Effectiveness of different types of Augmentative and Alternative Communication (AAC) in improving communication skills and in enhancing the vocabulary of children with ASD: A review

Christine K. Syriopoulou-Delli

Associate Professor

Department of Educational and Social Policy,

University of Macedonia

csyriop@gmail.com

Gkiolnta Eleni

Teacher, MSc Special Education

Department of Educational and Social Policy,

University of Macedonia

lls17002@uom.edu.gr

Running Head

Review on Language and Communication of Children with ASD using ACC

Corresponding author:

Christine K. Syriopoulou-Delli, Postdoc on Autism Spectrum Disorders, PhD

Assistant Professor, Autism Spectrum Disorders,

Department of Educational and Social Policy,

University of Macedonia, Thessaloniki,

156 EgnatiaSt.,

54336 Thessaloniki, Greece

Mobile phone +030 6938704339

csyriop@gmail.com

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Abstract

Communication deficits are one of the core symptoms of autism spectrum disorder (ASD), and augmentative and alternative communication (AAC) systems are utilized to facilitate the communication and language development of children with ASD. This review examines the research literature on the use of aided and unaided AAC systems in interventions for children with ASD, and investigates their effectiveness in enhancing language and communication skills in this population. Systematic review methodology was used to limit bias in the searchof electronic databases, and relevant studies were selected, 20 of which met the inclusion criteria for the review. The findings of these studiesindicate that AAC systems are able to facilitate and enhance communication skills in children with ASD. It is apparent that this is a method that will be used increasingly in the future, and it is imperative that meticulous research is conducted on the effects of the applications. Refinements in the study methodology are recommended, and additional questions that might be addressed in future research are discussed.

Keywords: Autism spectrum disorder, augmentative and alternative communication, communication, assistive technologies, children

Introduction

Autism spectrum disorder (ASD) is characterized by a deficitin communication, along with other symptoms. It is a neurodevelopmental disorder that affects the development of social interaction and communication skills, including both verbal and non-verbal communication (Lal, 2010). The main impairment is in the area of pragmatics, which is "employing language as a social system to communicate" (Eigsti et al., 2007), but children with ASD also exhibit other types of language impairment, including semantic (Coderre et al., 2017) and grammatical development (Wittke et al., 2017).According to Coderre et al. (2017), semantic development refers to "…the understanding of the meaning of a stimulus, be it a word, picture, sentence, or sound".

Kasari and colleagues (2013) estimated that approximately 30% of people with ASD are non-verbal or have minimal verbal abilities, and other authors report that between 25% and 50% of people with ASD never fully acquire functional language, although early diagnosis and intervention may reduce these rates (Brignell et al., 2016; Castelli, 2001; Mazza et al., 2017; Ramdoss et al., 2010). In addition, children with ASD display deficits inmaintaining joint attention (Ogletree 2008), which is the ability to alternate one's gaze between objects and people, and is an indicator of language development in children with ASD (Mundy et al, 1990).Also, according toBottema-Beutel's 2016 meta-analysis, joint attention deficits are directly linked to poor language outcomes.

The use of augmentative and alternative communication (AAC) is recommended to ensure that children with ASD donot establish patterns of communication failure (Prizant et al., 2003).AAC includes tools and strategies that an individual with speech and/or language impairments can use to complement or even to replace speech or writing (Brignell et al., 2016; ISAAC, 2018). Some examples of AAC are the picture exchange communication system (PECS), Makaton signing, andspeech-generating devices (SGDs).

AAC systems have been categorized into aided and unaided systems. Unaided systems, such as sign language, require no auxiliary equipment,and the individual's body is used as the means of communication. Aided AAC systems require auxiliary equipment for communication purposes. Onelow-technology example of an aided AAC system is PECS, while high-technology aided AACs include SGDs and other systems.

Research on the effects of AAC on communication is developing rapidly. Millar and colleagues (2006), using AAC for 27 adults and children with ASD or intellectual disability (ID),observedbetter speech production in 89% of the participants. There is as yet no consensus on which aided or unaided system is the best for teaching children with ASD(Mirenda, 2003; Schlosser &Sigafoos, 2006), and more recent studies (Gevarter et al., 2013) showed that both PECS and SGDs were almost equally successful in enhancing the communication skills of children with ASD, after conducting a systematic review and meta-analysis of 28 studies.

Many researchers have focused on the teaching of requesting skills to children with ASD with the use of AAC (Ganz et al., 2012a). This comes to no surprise, as the ability to make requests leads to greater independence (LeBlanc et al., 2009), and

children with ASD have less flexibility in making requests than their peers of typical development (TD) (Wahlberg & Jordan, 2001).Requesting or demanding is defined by Skinner as “a verbal operant in which the response is reinforced by a characteristic consequence and is therefore under the functional control of relevant conditions of deprivation or aversive stimulation” (Skinner, 1957). In other words, requesting allows individuals to express their wants and needs, and is an essential way of developing their communication skills (Still et al., 2015).

Objectives

This review aimed to evaluate the most widely used methods of enhancing the communication of children with ASD. The main object was to assess the effectiveness of each type of AAC in improvingthe communication skills of children with ASD and to investigate the possible impact of ACCon their vocabulary. We focused on requesting skills and vocabulary development in particular, preference assessment for different types of AACs, and also on generalization and maintenance of acquired skills. In this context, we also tried to showcase the different types of AAC employed by other researchers and explore whether they represent the range of currently available devices.

The review was based on the following research questions:

1. Were the forms of AAC used successful in teaching requesting skills to children with ASD?
2. Were the forms of AAC used successful in enhancing the vocabulary of children with ASD?

3. What types of AAC were employed, and do they adequately represent the range of devices available?
4. Were AAC interventions effective in increasing the maintenance and generalization of communication in children with ASD?
5. Did children with ASD demonstrate a preference for a particular AAC method?

Method

The methodology of this study was based on the5 essential methodological steps for conducting systematic reviews, as indicated by Khan and colleagues (2003). The first step was to formulate the research questions, which are presented above. The second step was to search for articles in electronicdatabases, includingPubMed, Google Scholar, Scopus, and Science Direct, for studies published between 2009 and 2019 that examined language and communication development using some form of AAC. The keywords used were "augmentative", "alternative", "communication", "autism", "ASD" and "children".

The third step was to formulate the eligibility criteria to assess the applicability of the research papers for this review. Specifically, only studies on preschool children and children of school age with a diagnosis for ASD were included, and each study should include an AAC instrument designed to promote communication in children with ASD. Thereview focuses on the effectiveness of different types of AAC for children with autism that are of preschool and school age. For reasons of space, studies with groups of adolescent children with autism spectrum disorders were not considered eligible. Each should be a peer-reviewed primary study

incorporating an intervention, experiment, or case study; each should be empirical and provide data that address the studyhypotheses andinclude a detailed description of the type of AAC used. Only studies that met the methodological and content criteria were included, and review articles, editorials, and meta-analyses were excluded. In addition, studies that included only specific age groups(e.g., only preschool children or adolescents) were not included. Lastly, studies providing no empirical data and those that didnot incorporate the use of an AAC instrument as a variable were omitted.

The review was conducted by two researchers, and in the case of disagreement regarding the inclusion or exclusion of research papers, the final decision was made after discussion. Figure 1 shows the flowchart used in the selection of papers, based on PRISMA, which is an evidence-based minimum set of items for reporting insystematic reviews and meta-analyses (Moher et al., 2010).

INSERT FIGURE 1 HERE

The fourth step was a summarization ofthe evidence provided in the final selection of studies. The evidence was categorized according to the participants, setting, communication modes, target communication skills, intervention outcome, maintenance, and generalization. The analysis of the study results includes the measurements of all the communicative behaviors that the researchers reported.The fifth and final review step was the interpretationof the findings, presented in the Discussion section. The findings in each category are discussed with reference to the initial research questions of the review.

Types of AAC

The various types of AAC systems used with individuals with ASD, and evaluated in the studies reviewed, are shown in Figure 2.

INSERT FIGURE 2 HERE

PECS

PECS was originally developed by Bondy and Frost in 1994. It is a picture-based AAC system that uses basic behavioral principles to teach children with ASD to use functional communication in social contexts. The pictures are used to communicate, in exchange for items or tasks(Bondy& Frost, 1994, 1998).It is of note that not all exchange-based communication interventions are PECS, some are referred to as picture exchange (PE).

PECS has been reported to besuccessful in interventions with individuals with ASD (Ganz & Simpson, 2004; Ganz et al., 2012b), but the intervention was usually focused on teaching the requesting of items, and not on enhancing other aspects of communication (Ganz et al., 2012a).Although PECS is successful, its paper-based nature has some disadvantages, such as preventing educators from tracking the child's progress, and adding social stigma because the child has to carry a book or a folder constantly (Miller et al., 2006).

SGDs

SGDs are a high-technology form of aided AAC. They are also referred to as voice-output communication aids (VOCAs)(Lancioni et al., 2007). SGDs are used to facilitate both the expressive and receptive communication of children with ASD (Sigafoos et al., 2003), and are popular with teachers and therapists because of the consistency that they provide in terms of the messages produced(Koul, 2003; Schlosser &Blischak, 2001).These systems implement the use of symbols and pictures

that represent words, and most children with ASD process and respond to information better when it is in visual form (Fleury et al., 2014).

SGDs include newer mobile tablets and other hand-held devices that produce electronic digitized or synthesized speech (Mirenda, 2003; Alamsaputra et al., 2006). They are easily accessible due to the wide availability of "smart" devices, and they are referred to as non-dedicated SGDs. In recent years, non-dedicated SGDs based on iPads are becoming increasingly popular,becauseiPads and other tablet devices areused bylarge numbers of people, including children, which makes them less "stigmatizing" for the user, unlike the dedicated SGDs used in the past (Kagohara et al., 2013).

Makaton

The Makaton Vocabulary is a language and communication system for people with learning difficulties thatwas originally designed by Margaret Walker in 1972 in the UK andis now used in over 40 countries worldwide. The Makaton program is used to teach communication and language skills, using manual signs and/or graphic symbols, accompanied by speech. Its vocabulary is based on a common core of functional concepts. Once basic communication skills have been acquired, a student may move towards more comprehensive language use (Grove & Walker, 1990).

The Makaton Vocabulary consists of a Core Vocabulary,with approximately 450 concepts, and a Resource Vocabulary of over 7,000 concepts, all of which are illustrated with signs and graphic symbols (Walker& Armfield, 1981).

Results

As shown in Figure 1, the initial search yielded 254 relevant publications for the years 2009-2019. Removal of duplicates and application of the first phase of the study criteria left 230 articles, which on scrutiny led to a selection of 45, of which 20 articles met the requirements of the review, and are listed in Table 1.

INSERT TABLE 1 HERE

Participants and settings

The 20 studies included a total of 242 children with ASD. For studies that included participants both with and without ASD, only data for the children with ASD were taken into consideration. In addition, data on participants that were below 5 years of age were not coded. The sample size ranged between 1 and 84 children, with a mean number of 12.1. Only two case studies concerned 1 participant. The age of the children in the studies ranged from 5 to 13 years (mean 8.8 years). Some of the studies provided only the age range of the participants and not their exact ages. In this case, the mean of the sample was used to calculate the overall mean age.

Most of the interventions were made in the participants' schools (65%), but 3 of the studies were conducted in university clinics (15%). One study (5%) was conducted in the participant's home, and two (10%) in both the school and the home.

Q1: Success of different forms of AAC in teaching requesting skills

Target communication skills

The dependent variables in this review were all target communication skills, delineated in each study and classified into broad categories. Specifically, the target communication skills were: a) requesting skills (e.g., asking for preferred items, food, snacks, activities, actions, etc.), b) speech, conversation,and social communication

skills, c) preference assessment for different types of AAC, d) use of multi-symbol messages, and e) reading and spelling skills.

The communication skills assessed in the studies, among others, were spontaneous communication, language and social behavior, use of intelligible words, and frequency of communication behavior.

Preference assessment is the process of enabling children to express their preference for one communication option over another (Van der Meer et al., 2011). Although clinicians and educators can follow guidelines in the choice of the best communication option for each child (Reichle, 1991), preference assessment for AAC devices is considered to be an important research variable (Van der Meer et al., 2011).

The use of multi-symbol messages refers to the ability of the child to combine multiple symbols on an AAC device in order to produce more complex forms of communication. Most children with ASD experience difficulty in processing and expressing multi-word messages (Smith & Grove, 2003), and tend to rely on single symbols to communicate when using AAC devices (Sutton & Morford, 1998). It is of note that the use of multi-symbol messages has not been explored in many studies on ASD. In this review, reading and spelling skills refer to sight word reading. Table 2 shows the target communication skills and the AAC methods used in the studies reviewed.

INSERT TABLE 2 HERE

For the purposes of this review, outcomes were classified into 5 broad categories, according to the target communication skills taught throughout the interventions. These 5 outcome categories will be discussed thoroughly throughout the results section. A study was considered to have a positive outcome when all the

participants showed improvement in the target communication skill, a negative outcome when none of the participants showed improvement, and a mixed outcome when some participants demonstrated improvement while others did not.

Requesting skills was one of the most common target communication skills assessed in the review studies, and the 12 relevant studies reported either positive results (83%, n=10) or mixed results (17%, n=2); no study reported a negative outcome.

Ganz and colleagues. (2009) reported that children using PECS to learn how to make requests all learned how to exchange pictures for items very quickly. Choi and colleagues (2010) reported that when children each used a different type of AAC (SGDs and PE), almost all managed to achieve high scores in requesting, rejecting, and re-requesting items. Only one required additional training in rejecting and re-requesting in order to reach the training criterion set by the researchers.

In one study, all 7 participants, starting from zero performance at baseline, demonstrated improvement in their requesting skills once the 4th phase of PECS training was completed (Cummings et al., 2012).

Another study with positive results regarding requesting skills was that of Van der Meer and colleagues (2012), who observed that two participants managed to perform requests using their preferred AAC system with ease (Van der Meer et al., 2012). Two other children in that study were excluded from this review as they were under 5 years. In a follow-up study, the same two participants initially failed to make requests, although this skill had been acquired previously. Following the intervention, both were successful in producing two-step requests, using an SGD, manual signing,

and picture exchange, although modifications were made for one (Van der Meer et al., 2013).

Waddington and colleagues (2014) evaluated a requesting procedure using an SGD for children with ASD. All the participants managed to make multi-step requests, although with fluctuation in their performance, requiring procedural modifications in order for them to perform the requesting sequence. In another study, two children were able to meet the research criteria for making requests with an SGD, using 4 different displays of the same device (Gevarter et al., 2017).

Three further studies that evaluated an SGD reported positive results regarding the requesting skills performance of the participants. Specifically, Alzrayer and colleagues (2017) observed that all 4 children managed to combine symbols from the SGD to varying degrees, and in another study, 3 children were successful in combining and using symbols for requesting, although with procedural modifications for two of them (Alzrayer et al., 2019). Muharib and colleagues (2019a) reported that the 3 children in their study were able to make different kinds of requests (incomplete vocal requesting, complete vocal requesting, and non-vocal requesting), to varying degrees. Not all the children managed to make and maintain all the kinds of requests, and only non-vocal requesting ability was acquired and maintained by all 3.

Mixed results were reported by 2 of the studies reviewed. One of these involved 84 minimally verbal children with ASD who had little previous experience with PECS. After PECS training, the spontaneous requesting skills of the group increased significantly (RR=2.17, 95 1.75-2.68, $p<0.001$), but some participants still made zero requests (Gordon et al., 2011). Boesch and colleagues (2013) conducted a stimulus preference assessment employing both PECS and an SGD to determine

which items were preferred by children with ASD. Strong effects in requesting items were observed with both PECS and the SGD using single picture cards, but when children were required to choose between two or more symbols, they had no success with either SGD or PECS.

Communication skills were assessed in 10 studies, 7 of which (70%) reported positive, and 3 (30%) mixed results. Ganz and colleagues (2009) used PECS for two male children with ASD both of whom showed an increased level of spoken words during the intervention, having produced no words at baseline. It should be noted, however, that one child occasionally used echolalia when producing speech (Ganz et al., 2009).

In a study of 8 children with ASD who participated in interventions with the Makaton system, all increased their scores significantly in both receptive language ($W = 0$, $p < 0.01$) and expressive language ($W = 1$, $p < 0.01$, according to Wilcoxon Value) (Lal et al., 2010).

Positive results were also reported by Van der Meer and colleagues (2013); one boy and one girl used at least one of the available AAC methods (PE, manual signing,and SGD), with high rates of communicative response, which were also evident at follow-up sessions. One boy with a dual diagnosis of cerebral palsy and ASD, who had previous experience with SGDs, showed an increase in communication skills after being introduced to a specific SGD, especially in the areas of refusing and obtaining items, as measured by goal attainment scaling (GAS) and a communication matrix (Desai et al., 2014).

Kasari and colleagues (2014) conducted a large-scale study with 61 minimally verbal children with ASD. They used SGD, along with two naturalistic behavioral

interventions. According to Schreibman et al. (2015), naturalistic interventions are "…implemented in natural settings, involve shared control between child and therapist, utilize natural contingencies, and use a variety of behavioral strategies to teach developmentally appropriate and prerequisite skills". Significant gains were observed in the spontaneous communication of the children when the SGD was used, compared with exposure to naturalistic behavioral interventions only. These gains in communication included different types of words and functions and not merely words for requesting.

Positive effects on communication were observed in a large-scale study, conducted with 35 children with ASD, comparing an SGD with PECS in teaching social communication behaviors. No significant difference was demonstrated between PECS and the SGD in terms of effectiveness, as both methods had equal success in enhancing the communication behaviors of the participants (Gilroy et al., 2018).

Mixed results in communication skills development were reported by 3 studies. PECS use had positive results for most of the 84 children in the study of Gordon and colleagues (2011), in terms of enhancement of spontaneous communication, but some remained at zero after the intervention. The most positive results were observed in those children with the least intense autistic symptoms. The increase in spontaneous communication skills concerned spontaneous object requesting and not communication for social purposes.

Flores and colleagues (2012) also reported that using SGDs or PECS produced positive results in the communication skills of some children, but not all of them. They note that no preference assessment was conducted before the intervention, which might have affected the results of the study. In the study of Muharib and

colleagues (2019b) the main objective was decreasing the challenging behaviors of children with ASD through establishing communication with an SGD. In one of the two participants, the challenging behaviors were minimized to zero, but the other continued to exhibit some challenging behaviors throughout the intervention.

Multi-symbol message use was assessed in one study, with positive results for all participants. The least-to-most (LTM) prompting procedure was followed by 6 participants, to achieve multi-symbol message production. SGD was used, and from no multi-symbol messages at baseline, after the intervention phase, where LTM was introduced, all participants were able to successfully produce multi-symbol messages (Finke et al., 2016).

Reading and spelling skills results were positive in one study, in which the reading and spelling skill observed was sight word reading, which is the automatic recognition of words that appear frequently. This study investigated whether the use of dynamic text alongside speech output and pictures from an SGD is effective in increasing sight word acquisition. At baseline, the 5 participants had low levels of accuracy when reading target words (less than 36% in total), but they scored almost 81% in total in the intervention phase, in which they were introduced to an AAC application with "Transition to Literacy" software (Caron et al., 2018).

Q2: Success of different forms of AAC in enhancing vocabulary

Success in vocabulary enhancement using various AAC modes was somewhat successful for children with ASD and was mentioned in only a few studies. Of the 20 studies that met the review criteria, only two were related to vocabulary assessment and acquisition in children with ASD (Flores et al., 2012; Caron et al; 2018), and even

in those, vocabulary enhancement and acquisition were not considered as variables, so this question cannot be answered by this review.

Q3: Types of AAC

The communication modes were considered in the studies as independent variables. As shown in Table 1, most studies (16/20) used SGDs for their intervention. Some used SGDs only, while others used SGDs and another form of AAC, to compare their effectiveness. PECS was used in 4/20 studies, Makaton in two and sign language in one.

INSERT TABLE 2 HERE

The specific devices used in the studies are shown in Table 2. Among the various SGDs that were utilized, most (almost 64%) were non-dedicated, meaning they were software applications that could be loaded onto a tablet or smartphone device (e.g., iPad, Samsung Galaxy tablet, etc.). The most popular of these is "Proloquo2Go" (Assistiveware, 2016). Evidence from another systematic review (Alzrayer et al., 2014) shows that "Proloquo2Go" is the most frequently researched non-dedicated SGD. Among the most important features of this application are the high-quality synthesized speech output, the wide range of pre-stored vocabulary, and the ability to customize icon size and number of icons displayed per page (Sennott& Bowker, 2009). Along with non-dedicated SGDs based on software applications (e.g., "Pick a word", "Proloquo2Go", "GoTalkNow", "DynaVox", etc.), some dedicated SGD devices were utilized also, including "Vantage", "Tech Speak", "SpringBoard" and "Proxtalker".

Q4: Follow-up and generalization

Of the 20 studies, 9 (45%) reported generalization probes, and 12 (60%) evaluated the maintenance of acquired skills. Generalization outcomes were positive in 8 out of 9studies (approximately 90%) and mixed in 1 out of 9 (approximately 10%). The various generalization probes concerned novel communication partners, new activities, new AAC devices or new preferred items, etc. Positive results were observed for maintenance in 8 out of 12 studies (approximately 66%) , and mixed results in 4 out of 12 studies (approximately 33%). For more detailed descriptions of these measures, readers must refer to the research articles that are cited in Table 1.

Q5: Demonstration of preference for particular AAC methods

Preference assessment was examined in two studies, both of which had positive outcomes. Preference for a specific AAC device or system was measured using the children's requests. In one study, two children with ASD indicated a preference for using one AAC system over the others; specifically, the boy chose the SGD over other AAC systems 91% of the total time, and the girl chose PE more often (69% of the total time), although she had been choosing the SGD at baseline (68% of the time) (Van der Meer et al., 2012). The same children participated in a follow-up study, in which each maintained the same preference (SGD for the boy and PE for the girl) (Van der Meer et al., 2013).

Discussion

Overall, as shown in Table 1, most of the studies demonstrated positive outcomes from AAC intervention, in terms of achievement of targeted skills. Intervention outcomes were classifiedinto 5 broad categories: requesting skills,

communication skills, preference assessment for AACs, multi-symbol message use, and reading and spelling skills. Other variables were also taken into consideration, such as modes of communication, intervention settings, andthe number of participants in each study. Our initial research hypotheses and the effects of these variables are discussed below.

Our first research question was whether the forms of AAC used in each study were successful in teaching requesting skills to children with ASD. The results from most of the studies that examined the effects of AAC (PECS, SGDs, manual signing, andPE other than PECS) in enhancing requesting skills were positive. Some studies focused on the accomplishment of single requests, while in others conducting multiple requests was the main objective. The study of Gordon and colleagues (2011), which included the largest number of participants (84l) showed mixed results using PECS, and some children didnot manage to make any requestsafter the intervention. It is of note the participants had little familiarity with PECS and that training occurred only at baseline and in the intervention phase. It is possible that the outcome may have been different if the PECS training had been applied prior to the intervention.

Teaching and enhancing requesting skills is one of the most common objectives in studies that use AAC devices. In some cases, it is the only skill that is being taught, by caregivers and researchers alike (Sigafoos et al., 2002; Mirenda, 2008). Future research should promote more complex types of communication, alongside requesting in general, taking multiple factors into account.

The second research question was whether using AAC modes was successful in enhancing the vocabulary of children with ASD. Unfortunately, our study was unsuccessful in proving that AACs did affect (either in a positive or in a negative

way) vocabulary development, as most studies on AAC tended to focus on other variables. The reason for this rather contradictory result is still not entirely clear, but we acknowledge that research on vocabulary enhancement and/or assessment for children with ASD using AAC devices is very limited and future studies should be focused on this aspect of language acquisition.

The third research question concerned the types of AAC devices or methods employed by researchers with children with ASD, and whether they represent adequately the range of devices available. Table 2 shows that those AAC modes were PECS, the Makaton language program, PECS, PE other than PECS, sign language and SGDs (both dedicated and non-dedicated). These represent most of the AAC methods available for children with ASD who have communication deficits, and in some cases, more than one AAC mode was used in the same study (Choi et al., 2010; Flores et al., 2012; Van der Meer et al., 2012; Van der Meer et al., 2013; Gilroy et al., 2018).

An important observation comes from Table 1 and Table 2 regarding the researchers' choice of AAC modes. Specifically, studies conducted in the past implemented low-tech or no-tech AAC modes (such as PECS, Makaton, manual signing, and more rarely, SGDs) while more recent studies are utilizing high-tech AAC devices (tablet-based SGDs) almost exclusively. This preference for high-tech non-dedicated SGDs among researchers is likely due to the fact that personal computers, tablet devices, and smartphones are widely used nowadays, and more and more children are familiar with this type of technology. Users of AAC are looking for devices that are low cost, lightweight, easily accessible and most importantly, accepted by society (Shane et al., 2012).

In addition, high-tech devices are really attractive to children with ASD, who become highly motivated to performactivities on electronic computers (Stromer et al. (2006). This is an indication that high-tech AAC devices can be suitable for children with ASD and other developmental disabilities who require alternative means of communication. A systematic review on aided AACs conducted by Ganz and colleagues. (2012a) identified 24 studies, 9 of which used PECS, 7 picture-based systems other than PECS, and 8 studies that implemented SGDs. In our review, 80% of the studies were based on the use of an SGD, mostly non dedicated.

Generalization and maintenance of acquired communication skills constitute the fourth question of this review. Generalization when using AAC devices is the ability to transfer acquired skills to different contexts and/or using different means of communication. Almost half of the studies reported generalization probes (novel communicative partners, new activities, AAC devices or preferred items, etc.), with mainly positive results. The only study with mixed results was that ofMuhariband colleagues (2019a), where not all participants managed to generalize requesting skills,although all were able to display requesting skills during the intervention generalization probe.

Maintenance refers to the ability to retain acquired skills long after the intervention. Maintenance was tested in a larger number of the studies and results were mainly positive. Mixed results were reported by Choi and colleagues (2010), where 1/4 participants failed to achieve high scores during follow-up sessions, and by Gordon and colleagues (2011), where follow-up scores were high only for spontaneous speech. In addition, follow-up scores were found not consistent across all AAC options (Van der Meer et al., 2013), and Muhariband colleagues (2019a) observed that only1/3 participants managed to maintain their newly acquired skills. It

must be noted that although generalization and maintenance assessments seem to have mainly positive results, readers should also refer to each study separately, where more information about these measures is given.

Preference for a specific AAC mode is considered to be an important variable by some researchers when designing interventions (Van der Meer et al., 2011). Preference assessment was conducted only in two studies (Van der Meer et al., 2012; Van der Meer et al., 2013). These studies involved the same two participants and they each expressed a clear preference for a specific different AAC mode in the primary study, which they maintained in the follow-up study. Assessing the preferences of children with ASD when using AAC is important, asthe use of the preferred mode can affect the intervention outcome (Van der Meer et al, 2011). It is important to note that as preference may change over time (Stafford et al., 2002), re-assessment might need to be made periodically.

Although AAC is mainly implemented for increasing communication in children with ASD, its effects on the academic skills, challenging behaviors, and social skills of these children should also be explored (Ganz et al., 2012a). Muhariband colleagues (2019b) examined the decrease in challenging behaviors of two children with ASD, using AAC for requesting preferred items. The intervention was successful for one child, who exhibited no challenging behavior during the intervention,but more participants would be needed to elicit conclusions.

Conclusions

Overall, this review indicates that using AAC systems has positive outcomes in enhancing the communication skills of children with ASD, but the findings should be viewed with some caution. There is a lack of uniformity in the sample sizes of the

studies, some of which referred to interventions with small samples of children, while in others the AACs were implemented for larger groups. A meta-analysis of the results could be a better indicator of the AAC effects.

Studies are needed on AAC intervention with larger samples of children with ASD, with clear indications of their level of functioning before the intervention, and with a range of outcome measures. Future studies should investigate additional questions, including the effects of AACsystems on the academic skills and social skills of children with ASD. The outcomes of each AAC strategy could also be compared, and the use of different types of symbols, as different methods may work in different ways for each individual with ASD, and for different age groups. Finally, the training in the use of AAC systems and the variation in the methods of specialists should also be considered as variables in future systematic reviews, because there might be some differential effects on the communicative performance of the children. For all these reasons, meticulous future research is imperative.

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Authors	Participant(s)	Setting	Type of AAC	Target communication skills	Target outcome(s)	Summary of results	Generalization	Maintenance
1.Ganz et al. (2009)	2 boys; age 5 to 6 years; ASD	School (private assessment suite)	PECS	Requesting skills/ Communication skills	Impact of PECS on communication and effects on maladaptive behaviors	Participants learned how to exchange pictures for requested items; generalization was achieved for some pictures	Positive Results	Positive Results
2.Choi et al. (2010)	4 boys; age 6 to 9 years; DD, SCI	Classroom (special education school)	PE and SGD	Requesting skills	Effectiveness of combining the missing-item and wrong-item formats to teach requesting and rejecting items	Increase in correct rejecting responses for all participant	Positive Results	Mixed Results
3.Lal (2010)	8 children; age 9 to 12	(Not	Makaton	Communication skills	Effectiveness of the	Change in social behavior and	-	-

	years; ASD	specified)			Makaton Vocabulary on development of language and social behavior	language, positive effect of AAC on development of receptive and expressive language		
4.Gordon et al. (2011)	84 children; age 4 to 10 years; ASD, ID	Classroom (special education school)	PECS	Communication skills/ Requesting skills	Form and function of spontaneous communication in non-verbal children with autism	Enhancement in children's spontaneous communication using PECS	-	Mixed Results
5.Cummings et al. (2012)	7 children; age 4-11 years; 3 with ASD	School (private assessment suite)	PECS	Requesting skills	Demonstration of experimental control of each PECS training condition over its respective target behavior	PECS protocols included well-sequenced training phases	-	-

6.Flores et al. (2012)	5 children; age 8 to 11 years; 3 with ASD	School (private assessment suite)	SGD and PECS	Communication skills/ Requesting skills*	Utility of the Apple iPad™ as a communication device compared with a picture-based system	Some increase in communication with the iPad. Preference for using the iPad rather than PECS	-	-
7.Van der Meer et al. (2012)	2 children; age 10 to 11 years; ASD	Home/ Classroom (special education school)	MS, PE and SGD	Requesting skills/ Preference assessment	Ability to learn requesting using 3 different AAC modes and preference	All participants learned how to make requests using at least one of the 3 AAC modes	-	Positive Results
8.Boesch et al. (2013)	3 children; age 4 to 12 years; ASD	University Speech Clinic (private assessment suite)	SGD ("ProxTalker"), PECS	Requesting skills	Efficacy of an SGD compared to PECS; validation of the PECS protocol modification	Increase in requesting skills with both AAC modes; no significant difference between PECS and the SGD	-	Positive Results
9.Van der	2 children;	Home/	MS, PE and	Requesting	Comparison	Both	Positive Results	Mixed Results

Meer et al. (2013)	age 10 to 11 years; ASD	Classroom (special education school)	SGD	skills/ Communication/ Preference assessment	of multistep requesting and communication acquisition using SL, PE and an SGD.	participants acquired the skill of multi-step requesting using each AAC mode. One showed preference for SGD		
10.Desai et al. (2014)	1 child; age 13 years; ASD	School (private assessment suite)	SGD	Communication skills	Efficacy of the SGD (training of student, teacher, educational assistant, parents)	Increase in communication skills	-	-
11.Kasari et al. (2014)	61 children; age 5 to 8 years; ASD	University Clinic (self-contained)	SGD	Communication skills	Efficacy of an SGD for improving spontaneous speech in minimally verbal children with ASD	Improvement in spontaneous communicative utterances, novel words and comments	-	Positive Results
12.Waddington et	3 children; age 7 to 10	University Clinic	SGD	Requesting skills	Evaluation of teaching	Improvement in performing	Positive Results	Positive Results

al. (2014)	years; ASD, SCI	(private assessment suite)			children to use an iPad-based SGD for making requests	communication sequences. Maintenance of the acquired skill		
13.Finke et al. (2016)	6 children; age 9 to 13 years; ASD	Classroom (private room in school)	SGD	Multi-symbol message use	Efficacy of a least-to-most prompting procedure for increasing use of multisymbol messages	Increase in multisymbol message production	Positive Results	Positive Results
14.Alzrayer et al. (2017)	4 children; age 8 to 10 years; ASD	Classroom (self-contained)	SGD	Requesting skills	Efficacy of systematic instruction on teaching multistep requesting skills using an SGD	Increase in multistep requesting using a tablet-based SGD. Generalization was demonstrated	Positive Results	-
15.Gevarter et al. (2017)	2 children; age 6 to 8 years; ASD	Home	SGD	Requesting skills	Efficacy of teaching requesting skills using different	Request of preferred, available items using different AAC app display	-	-

					types of AAC. Impact on acquisition, rate of acquisition, consistency of requests	formats; these must be customized to each child's needs		
16.Caron et al. (2018)	5 children; ages 6 to 14 years; ASD	Classroom (self-contained)	SGD	Reading & spelling skills	Efficacy of an SGD software in teaching sight word reading skills	Increase in accuracy of identification of sight words	Positive Results	Positive Results
17.Gilroy et al. (2018)	35 children; age 5 to 13 years; ASD	School (special education school)	PECS and SGD	Communication skills	Comparison of a high-tech SGD with PECS in teaching social and communication skills	Both types of intervention were effective, with no significant difference between the two	-	-
18.Alzrayer et al. (2019)	3 children; age 7 to 10 years; ASD	School (private assessment suite)	SGD	Requesting skills	Effectiveness of an SGD in teaching multistep social-	Success in performing multistep requesting sequences,	Positive Results	Positive Results

					communication skills	after modifications for two		
19.Muharib et al. (2019a)	3 boys; age 6 to 8 years; ASD, DD	Classroom (self-contained)	SGD	Requesting skills	Effectiveness of behavior-based instruction combined with SGD on acquisition of functional communication skills	Increase of both SGD-based and vocal requesting in all 3. Generalization achieved for two of them	Mixed Results	Mixed Results
20.Muharib et a (2019b)	2 children; age 5 to 6 years; ASD	Classroom (self-contained)	SGD	Communication skills	Effects of functional communication training using an iPad as an SGD on challenging behaviors	Decrease in levels of challenging behaviors after intervention	-	-

Table 1. Studies on the effectiveness of augmentative and alternative communication (AAC) in children with autism spectrum disorder (ASD) included in the review (n=20)

* requesting skills here were NOT a variable in this study, but only the means of measuring frequency of communication

DD= Developmental Disabilities

ID= Intellectual Disability

SCI= Severe Communication Impairment

SGD= Speech-Generating Device

SL= Sign Language

PECS= Picture ExchangeCommunication System

Table 2. Target communication skills and augmentative and alternative communication (AAC) systems used in the studies on children with autism spectrum disorder (ASD) included in the review

Authors	**Communication skills taught**	**Type of AAC**	**AAC Details**

1. ***Ganz et al. (2009)***	Requesting items (a)/ use of speech and intelligible words (b)	PECS	-
2. ***Choi et al. (2010)***	Requesting-rejecting sequence (for items) (a)	SGD/ PE	Vantage, Tech Speak, Springboard
3. ***Lal et al. (2010)***	Development of language and social behavior (b)	Makaton	-
4. ***Gordon et al. (2011)***	Spontaneous communication (b)/ spontaneous communication for requesting objects/ spontaneous requesting for social purposes (a)	PECS	-
5. ***Cummings et al. (2012)***	Exchanges/ requesting skills (a)	PECS	-
6. ***Flores et al. (2012)***	Frequency of communication behaviors (b) (through requesting skills*)	SGD/ PECS	iPad with Pick a word
7. ***Van der Meer et al. (2012)***	Requesting skills (a) / preference assessment for 3 different AAC methods (c)	MS/ PE/ SGD	iPod Touch with Proloquo2Go
8. ***Boesch et al. (2013)***	Requesting skills (a)	SGD	Logan “Proxtalker” device
9. ***Van der Meer et al. (2013)***	Requesting skills (a) / Communication skills (b)/ preference for AAC and social communication (c)	MS/ PE/ SGD	Proloquo2Go
10. ***Desai et al. (2014)***	Communication skills (b)	SGD	iPad with GoTalk Now
11. ***Kasari et al. (2014)***	Spontaneous communication utterances (or: spoken spontaneous language) (b)	SGD	iPad/ Dynavox
12. ***Waddington et al.***	Requesting skills (via three-	SGD	iPad with Proloquo2Go

(2014)	step communication sequence) (a)		
13. Finke et al. (2016)	Use of multi-symbol messages (d)	SGD	iPad with Proloquo2Go
14. Alzrayer et al. (2017)	Requesting skills (multistep) (a)	SGD	iPad with Proloquo2Go
15. Gevarter et al. (2017)	Requesting skills (a)	SGD	iPad with AutisMate
16. Caron et al. (2018)	Sight-word reading (e)	SGD	Tablet device with T2L
17. Gilroy et al. (2018)	Improvement of social communication behaviors(b)	SGD/ PECS	Samsung Galaxy Tablet with AAC app based on PECS
18. Alzrayer et al. (2019)	Requesting skills (multistep) (a)	SGD	iPad with Proloquo2Go
19. Muharib et al. (2019a)	Requesting skills (a)	SGD	iPad with Proloquo2Go
20. Muharib et al. (2019b)	Challenging behaviors (b) (through requesting preferred stimuli)	SGD	iPad with GoTalkNow

*requesting skills here were NOT a variable, but only the means of measuring frequency of communication

a) requesting skills, b) communication skills, c) preference assessment, d) multi-symbol message use, e) reading/spelling skills

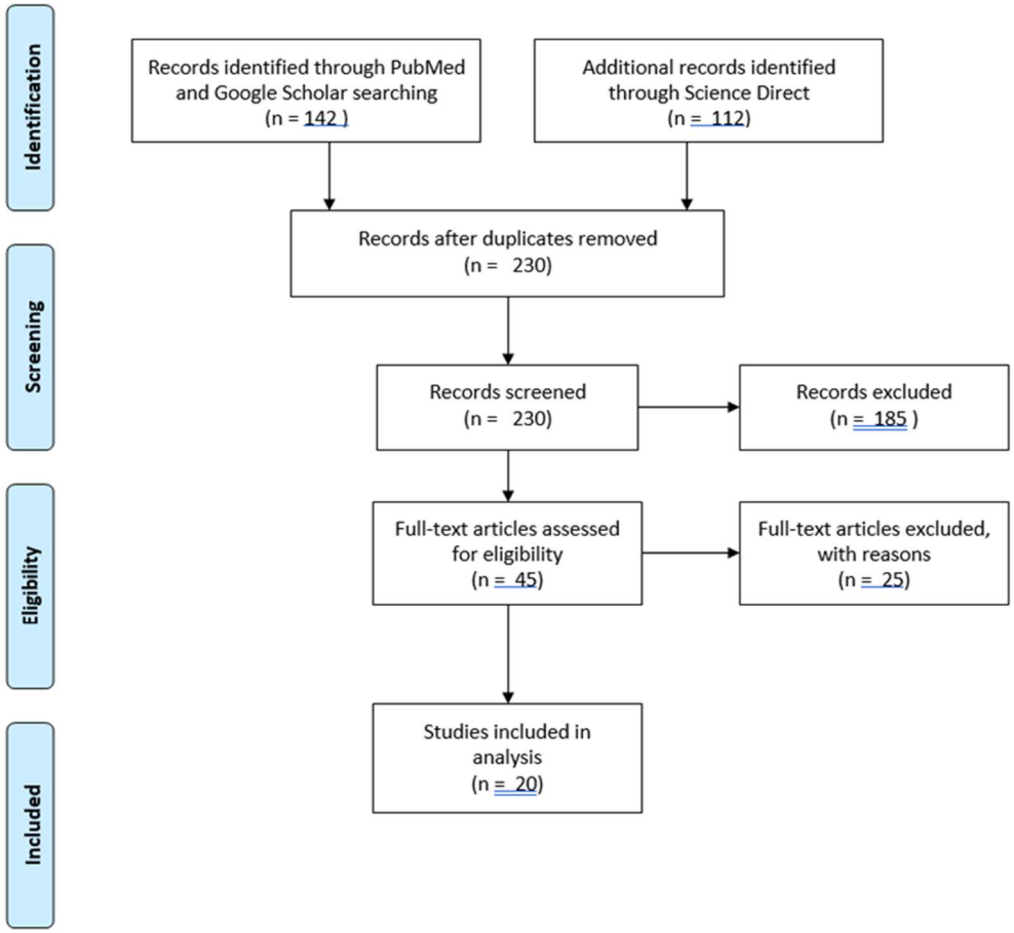

Figure 1. PRISMA Flow Diagram(after Moher et al., 2010).

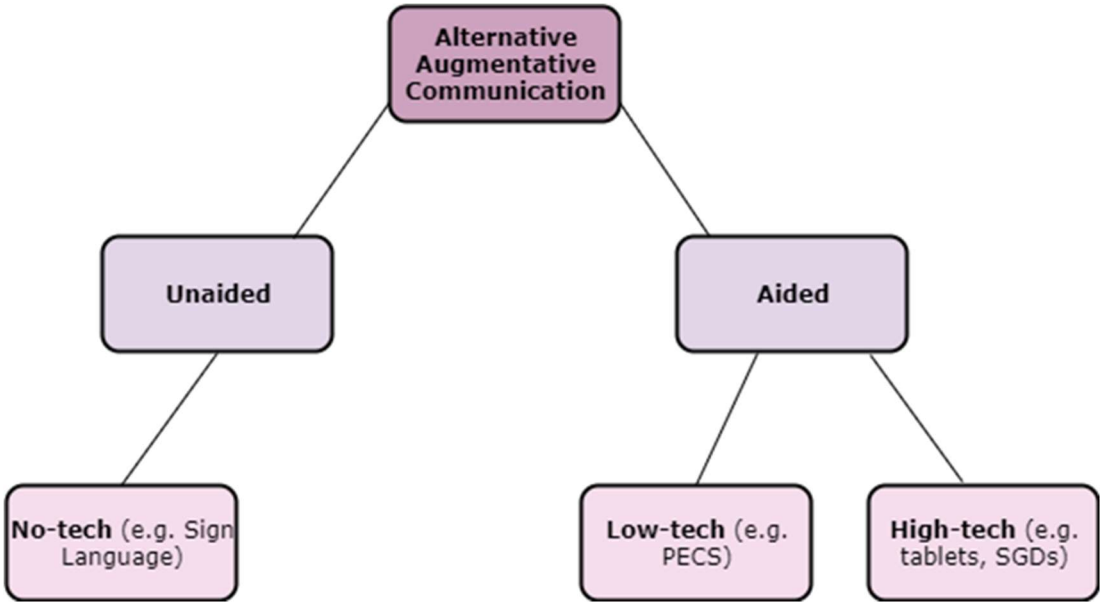

Figure 2. Categorization of augmentative and alternative communication (AAC) systems