A comparison of Picture Exchange Communication System (PECS) and Speech-Generating Device (SGD) as communication aids for children with Autism Spectrum Disorders

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Abstract

The aim of the study was to compare the effectiveness of two different Augmentative Alternative Communication (AAC) tools, the Picture Exchange Communication System (PECS) and a Speech-Generating Device (SGD), as communication aids for children with autism. The participants were three children with severe autism who were minimally verbal or had no functional language. The results indicate that both AAC intervention strategies led to an increase in communicative behavior, with a slightly shorter acquisition time observed for the SGD training. Furthermore, two out of three participants showed a preference for the SGD.

Moreover, we observed a reduction in problem behaviors and an improvement in vocal production in one of the participants. These findings suggest that both PECS and SGD are equally suitable for developing initial request skills and can also encourage speech production in students with specific prerequisites. Overall, the study highlights the potential benefits of both PECS and SGD in facilitating communication for children with autism.

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1. Introduction

People diagnosed with autism spectrum disorder (ASD) have significant difficulties with social interaction skills, such as making eye contact, responding to their name, and difficulty in understanding social stimuli (e.g., facial expressions, body language, changes in speech inflection). According to the National Institute on Deafness and Other Communication Disorders (NIDCD, 2010), about 25% of people with ASD are unable to use language naturally to communicate. These deficits tend to persist throughout life (Howlin, Mawhood, & Rutter, 2000); however, improvements are possible when early and intensive behavioral interventions (EIBI) are implemented (Matson, Matson, & Rivet, 2007) and treatment is personalized to meet the needs of the individual (Cerasuolo, Simeoli, Nappo, Gallucci, Iovino, Frolli *et al.*, 2022; Iovino, Canniello, Simeoli, Gallucci, Benincasa, D'Elia *et al.*, 2022).

Alternative Augmentative Communication (AAC) tools offer forms of communication that can make communication easier for children with ASD than traditional forms, such as spoken language. Three forms of AAC used with children with ASD include unaided approaches (e.g., signs and gestures), low-tech image-based systems (e.g., PECS), and "hi-tech" speech-generating device (SGD) systems (Ganz, 2015).

AAC tools must be customized to user needs. For this reason, Blackstone and colleagues (Blackstone, Williams, & Wilkins, 2007) suggested that the prerequisite skills required for any form of AAC take into account and match the child's strengths (Blackstone *et al.*, 2007). The effectiveness of an AAC method also depends on the ability to personalize the tool with which the child will interact. Furthermore, the authors recommend that the communication context, as well as communicative goals, be taken into consideration when selecting an AAC device. Therefore, the choice of an appropriate AAC system can be considered one of the most important aspects of language intervention. The literature on this topic is still very controversial. Although it is clarified that there are prerequisites for choosing between signs and picture systems, when it comes to choosing between different picture systems, the literature remains very limited. In other words, we are not yet able to establish which child is best suited to using pictograms and traditional PECS systems and which child is best suited to using a technological system, such as SGDs. For this reason, this study focused precisely on this aspect.

Several studies indicate that for children with ASD, the most effective

AAC tools are PECS and SGD (Bondy & Frost, 1998; Bondy, 2001; Schlosser & Blischak, 2001; Thomson, 2003; Lorah, Holyfield, Miller, & Griffen, 2022). Some recent studies have highlighted the preference for technological tools, such as tablets, as they are more engaging for children (Simeoli, Arnucci, Rega, & Marocco, 2019). During PECS training, the student is asked to hand a picture to a communication partner, the picture corresponds to the object he/she wishes to obtain (Bondy & Frost, 1998). With SGD, instead of exchanging a picture, the student learns to touch or drag an icon, depicting the desired object, onto the screen of an electronic device, which produces a recorded message structured in the following form: "I want" (Sigafoos, Didden, & O'Reilly, 2003).

The PECS system was originally designed to increase spontaneous requests. However, several studies have demonstrated additional positive effects. Numerous studies have shown that interventions targeting communicative skills are the preferred strategies for mitigating problem behavior (Iovino *et al.*, 2022). Charlop and colleagues (Charlop-Christy, Carpenter, Le, LeBlanc, & Kellet, 2002) also reported a decrease, and in some cases complete elimination, of problem behaviors after the implementation of PECS. In the same study, the beneficial effects of PECS on several communicative and social behaviors (e.g., eye contact, joint attention, and shared play) were demonstrated. Other studies have also shown positive effects of the PECS system on spontaneous language production (Charlop-Christy *et al.*, 2002; Tincani, Crozier, & Alazetta, 2006). Some authors (Schlosser & Wendt, 2008; Preston & Carter, 2009; Hart & Banda, 2010) concluded that PECS is the best method to increase the mand repertoire, as well as other communication skills.

On the other hand, SGDs are devices designed to produce recorded or synthesized vocal outputs. They are designed to accommodate a variety of configurations that allow for customization and individualization, which is especially helpful for students with severely limited language skills (Lloyd, Gatherer, & Kalsy, 2006).

Many SGD studies demonstrated increased manding capabilities (Durand, 1993; Sigafoos *et al.*, 2003; Sigafoos, Drasgow, Halle, O'Reilly, Seely-York, Edrisinha *et al.*, 2004; van der Meer, Didden, Sutherland, O'Reilly, Lancioni, & Sigafoos, 2012; Rega, Somma, & Simeoli, 2018), while a few studies have demonstrated a more general increase in vocal production (Parsons & La Sorte, 1993; Olive, de la Cruz, Davis, Chan, Lang, O'Reilly *et al.*, 2007) or other communication and social interaction skills (Sigafoos, Green, Payne, Son, O'Reilly, & Lancioni, 2009). Data from

Schlosser and Wendt (2008) revealed that SGDs can help increase students' speech production. While increased language skills are well documented with SGDs, information is scant concerning the effects of SGDs on social interaction skills.

The SGD we used for this study, the Language Interface for AAC Rehabilitation (LI-AR), is a new type of SGD (Rega, Mennitto, & Iovino, 2017; Simeoli, Iovino, Rega, & Marocco, 2020). Its software creates innovations to teach social interaction skills. During LI-AR training, vocal output is completely managed by a communication partner/therapist. Through a Bluetooth device, the therapist decides to activate the voice output only if the student has successfully completed the communication task, approaching the therapist and handing him/her the tablet. External management of vocal output ensures that training is focused on the prerequisites of communication, in this case the communicative exchange.

Only a few studies have compared the acquisition of manding skills using the PECS and SGD systems and there are only minimal differences between the two systems in terms of ease of use and speed of skill acquisition. For example, Sigafoos and colleagues (2009) studied the timing and preferences of acquiring the skills required for the two types of communication systems. The results showed slight differences in terms of speed of skill acquisition, with PECS being slightly more efficient. Two participants showed a preference for SGD during the first sessions of assessment, but this preference shifted to PECS towards the final stages of the intervention.

Son and collaborators (Son, Sigafoos, O'Reilly, & Lancioni, 2006) compared the effectiveness, preference, and speed of skill acquisition between SGD and PECS, noting a slight preference for two of the participants who used the PECS system; this preference, however, was not related to better performance or faster skill acquisition (Son *et al.*, 2006). Other studies have produced opposite results; for example, Lorah and colleagues (Lorah, Tincani, Dodge, Gilroy, Hickey, & Hantula, 2013) compared the use of the iPad with SGD and the PECS system in 5 preschool students with autism. All participants acquired communication skills using both tools, but students produced more independent requests via SGD and 4 of the 5 participants showed a preference for it over the PECS system.

According to what has emerged from the data reported thus far, most of the studies that have compared the effectiveness of PECS and SGD have mainly focused on the ability to request what is desired, neglecting all the aspects simultaneously involved in verbal behavior, such as communication prerequisites. An important aspect is social interaction, which is the basis of

every truly communicative act. Communication is a behavior, topographically defined by the community, directed towards another person who then provides the consequence. Verbal behavior can only be defined as effective if it includes the mediation of another person (Skinner, 1957).

Social interaction can be defined as the ability to actively initiate and maintain communication with a partner and to refrain from other socially inappropriate behaviors (Gresham & Elliott, 1984; Matson & Wilkins, 2007). Effective social interaction requires the integration of various social and communication skills. For example, when a communication exchange begins to gain a preferred element, it would be socially appropriate for those using an AAC system to look and orient towards the communication partner, rather than look in the opposite direction. Sigafoos and collaborators (2009) observed that there were no significant differences between the social interaction effects on the social interaction of PECS and SGD training, although training with the PECS method required a slightly more direct interaction with a communicative partner. However, this result cannot be considered exhaustive and the aspect should therefore be explored further. This study was aimed at comparing the use of SGD and PECS to teach manding skills to children with ASD, using a specific LI-AR AAC software for the SGD training procedure. Of primary interest in this study was the relative (i) efficacy; (ii) preference for and (iii) acquisition time associated with each system. A secondary interest of the study was to evaluate the effect on two additional dependent variables, namely: (i) the increase in communication ability (e.g., understandable vocalization, word production, signs, pointing, request with SGD or PECS), and (ii) decrease in minor problem behaviors.

2. Methods

2.1. Participants

Three children aged between 3 and 10 years old with a diagnosis of autism spectrum disorder detected via ADOS-2 (Autism Diagnostic Observation Schedule) participated in the study. Parents and caregivers of all participants gave their informed consent for inclusion before participating in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Psychological Research Ethics Committee of the Department of Humanities of the University of Naples Federico II (Italy).

The 3 children did not have communication skills acquired through PECS, nor SGD systems. Participants had communication skills of ≤ 2.0 years old and fine motor skills of 1.0 years old, as measured by the Vineland Adaptive Behavior Scale (VABS-II; Sparrow, Cicchetti, & Balla, 2005). The Leiter-3 test was used to obtain IQ scores that ranged between 60 and 85. Both assessment tools were administered by an appropriately trained psychologist who was completely unaware of the research hypothesis.

Laura was a 10 year old girl. Before the study, her non-verbal communication skills were affected by verbal dyspraxia, resulting in difficulty articulating speech; however, when objects were present, she neither attempted to reach for nor grasp them.

Dario was a 4 year old boy. He lacked functional use of language; he exhibited echolalia of partial words and predominantly monosyllabic vocalizations. Additionally, he did not possess communication skills via either PECS or SGD. Previous attempts at sign language training were unsuccessful due to Dario's tendency to scroll, prompting termination.

Marco was a 3 year old boy. He did not use language in a functional way, but we observed only a few episodes of echolalia. He did not initiate verbal requests; instead, he obtained, indicated, or echoed the requests made to him to satisfy his needs or desires. Prior to this study, he had never had experience with any AAC system, nor with any visual-graphic tool, including PECS or SGD. Moreover, he exhibited escape and avoidance behaviors, as well as expressed complaints resulting from frustration.

In compliance with privacy regulations, the names used are fictional.

2.2. Materials, settings, and sessions

The experiment took place in a 5 by 3 meter room, in the presence of both a therapist and an assistant as prompter. Inside the room, there was a table and two chairs arranged facing each other. During the sessions, the Speech Generating Device (SGD) and the Picture Exchange Communication System (PECS) book remained on the table, except during the training sessions when only the system being trained was present. Once the favorite objects were identified, they were placed inside a transparent container, positioned where the child could see them but not reach them. During the SGD training, we used the LI-AR software, an Augmentative and Alternative Communication (AAC) program, installed on an Android 6.0 Tablet. For PECS training, we used a standard PECS book, where each symbol represented a preferred item. Through a preference assessment, we

identified a minimum of 5 favorite items for each participant. To determine the most preferred items, the Multiple Stimuli Without Replacement procedure was used, as described by DeLeon and Iwata (1996). To ensure comparability, three sets of reinforcers were selected, each set being equivalent but independent, and then randomly assigned to the SGD or PECS condition. During the sessions, communication behaviors were meticulously recorded using a verbal behavior observation form.

The three participants engaged in various sessions for the study, ranging from a minimum of 22 to a maximum of 29. These sessions included baseline, treatment, and follow-up sessions structured as described in the procedure paragraph. Furthermore, each child was offered a preference assessment protocol before starting the study and, every 4 training sessions, a short preference assessment session for AAC tools was proposed (see procedure paragraph). Baseline sessions were estimated to last 10 minutes, while training sessions could vary in duration and had to include at least 3 teaching trials.

2.3. Response definition and measurements

2.3.1. Primary measurements

In accordance with the main objective of the study, to evaluate the change in communication behaviors, we recorded the percentage of occurrence of:

(a) Mand;
(b) understandable vocalizations;
(c) word production;
(d) pointing;
(e) AAC.

The term mand or request refers to the verbal response to a non-verbal discriminative stimulus, in the absence of a verbal discriminative stimulus (Charlop, Schreibman, & Thibodeau, 1985).

To analyze the change in vocal production, we calculated a "speech quality" index for each occasion of request, as described below:

(a) 0 points were scored if no vocalization occurred;
(b) 0.5 points for non-functional and not understandable vocalization;
(c) 1 point for each vocalization that was functional and understandable, but not completely pronounced (e.g., at least half of the syllables of which the original word was composed);
(d) 2 points for understandable and functional vocalization.

The request with an AAC system occurred whenever a participant independently exchanged an image from the PECS notebook or when they used the tablet to obtain the preferred item in accordance with the stage of training reached. These dependent variables were monitored and recorded before, during, and after training.

2.3.2. Secondary measurements

In addition to communication behaviors, several secondary measurements were recorded:

(a) acquisition speed (the percentage of correct responses to the training);
(b) the preference for a specific AAC method;
(c) minor problem behaviors;
(d) vocal production.

These behaviors were recorded during 10-min sessions divided into 20 30-second intervals.

Problem behaviors were topographically defined as:

(a) Grabbing: try to grab an object from the operator's hands during the training;
(b) Out of seat: leave the chair or move away without permission;
(c) Tantrum: cry or complain;
(d) Disruptions: destroy objects, injuring oneself or attempting to injure others.

All of these measures were recorded across sessions and averaged per session (as shown in the following graphs). More specifically, a partial interval recording was applied to measure the occurrence of behaviors.

Probe sessions were organized twice a week for the duration of the baseline period and every 4 days of training, during the training period. As for the baseline, follow-up occurred twice a week, 2 months after the end of the training period. These sessions were detailed in the paragraph below.

All sessions were videotaped to enable two observers to collect all data on target behaviors separately. The two observers independently scored 100% of the sessions to calculate inter-observer agreement (IOA). Partial interval agreement was calculated by dividing the sessions into 30-s intervals and dividing the number of agreements per interval by the number of agreements plus disagreements and multiplying the result by 100.

2.4. Experimental conditions and design

To compare the results and verify the onset of a change in the

participants' communication behavior, a multiple baseline design (MBD) across participants (Baer, Wolf, & Risley, 1968) was used in this study combined with an adapted alternating treatment design (AATD; Sindelar, Rosenberg, & Wilson, 1985). The MBD allowed the introduction of the treatment at different times, for each of the participants, to evaluate whether the onset of behavioral change coincided with the treatment itself. The AATD allowed therapists to simultaneously teach the request using both systems, without any interruptions.

2.4.1. AAC Preference Assessment and Probe Sessions

At the beginning of the study, a preference assessment was conducted according to the multiple stimulus-without-replacement assessment procedure (DeLeon & Iwata, 1996; DeLeon, Iwata, & Roscoe, 1997).

After every 4 days of training (i.e., 2 for PECS, 2 for LI-AR), to avoid sequence effects, the participant was offered the opportunity to choose which communication device to work with. The session was set up just like the baseline sessions where we created 5 request opportunities by imposing an Establishing Operation (EO). The participant had the opportunity to choose how to communicate, and both AAC tools were available on the table. The therapist asked the child "What do you want?" and then observed which of the two tools was chosen. At the end of the session, the therapist started a training session with the most chosen tool and then trained the least used tool during the next session.

After carrying out the initial assessment of preferences, the research protocol began, following the sessions described below.

2.4.2. Baseline

During baseline sessions, both systems (PECS and SGD) were placed on the table. Students had the opportunity to make requests whenever they wanted, but the therapist arranged 5 request opportunities according to the following procedure. The therapist showed the preferred items to increase the student's motivation operation (MO) and provided a brief period of free access to the suspected reinforcers and subsequently blocked access to those items (Endicott & Higbee, 2007; Jennett, Harris, & Delmolino, 2008). The baseline lasted 10 min during which the therapist kept the student engaged in work or play activities and created 5 opportunities to request the preferred items, showing the child the most motivating objects, arranged on a tray, positioned to be visible but not reachable by the child. The therapist enhanced the child's motivation by providing brief access and then depriving

him/her for a short period.

During the 10 seconds following withdrawal of the reinforcer, any behaviors aimed at regaining access to the reinforcer were recorded. At the end of the 10 seconds, reinforcers were delivered regardless of the student's responses.

2.4.3. Training

During the training sessions, the two AAC systems were introduced, alternately. Each training phase included three sessions, each of three trials. The selection of the initial system for each participant was randomized (Flores, Musgrove, Renner, Hinton, Strozier, Franklin *et al.*, 2012). After one of the three participants completed the baseline sessions, a system to start with was decided. Subsequently, the other participant started with the alternative system once the baseline sessions were concluded.

The training procedure for each tool is explained in detail below.

For PECS training, all participants experienced the first 3 phases of training according to the original PECS protocol (Bondy & Frost, 1998), and a fourth phase added for the purposes of this study in which children were taught to use the PECS book to select a single picture. This was done to make the two procedures comparable. Pictures at this stage were categorically divided within the book onto different sheets. During the study, the PECS binder only included images selected from the reinforcers, as did the SGD.

We did not teach how to construct more complex sentences. A student's participation in the training portion of the study ended when he/she learned to functionally request a single item at a time.

The LI-AR training was presented after a minimum of 5 baseline sessions. It was delivered by a Board-Certified Behavioral Analyst who had been previously trained in LI-AR training procedures, who was unaware of the research hypotheses, and exclusively followed the LI-AR teaching procedure.

The LI-AR training phase was organized to be comparable to that used for PECS. The prerequisite for LI-AR training only required the ability to drag an object on a touchscreen.

The tool involved five distinct phases; in this study, students participated in three of these phases and in a fourth phase, which was adapted for the study, in which the children were taught to select a picture and the pictures were categorically divided into different pages reachable by swiping on the tablet screen from right to left and vice versa.

2.4.3.1. *Phase I*

The child was in the presence of his/her major reinforcers. When the participant's MO was revealed, the therapist asked the student to drag the image corresponding to the desired item towards the box positioned at the top of the screen, as shown in Figure 1. This action produced the vocal output and the student obtained the item requested.

Figure 1 – *An example of the SGD screen during Phase I and Phase II*

2.4.3.2. *Phase II*

The conditions were the same as in the previous phase, but in this phase, the student learned to "exchange". The vocal output was produced by an external action of the therapist, only after the child handed the tablet to the therapist. More specifically, after the student dragged the image in the right way (Fig. 1), the prompter, who was positioned behind the student, invited the student to take the tablet and hand it to the therapist. After the exchange, the therapist managed the vocal output through the Bluetooth device and, subsequently, reinforced the student with the chosen item.

During this phase, the student learned that the exchange, i.e. bringing the tablet to the therapist, was necessary to obtain the item.

This phase was divided into two different parts as per phase II of the PECS training. The therapist worked on distance and persistence, progressively moving away from the child.

2.4.3.3. *Phase III*

The teaching procedure and conditions were the same as in the previous phases. The only difference was that the pictures shown on the screen were managed by the therapist; more specifically, the therapist managed the presence of distractors to train the discrimination skill (Fig. 2).

Figure 2 – *The SGD screen during Phase III. Some distractors are presented in addition to the image ofthe main reinforcement*

2.4.3.4. *Phase IV*

This condition was like the previous, but the pictures on the screen were categorically divided into several sheets (Fig. 3). In this phase, the student had to learn to find the picture corresponding to the desired object by navigating between the various pages. Students were completely free to choose any of the reinforcers following their MO. Each complete exchange, according to this procedure, was considered a complete functional communication behavior.

Figure 3 – *The SGD screen during Phase IV. All items are presented, they are divided into differentsheets, according to their category*

2.4.4. Follow-up

Two months after the last observation, three probe sessions were proposed to observe the maintenance of the acquisitions. These sessions were arranged as for the baseline (see paragraph 2.4.2).

3. Results

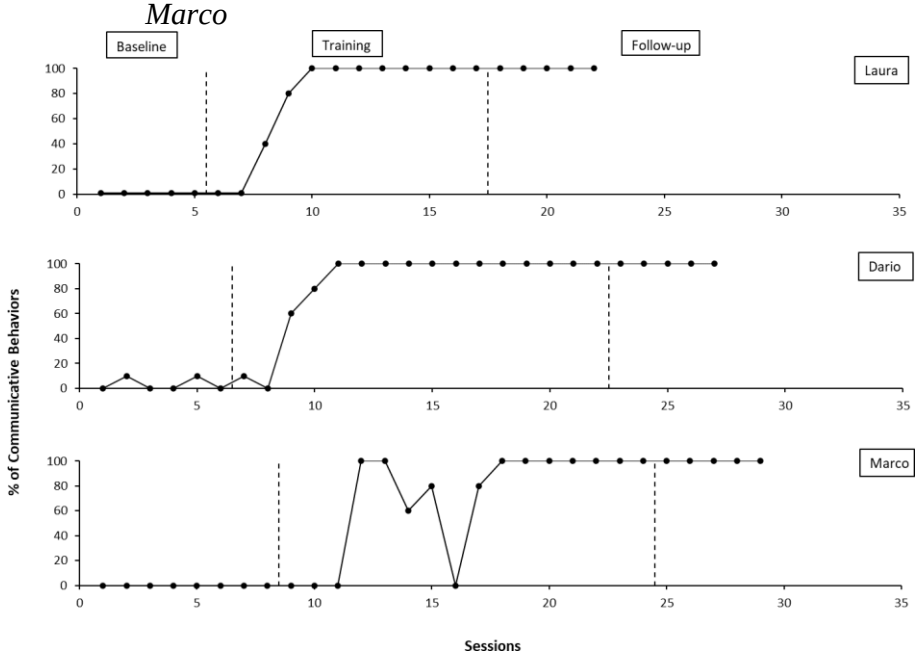
During baseline (Fig. 4), none of the participants exhibited functional communication behaviors. Laura mostly emitted some indistinct moans

perhaps as a request, Marco presented some incomprehensible vocalizations and a few approximations of words. Dario displayed disorganized behavior to obtain what he wanted on his own. As shown in Table 1, all the participants showed some attempt to communicate with either system since the first probe session was presented after the first 4 training sessions. The training took effect with a very short latency (Fig. 4).

Table 1 – *Percentage of preference for PECS and LI-AR tools during the observation sessions*

	Baseline		Phase I		Phase II		Phase III		Phase IV		Follow up	
	PECS	LIAR	PECS	LIAR	PECS	LIAR	PECS	LIAR	PECS	LIAR	PECS	LIAR
Laura	-	-	-	100%	5%	95%	-	100%	20%	80%	-	100%
Dario	-	-	40%	60%	20%	80%	-	100%	-	100%	-	100%
Marco	-	-	-	-	18%	82%	83%	17%	60%	40%	50%	50%

Figure 4 – *Percentage of intervals in which a communicative behavior appears (understandable vocalization, word production, pointing, sign, use of PECS or SGD) for Laura, Dario and Marco*



Laura showed a rapid increase in communicative behavior, she reached 100% of communicative behavior halfway through the training phase. This

percentage was high and stable along the progress of the study. After the training was introduced, she chose to communicate with LI-AR with an average percentage of 95% during the probe session (Tab.1).

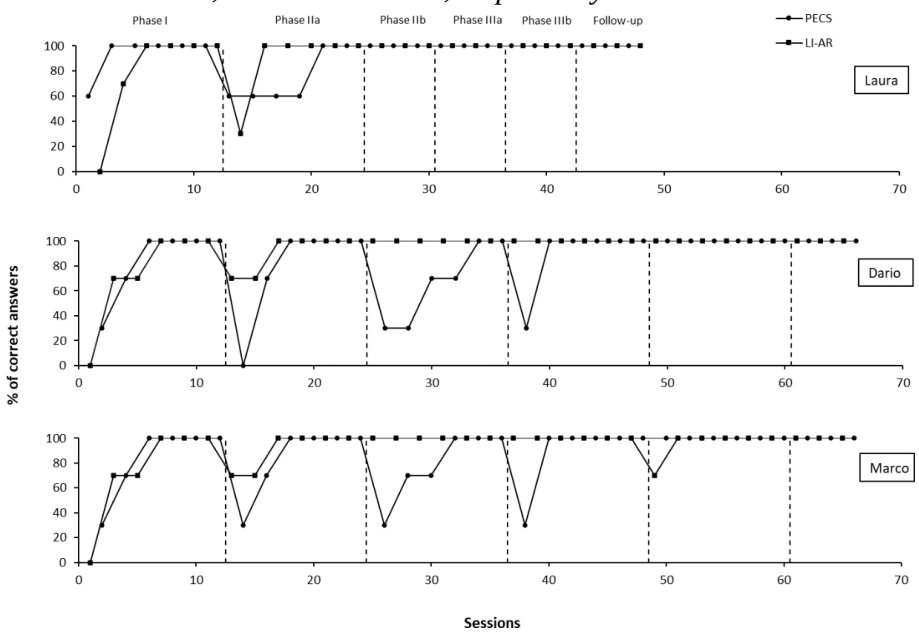
Dario also showed a rapid increase in communicative behaviors. He achieved 100% communicative behavior after 4 probe sessions during training. He showed a preference for LI-AR with a percentage of 88% (Tab. 1).

Marco had a more fluctuating and deviant trend than the others. At the beginning of treatment, he did not show any communicative behavior. After 3 probe sessions during the training period, there was an increase followed by a sharp decrease in communicative behaviors. After this episode the communicative behaviors increased, remaining high throughout the study. Marco showed a preference for PECS with a percentage of 53% (Tab. 1).

This data was analyzed by a second independent observer for 50% of the sessions. An Interval-by-Interval IOA method showed an accordance of 95%.

Visual inspection showed that the acquisition criteria for the SGD condition were reached before the PECS condition (Fig. 5).

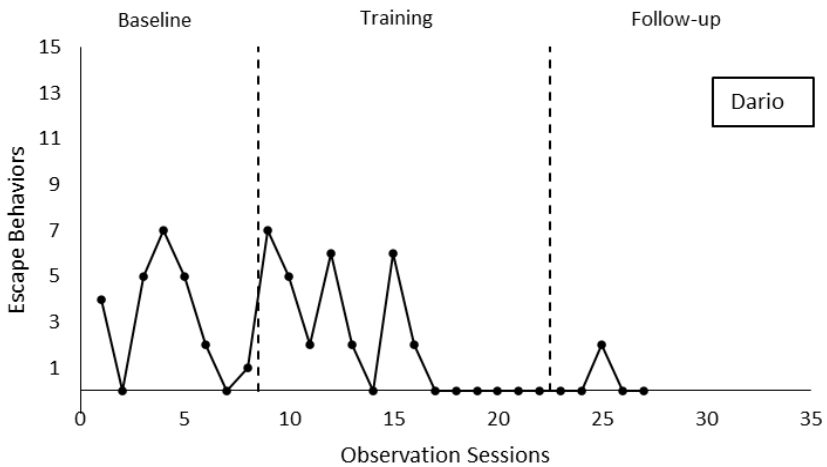
Figure 5 – *Percentage of correct answers per session for both SGD and PECS training in an AATD. Fromtop to bottom the graphs for Laura, Dario and Marco, respectively*



A consistent downward peak emerged each time the children changed phase with PECS. For SGD training, a declining peak emerged only for Phase I. The acquisition times were consistent within the students but not between them. In fact, Laura reached the acquisition criteria very quickly (18 LI-AR sessions, 24 PECS sessions). Dario needed 24 LI-AR training sessions and 30 PECS training sessions to reach the acquisition criteria, while Marco required 23 LI-AR training sessions and 27 PECS training sessions to reach the acquisition criteria. For all participants the acquisition criteria for SGD training were achieved faster than those for PECS training.

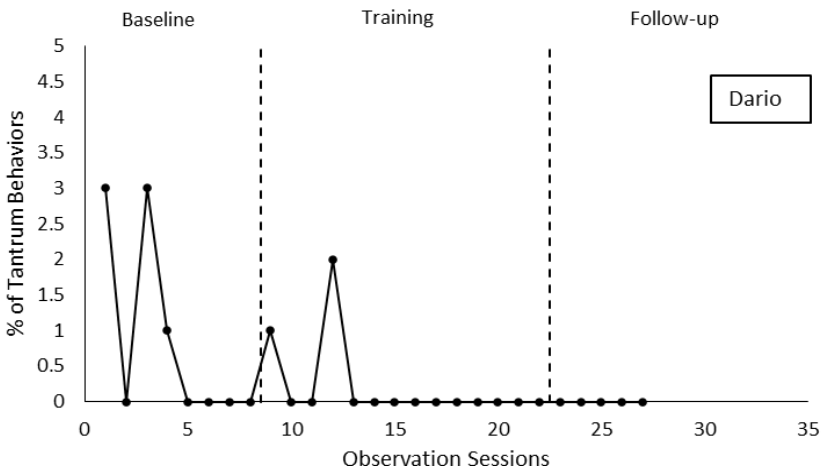
Problem behaviors and vocal production were observed for Dario, who was the only one to show hints of understandable vocalization and problem behaviors (e.g., escaping and complaining) before the study. Escape and tantrum behaviors were observed separately. The graphs in Figure 6 and Figure 7 shows the percentage of intervals in which these two behaviors occurred, respectively.

Figure 6 – *Percentage of interval with the occurrence of escape behaviors. The graph shows the results for Dario before, during and after treatment*



As shown in Figure 6, escape behaviors occurred with an average of 3 for session during baseline, a decreasing trend was clear during treatment with an average of 2.3 per session. During follow-up the occurrence of this behavior reached an average of .4.

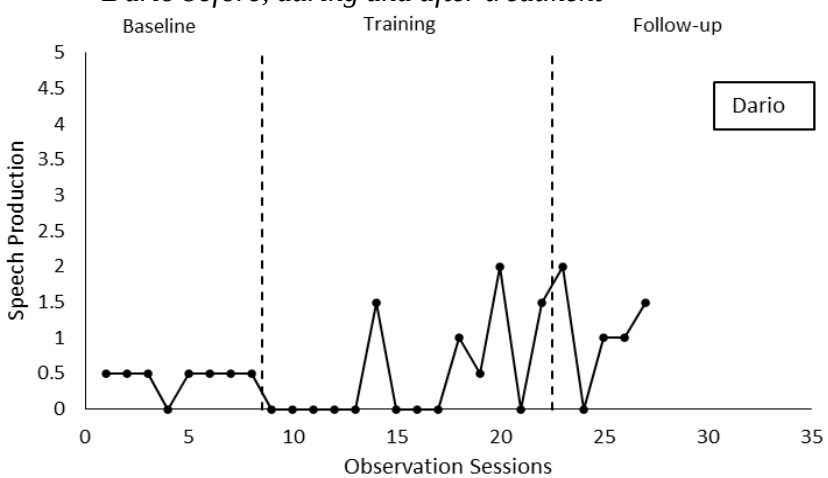
Figure 7 – *Percentage of interval with the occurrence of tantrum behaviors. The graph shows the results for Dario before, during and after treatment*



Tantrum behavior (Fig. 7) occurred with an average per session of .87 during baseline. The trend was descendent, once the treatment was presented, with an average of .23 per session during the treatment phase and an average of 0 for follow-up.

This data was analyzed by a second independent observer for 50% of the sessions. An Interval-by-Interval IOA method showed 90% compliance. The graph in Figure 8 shows the trend of Dario's vocal productions.

Figure 8 – *Quality and quantity of changes in verbal production, shown by Dario before, during and after treatment*



Visual inspection revealed that speech production increased in quality, from an average of .4 during baseline to 1 point during follow-up, confirming an improvement in the "quality of speech". The number of attempts remained stable with a slight decrease at the beginning of treatment. Halfway through the treatment, Dario showed, for the first time, an understandable and functional vocalization.

This data was analyzed by a second independent observer for 50% of the sessions. An Interval-by-Interval IOA method shown 95% agreement.

A Student *t*-test revealed a *p*-value of .069. In the pre-intervention the maximum score that the child could obtain out of the total possibilities was equal to .66, according to the values established to evaluate its correctness, as described above; after training the average of vocalizations reached a maximum score of 2, indicating that the child tended to emit correct words more often from both a grammatical and functional point of view. More specifically, we observed that at the end of the training phase and in the follow-up, Dario achieved an average score of 2 points, which means that speech production improved in terms of quality.

4. Discussion

The main objective of the study was to evaluate whether children diagnosed with Autism Spectrum Disorder (ASD) could effectively learn to use PECS and/or an SGD for the purposes requested. The data revealed that both AAC options were successfully acquired for requesting, consistent with findings from previous research (e.g., Schlosser, 2003; Flores *et al.*, 2012). The second aim focused on comparing the speed of acquisition of the required skills. All three participants reached the mastery criterion in a comparable time frame, indicating that both AAC options were equally effective in teaching communication skills. Notably, two out of three participants demonstrated a faster acquisition speed with the LI-AR system. During the LI-AR phase, all participants reached acquisition criteria more quickly than PECS and showed fewer errors at the onset of each new phase with the SGD (Fig. 5).

The third objective aimed to evaluate modality preferences using various techniques. As noted by Van der Meer and colleagues (2012), a communication system can be considered preferable when it is chosen more frequently than another option. Preference assessment probes indicated an overall preference for LI-AR in two out of three participants (Table 1). Laura and Dario showed a preference for LI-AR, continuing to use this

system for post-treatment communication. However, Marco's preference assessment indicated a preference for PECS, which he continued to use for post-treatment communication. Follow-up data revealed that children who continued using LI-AR as their preferred system showed a 100% preference for this tool during follow-up. In contrast, Marco, who initially preferred PECS during treatment, decided to use LI-AR (50%) for communication during follow-up, as shown in Table 1. This shift in preference could be attributed to Marco's previous habit to stimulate himself with the Velcro behind the PECS, potentially influencing his initial preference. These results are in contrast with the literature (e.g., Agius & Vance, 2016) in which a faster acquisition and a greater preference for PECS was observed.

The fourth aim investigated whether children with communication difficulties could improve their vocal production during AAC training. The study revealed that one participant, Dario, demonstrated improvement in vocal production (Figure 8). Initially, Dario was the only one to vocalize, but during the treatment, he acquired the ability to produce fully understandable words. These findings suggest that AAC training does not hinder the development of vocal communication and may even improve the quality of speech production. Additionally, a decrease in problem behaviors was observed during and after AAC training, supporting the literature (e.g., Charlop-Christy *et al.*, 2002) and indicating a correlation between the acquisition of communication skills and the reduction of problem behaviors.

However, the data suggests that both PECS and SGD may be considered useful for initial intervention to teach mands to children with ASD with limited verbal skills, but further studies are needed to confirm these results. Nonetheless, this study extends the existing literature in three ways: (i) it demonstrates that an adapted communication protocol can be successfully used to teach communication through an SGD; (ii) children with ASD and with few vocal repertoires can improve speech production through the use of an AAC tool; (iii) the acquisition of a new mode of communication can influence the frequency of problem behavior.

The limitations of this study concern the sample size and the individual characteristics of the participants. Conducted as a clinical case study using a multiple baseline design, the study evaluated three individual cases with different ages and different symptomatic characteristics. Although the results cannot be generalized to the entire population of individuals with autism, they offer valuable insights for personalizing communication training based on individual characteristics. The choice of a single case report design was deliberate due to the variability of autistic

symptomatology, allowing observation of customized treatments. Despite their limited generalizability, single case studies remain scientifically relevant, providing valuable insights into interventions tailored to specific populations, which could improve each participant's quality of life and produce practical and meaningful outcomes.

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