set of videos based on child's interest.	Communicative turns (social interaction done by children) Speech or words used by children. Eye contact, body orientatior or movement with communication partner.	All three children exhibited increase in communication turns (social interaction). One child did not show significant increase in speech or words used. Increase in eye contact, body orientation, or movement with communication partner.	Interobserver agreement was 90.8% across all studies.
Laubscher et al., 2019	MPD	One participant minimally verbal, age 8 years.	School setting, 2-month period, conducted with 5-min sessions in each baseline and intervention phase, 3–5 times per week.	VSD	Effect of intervention on communication turn (social interaction).	Incease in communicative turns (social interaction).	Interobserver agreement was between 93% and 100%.
Tan et al., 2014	MBD	Three participants, minimally verbal, age 3–4 years.	Clinical setting, three 10-min sessions during baseline and intervention phase, over a period of 12 weeks with 3 sessions per week.	Use of KWS and manual sign.	Speech production and gestures.	All three childen showed a significant increase in speech production. One child did not show a difference in gestures, while the other two showed an increase in gestures.	Interobserver agreement was 87–94% from baseline to intervention.

Table 2

Characteristics of the Included Single Case Experimental Design (SCED) Determining the Effect of Various AAC Interventions on Communication, Social Interaction, Speech Production, Behavior and Expression

Study	Design	Participants	Intervention setting	AAC intervention	Dependent variable	Outcomes	Interobserver agreement
Sigafoos et al., 2018	MBD	Two participants, minimally verbal, age 7–9 years.	University clinic room, 1:1 teaching session once per week for ~60 min. One child had 19 weekly clinic visits over a period of 5 months and two children had 22 clinic visits over period of 6 months.	SGD	Requesting preferred items and rejecting nonpreferred item, communication responses for multifunction.	Results showed a positive response for communication and SGD used to treat different communication function in different contexts.	Interobserver agreement was 98% for one child and 95% for second child.
Alzrayeret al., 2020	MBD	Four participants, minimally verbal, age 3–5 years.	Clinical setting, one 15-min session per day, four sessions per week over a period of 4 months.	Moving from PECS to SGD.	Effect on speech production, PECS-based requesting and SGD-based requesting.	Increase in speech production on moving from PECS to SGD, as well as increase in requesting in childen with limited speech.	Interobserver agreement mean for SGD and PECS requesting was 99% and for speech production was 93%.

Note. All participants met the criteria of having ASD unless otherwise indicated. Experimental design included KWS: key word sign; MBD: multiple baseline design; MPD: multiple probe design; PECS: Picture Exchange Communication System; SGD: speech-generating device; VSD: visual scene display.

In RCT conducted by Yoder and Stone (2006), the study compared the efficacy of PECS with RPMT in facilitating object exchange, turn taking (social interaction), as well as facilitating request (speech production) with a hypothesis that PECS is superior in improving request in comparison with RPMT. The result also favored the hypothesis of this trial, and PECS was found to be superior in improving request in comparison with RPMT but only in those participants who were not taking any joint attention therapy or had not taken any other therapies. Pretreatment scales used were the Autism Diagnostic Observational Schedule (ADOS) and Early Social-Communication Scales (ESCS). The average ICC was 0.85 during treatment and 0.95 posttreatment. This study also used a 3-point fidelity of treatment rating scale (1 = *poor*, 2 = *good*, 3 = *excellent*) for both RPMT and PECS (Yoder & Stone, 2006).

This follow-up study by Yoder and Stone (2006) used a similar methodology aimed only at facilitating object request because that provides integral steps for social communication and help in acquiring spoken language. The result showed a significant improvement in object requesting in children who were undergoing RPMT treatment as compared with PECS. Objects that are basically used in our day-to-day routines are primarily enforced to the children, along with prompting and rewarding for intentional communication. The practitioner can use this routine object in a positive way on children. For building a triadic interaction with the children, routine action provides a better support. However, participants in this study were not getting joint attention initiation treatment, which could have influenced the findings of the study. Hence, results or improvements were purely based on interaction (i.e., RPMT or PECS). Scales used for preassessment were the same

(ADOS and ESCS), whereas the scales used for postassessment scale were the Mullen Scales of Early Learning (MSEL). Interobserver reliability was conducted for object request and found to be 0.90 (McDuffie et al., 2012).

A study conducted by Alzrayer (2020) showed a positive result in speech production in children with limited requesting when they moved from PECS to SGD. All participants showed a correct response using a picture book across baseline between 9 and 9.4 out of 10 responses. Whereas for SGD-based requesting, none of the participants showed great vocalization during baseline, but after intervention phase all the four participants and data showed a positive increase in vocalization value ranging between 7.4 and 9.3, showing a significant improvement. Tau-U analysis ranged between 0.80 and 0.96, showing moderate to higher effects that were statistically significant, $p = .01$ (Alzrayer, 2020).

A study by Tan et al. (2014) aimed to evaluate the effectiveness of keywords in manual sign on production of speech and gestures. All participants showed a significant increase in speech production; for gestures, only two participants revealed significant improvements. Tau-U analysis for two out of three participants' data ranged from 0.82 to 0.94, whereas *p* value was found statistically significant for speech production and ranged between .016 and .036 for all participants. The average reliability index for baseline was 85% to 97% and for intervention was 84% to 93% (Tan et al., 2014).

Effect of AAC Intervention on Social Communication and Interaction

Two articles used VSD as their treatment aid, and their findings suggest that VSD was effective in increasing social communication and interaction.

Laubscher et al. (2019) during baseline natural speech along with communication turn for participant for different activities was 11/47, 8/64, and 5/57, which increased postintervention to 35/47, 53/64, and 53/57, respectively. Tau-U analysis for all activities reported values between 0.1 to 1.0, whereas the mean Tau-U was 0.8, indicating large effect size following treatment. An average procedural integrity was 100% for both baseline and intervention (Laubscher et al., 2019).

Chapin et al. (2022) used the same intervention aid (i.e., VSD) but with different methodology. During baseline the communication turn taken by the participants was much less (i.e., 0–1), but following intervention all the participants showed a significant improvement in communication turns (social interaction). Tau-U analysis was 1.0 for all of the participants, showing a stronger effect size. The procedural integrity checklist for baseline, intervention, and generalization was found to be 100%, 97%, and 94%, respectively (Chapin et al., 2022).

Effect of AAC Intervention on Behavior

Ganz and colleagues (2009) indicated the efficacy of PECS improving maladaptive behavior. IRD of this study showed a questionable effect for maladaptive behaviors for all three participants because one participant showed a decrease in maladaptive behavior during baseline, followed with an increase in maladaptive behavior in intervention (i.e., 1.75–2.8); whereas two participants showed a decrease in maladaptive behavior during intervention and baseline phases but an increase in generalization phases ranging between 2.3 and 4.0, respectively (Ganz et al., 2009).

Effect of AAC Intervention on Expression

We found only one study primarily focusing on use of SGD as an effective mean for improving expression in children with autism.

In 2018, Sigafoos and colleagues' study result revealed heightened response for communication using SGD in treating communication in different contexts. Mean of one participant's rate of rejecting increased to 66.25% (0–100%), whereas another participant's rate of requesting improved up to mean of 40% (0–100%). A procedural integrity checklist showed 80–100% correct implementation (Sigafoos et al., 2018).

Discussion

The finding in this study primarily focused on the use of AAC to support communications and functions. through different forms of requesting like object request, accepting preferred items and rejecting nonpreferred items, socially interacting with the partners, and vocal requesting as well as commenting.

Functions like object request were taught successfully in all trials, according to McDuffie et al. (2012). For the development of spoken language and early communication, object-based routines provide a wide variety of skills that are important for this development. If children are provided different varieties of objects and play action, it gives them more opportunities to use different sets of vocabulary words. Addressing object request may

help in overcoming problems like stereotypes and repetitive actions which an ASD child often faces. Hence, object request could be considered as developmentally appropriate and a strength-based goal for children with ASD who are minimally verbal (McDuffie et al., 2012).

Teaching skills in more social communication function (i.e., interacting, requesting, commenting) helps in establishing strength for children with ASD who are minimally verbal and could be a key to eventually increasing communication for purely social ends and consequences. Requesting for social games and routines or responses like greeting or acknowledgement of questions will direct towards more socially oriented outcomes (Laubscher et al., 2019).

Effect of AAC Intervention on Speech Production

According to Tan et al. (2014), PECS in ASD children showed a positive change in speech production and gestures. For clinical practice this study showed that the child with communication needs progresses from no use of sign to use of sign and speech for repertoire to communicate their wants and needs. At the end, the visual and statistical analysis from this study showed a significant improvement in speech production and gestures. It also suggests that for children with little functional speech communication this approach of sign and speech-based intervention was appropriate as it provides a model in sign of targeted vocabulary with addition of multiple prompts.

KWS is comprised of core vocabulary and fringe vocabulary. Fringe vocabularies contain specific words and messages individualized from person to person, whereas core vocabularies consist of words and phrases which are universal among all people. KWS is specially designed to provide support to children with complex communication needs like practicing social etiquette, exchanging information, and developing social interaction (Tan et al., 2014).

Ganz et al. (2009) discussed the use of PECS with respect to make request, use of words to increase speech and decrease in maladaptive behavior. This study showed a clear relationship between uses of pictures to make request when given PECS as an intervention aid and suggest a rapid acquisition of PECS by children with ASD; PECS was found to be effective for picture use for all three participants. Maladaptive behavior seen in participants might be due to rejection of undesired items or the participant ignorance by the surrounding people. Also, participant's maladaptive behavior examined during interventions was not targeted specifically as a primary variable. Investigation using PECS as treatment aid for longer duration could help in evaluating whether the changes found in these studies like decrease in maladaptive behavior were primarily due to PECS or some other factors affecting the decreased in behavior patterns. Studies could be done to investigate the effect of PECS on rate of speech or use of echolalia level in children with little or speech (Ganz et al., 2009).

Alzrayer (2020) supports and provides evidence that synthetics speech output devices like SGD have a positive effect on increasing spontaneous vocal requesting in children with limited functional speech. Speaking skills like vocalization, word approximation, and echolalia were all limited when requests were made from PECS, but after implementing SGD vocal production improved. Also, this synthetics speech output device increased participants' motivation to use this device for requesting. Findings also stated that participants opted more for SGD than PECS book during posttraining intervention, providing a support for the practitioner that they can transition between modalities when children learn discrimination skills. The practitioner should consider the allocated and effort response for determining the optimal AAC modality option for their learner (Alzrayer, 2020).

Effect of AAC Intervention on Social Communication and Interaction

AAC provides a new tool for supporting expressive communication in children with complex communication needs. Videos embedded in VSD have language concepts which provide a strong conceptual support for communication; familiar videos in VSD provide strong support for increasing communication turn for children who are minimally verbal or nonverbal (Chapin et al., 2022). Holyfield and colleagues also stated that an increase in communication behavior is the first step towards advanced communication (Holyfield, 2019).

VSD-based intervention is effective in increasing social communication and interaction in children with ASD, and this improvement was seen in a relatively short period of time. This communication turn from baseline to intervention was purely based on AAC application. In context of supported communication interaction, children learn new language and motor skills followed by increase in speech. These communication gain results are consistent with the earlier finding that AAC intervention does not hinder their speech production (Cagliani et al., 2017; Laubscher et al., 2019).

Effect of AAC Intervention on Expression

Sigafoos et al. (2018) provides the valid point that learning gained by the children through SGD helped them in accomplishing important communication function like expressing their wants, needs, and preferences, affecting minimally verbal children directly. Expressing one's needs and wants, accepting preferred items, and rejecting or not accepting nonpreferred items are all communication functions and typically the very first features in developing children. Therefore, these domains can be termed as foundational skills and should be to taught to children who are deprived of communication and social interaction, as appears in ASD children. Only one command and one symbol were given to the participants either in baseline or intervention phases. So, the change of error was rare and an easy learning environment was created, further suggesting that an errorless learning environment is appropriate for children who are initially learning AAC (Sigafoos et al., 2018).

Conclusion

The findings of this review display an emerging support for the effectiveness of both aided and unaided intervention in minimally verbal children with ASD in improving the wide variety of communication functions like object requesting, accepting preferred items and rejecting nonpreferred items, socially interacting with the partners, and vocal requesting as well as commenting.

Studies included in this review were based on high technology, like VSD and SGD, and low technology, like PECS and manual sign. All these aids provide effective tools for increasing communication in children with ASD who are minimally verbal, but high technology was found to be more effective in increasing social communication and interaction along with speech production and expression. Children also preferred high technology over low technology, although low technology like PECS and manual sign were found to be effective in increasing speech production (core vocabulary) and functional communication (requesting).

Addressing issues like delayed speech production, noninteraction, no communication turns, and finding out appropriate interventions offers the potential to reduce challenges faced by children with ASD (e.g., social communication) to a greater extent.

Future Scope

The studies in this review relevantly address significant communications and learning needs of children with ASD who are minimally verbal and provide an evident need for further research focused on varied communication functions which are socially motivated so as to improve the quality, quantity, and consistency of the evidence.

Areas for future research include investigating the effectiveness of both aided and unaided intervention on different populations like Down syndrome, or any pathological condition in people leading to delayed speech production or no speech at all. Also, a younger nonverbal population can be included. Studies directly focusing on maladaptive behaviors could be studied along with functional analysis to rule out the cause of this maladaptive behavior in ASD children. Other child-related factors like joint attention should also be taken into consideration as it predisposes children benefits more from one intervention to another. Requirement of different intervention mediates one's outcome. Studies need to be done to rule out whether AAC interventions are sustainable or generalizable. Future research can also help clinicians make an informed decision about more potential benefits of AAC intervention and how to implement AAC interventions in children with ASD for better results. Such studies may also provide support for children who do not respond to speech-focused intervention alone, where additional support is required.

Limitation

Due to scarcity of literature available in this area, MBD-MPD with only two RCT was included in this review, reducing the strength of evidence available. Because of the MBD-MPD baseline design, a well-defined pretreatment assessment was not elaborated, although posttreatment was purely based on interobserver agreement but procedural integrity was evident. For building and ensuring greater confidence in the relationship between intervention and outcomes in future research, addressing these concerns is very important.

Author Disclosure

Authors have no grants, financial interests, or conflicts to disclose.

References

Alzrayer, N. M. (2020). Transitioning from a low- to high-tech Augmentative and Alternative Communication (AAC) system: Effects on augmented and vocal requesting. *Augmentative and Alternative Communication*, *36*(3), 155–165. https://doi.org/10.1080/07434618.2020.1813196

Alzrayer, N. M., Banda, D. R., & Koul, R. K. (2019). The effects of systematic instruction in teaching multistep social-communication skills to children with autism spectrum disorder using an iPad. *Developmental Neurorehabilitation*,

22(6), 415–429. https://doi.org/10.1080/17518423.2019.1604578

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Baio, J., Wiggins, L., Christensen, D. L., Maenner, M. J., Daniels, J., Warren, Z., Kurzius-Spencer, M., Zahorodny, W., Rosenberg, C. R., White, T., Durkin, M. S., Imm, P., Nikolaou, L., Yeargin-Allsopp, M., Lee, L.-C., Harrington, R., Lopez, M., Fitzgerald, R. T., Hewitt, A., Pettygrove, S., … Dowling, N. F. (2018). Prevalence of autism spectrum disorder among children aged 8 –ears - autism and developmental disabilities monitoring network, 11 sites, United States, 2014. *MMWR Surveill Summ*, *67*(6), 1–23. https://doi.org/10.15585/mmwr.ss6706a1

Binger, C., Kent-Walsh, J., Ewing, C., & Taylor, S. (2010). Teaching educational assistants to facilitate the multisymbol message productions of young students who require augmentative and alternative communication. *American Journal Of Speech-Language Pathology*, *19*(2), 108–120. https://doi.org/10.1044/1058-0360(2009/09-0015)

Bondy, A. S., & Frost, L. A. (1998). The picture exchange communication system. *Seminars In Speech and Language*, *19*(4), 373–389. https://doi.org/10.1055/s-2008-1064055

Cagliani, R. R., Ayres, K. M., Whiteside, E., & Ringdahl, J. E. (2017). Picture exchange communication system and delay to reinforcement. *Journal of Developmental and Physical Disabilities, 29*(6), 925–939. https://doi.org/10.1007/s10882-017-9564-y

Cashin, A. G., & McAuley, J. H. (2020). Clinimetrics: Physiotherapy Evidence Database (PEDro) Scale. *Journal of Physiotherapy*, *66*(1), 59. https://doi.org/10.1016/j.jphys.2019.08.005

Chapin, S. E., McNaughton, D., Light, J., McCoy, A., Caron, J., & Lee, D. L. (2022). The effects of AAC video visual scene display technology on the communicative turns of preschoolers with autism spectrum disorder. *Assistive Technology*, *34*(5), 577–587. https://doi.org/10.1080/10400435.2021.1893235

Dimitrova, N., Özçalışkan, Ş., & Adamson, L. B. (2016). P'rents' translations of child gesture facilitate word learning in children with autism, down syndrome and typical development. *Journal of Autism and Developmental Disorders*, *46*(1), 221–231. https://doi.org/10.1007/s10803-015-2566-7

Ganz J. B. (2015). AAC interventions for individuals with autism spectrum disorders: State of the science and future research directions. *Augmentative and Alternative Communication*, *31*(3), 203–214. https://doi.org/10.3109/07434618.2015.1047532

Ganz, J. B., Parker, R., & Benson, J. (2009). Impact of the picture exchange communication system: Effects on communication and collateral effects on maladaptive behaviors. *Augmentative and Alternative Communication*, *25*(4), 250–261. https://doi.org/10.3109/07434610903381111

Gevarter, C., O'Reilly, M. F., Rojeski, L., Sammarco, N., Sigafoos, J., Lancioni, G. E., & Lang, R. (2014). Comparing acquisition of AAC-based mands in three young children with autism spectrum disorder using iPad® applications with different display and design elements. *Journal of Autism and Developmental Disorders*, *44*(10), 2464–2474. https://doi.org/10.1007/s10803-014-2115-9

Gilroy, S. P., Leader, G., & McCleery, J. P. (2018). A pilot community-based randomized comparison of speech generating devices and the picture exchange communication system for children diagnosed with autism spectrum disorder. *Autism Research*, *11*(12), 1701–1711. https://doi.org/10.1002/aur.2025

Holyfield, C. (2019). Preliminary investigation of the effects of a prelinguistic AAC intervention on social gaze behaviors from school-age children with multiple disabilities. *Augmentative and Alternative Communication*, *35*(4), 285–298. https://doi.org/10.1080/07434618.2019.1704866

Laubscher, E., Light, J., & McNaughton, D. (2019). Effect of an application with video visual scene displays on communication during play: Pilot study of a child with autism spectrum disorder and a peer. *Augmentative and Alternative Communication*, *35*(4), 299–308. https://doi.org/10.1080/07434618.2019.1699160

Light, J., Wilkinson, K. M., Thiessen, A., Beukelman, D. R., & Fager, S. K. (2019). Designing effective AAC displays for individuals with developmental or acquired disabilities: State of the science and future research directions. *Augmentative and Alternative Communication, 35*(1), 42–55. https://doi.org/10.1080/07434618.2018.1558283

Lobo, M. A., Moeyaert, M., Baraldi Cunha, A., & Babik, I. (2017). Single-case design, analysis, and quality assessment for intervention research. *Journal of Neurologic Physical Therapy*, *41*(3), 187–197. https://doi.org/10.1097/npt.0000000000000187

Mazurek, M. O., Lu, F., Symecko, H., Butter, E., Bing, N. M., Hundley, R. J., Poulsen, M., Kanne, S. M., Macklin, E. A., & Handen, B. L. (2017). A prospective study of the concordance of DSM-IV and DSM-5 diagnostic criteria for autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *47*(9), 2783–2794. https://doi.org/10.1007/s10803-017-3200-7

McDuffie, A. S., Lieberman, R. G., & Yoder, P. J. (2012). Object interest in autism spectrum disorder: A treatment comparison. *Autism*, *16*(4), 398–405. https://doi.org/10.1177/1362361309360983

Mirenda, P. (2003). Toward a functional augmentative and alternative communication for students with autism: Manual signs, graphic symbols, and voice output communication aids. *Language, Speech, and Hearing Services in Schools, 34*(3), 203–216. https://doi.org/10.1044/0161-1461(2003/017)

Norrelgen, F., Fernell, E., Eriksson, M., Hedvall, Å., Persson, C., Sjölin, M., Gillberg, C., & Kjellmer, L. (2015). Children with autism spectrum disorders who do not develop phrase speech in the preschool years. *Autism*, *19*(8), 934–943. https://doi.org/10.1177/1362361314556782

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., McGuinness, L. A., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Systematic Reviews*, *10*(1), 89. https://doi.org/10.1186/s13643-021-01626-4

Parker, R. I., Vannest, K. J., & Davis, J. L. (2011). Effect size in single-case research: A review of nine nonoverlap techniques. *Behavior Modification, 35*(4), 303–322. https://doi.org/10.1177/0145445511399147

Sigafoos, J., Roche, L., Stevens, M., Waddington, H., Carnett, A., van der Meer, L., O'Reilly, M. F., Lancioni, G. E., Schlosser, R. W., & Marschik, P. B. (2018). Teaching two children with autism spectrum disorder to use a speech-generating device. *Research and Practice in Intellectual and Developmental Disabilities*, *5*(1), 75–86. https://doi.org/10.1080/23297018.2018.1447391

Tan, X. Y., Trembath, D., Bloomberg, K., Iacono, T., & Caithness, T. (2014). Acquisition and generalization of key word signing by three children with autism. *Developmental Neurorehabilitation*, *17*(2), 125–136. https://doi.org/10.3109/17518423.2013.863236

Thiemann-Bourque, K., Brady, N., McGuff, S., Stump, K., & Naylor, A. (2016). picture exchange communication system and pals: A peer-mediated augmentative and alternative communication intervention for minimally verbal preschoolers with autism. *Journal of Speech, Language, and Hearing*

Research, *59*(5), 1133–1145. https://doi.org/10.1044/2016_JSLHR-L-15-0313

Thistle, J. J., Holmes, S. A., Horn, M. M., & Reum, A. M. (2018). Consistent symbol location affects motor learning in preschoolers without disabilities: Implications for designing augmentative and alternative communication displays. American *Journal of Speech-Language Pathology, 27*(3), 1010–1017. https://doi.org/10.1044/2018_AJSLP-17-0129

van der Meer, L., Kagohara, D., Roche, L., Sutherland, D., Balandin, S., Green, V. A., O'Reilly, M. F., Lancioni, G. E., Marschik, P. B., & Sigafoos, J. (2013). Teaching multi-step requesting and social communication to two children with autism spectrum disorders with three AAC options. *Augmentative and Alternative Communication*, *29*(3), 222–234. https://doi.org/10.3109/07434618.2013.815801

van der Meer, L. A., & 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

Wodka, E. L., Mathy, P., & Kalb, L. (2013). Predictors of phrase and fluent speech in children with autism and severe language delay. *Pediatrics*, *131*(4), e1128–e1134. https://doi.org/10.1542/peds.2012-2221

Wray, C., Norbury, C. F., & Alcock, K. (2016). Gestural abilities of children with specific language impairment. *International Journal of Language & Communication Disorders*, *51*(2), 174–182. https://doi.org/10.1111/1460-6984.12196

Yoder, P. J., & Layton, T. L. (1988). Speech following sign language training in autistic children with minimal verbal language. *Journal of Autism and Developmental Disorders, 18(*2), 217–228. https://doi.org/10.1007/BF02211948

Yoder, P., & Stone, W. L. (2006). Randomized comparison of two communication interventions for preschoolers with autism spectrum disorders. *Journal of Consulting and Clinical Psychology*, *74*(3), 426–435. https://doi.org/10.1037/0022-006X.74.3.426

Yoon, S. Y., & Bennett, G. M. (2000). Effects of a stimulus-stimulus pairing procedure on conditioning vocal sounds as reinforcers. *The Analysis of Verbal Behavior*, *17*, 75–88. https://doi.org/10.1007/bf03392957

Received: April 20, 2023
Accepted: August 4, 2023
Published: December 19, 2023