



Comparative efficacy of the Picture Exchange Communication System (PECS) versus a speech-generating device: Effects on requesting skills

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ABSTRACT

An experimental, single-subject research study investigated the comparative efficacy of the Picture Exchange Communication System (PECS) versus a speech-generating device (SGD) in developing requesting skills for three elementary-age children with severe autism and little to no functional speech. Results demonstrated increases in requesting behavior for all participants across intervention phases with both augmentative and alternative communication (AAC) intervention strategies; however, difficulties were observed with picture discrimination. The Wilcoxon signed pair test did not reveal significant differences between PECS and the SGD for any participant. Findings suggest PECS and SGD are equally appropriate for developing initial requesting skills. Based on the current findings, successful implementation of either AAC strategy is achievable when appropriate instructional strategies are used.

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1. Introduction

According to the *diagnostic and statistical manual of mental disorders* (DSM-IV-TR; American Psychiatric Association, 2000), autism is characterized by impairments in communication, social interactions, and restricted repetitive and stereotyped behavior and interests. Unlike individuals diagnosed with only communication disorders, individuals with autism who have spoken language show unique spoken language difficulties. These unique difficulties include echolalia and other unusual speech patterns such as rigidity and prosodic oddities (Eigsti, de Marchena, Schuh, & Kelley, 2011). Other communicative difficulties in autism include late speech development, speech regression, difficulties in auditory comprehension, and pragmatic deficits (Eigsti et al., 2011; Tager-Flusberg, Edelson, & Luyster, 2011; Williams, 2012). Although some develop spoken language, approximately 50% of individuals with autism have limited or no functional speech (Charlop & Haymes, 1994; Light, Roberts, DiMarco, & Greiner, 1998; Peeters & Gillberg, 1999; Wing & Attwood, 1987). Without functional speech and/or handwriting, these individuals often face barriers to full participation and inclusion in education, employment, independent living, and leisure activities (Beukelman & Mirenda, 2012).

Augmentative and alternative communication (AAC) is used to address these communication deficits (Mirenda & Schuler, 1988). AAC is defined as the supplementation or replacement of natural speech and/or writing through alternate means of communication including speech-generating devices (SGDs), gestures, graphic symbol sets/systems, or manual signs (Lloyd, Fuller, & Arvidson, 1997). The Picture Exchange Communication System (PECS; Bondy & Frost, 1994) and speech-generating

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devices (SGDs) have recently increased in popularity for targeting communication disorders in autism and other developmental disabilities (Lancioni et al., 2007).

PECS is a prominent intervention for teaching functional communication skills. It involves the systematic instruction of self-initiated communication skills using six phases (Bondy & Frost, 1994, 1998, 2001). The PECS training protocol was designed to systematically build on each learned behavior to achieve more communicative independence. In other words, as proficiency is gained, the user advances from one phase to another. Initially, the user is taught to initiate a request by selecting picture cards and exchanging them with a communicative partner for preferred items. In the final phases, the user is taught to respond to “What do you want?” and to comment. By the end of the training program, PECS users are expected to be able to make more detailed requests using descriptors (e.g., “I want a yellow gummy bear”) and make comments (e.g., “I see a blue sky”). Not all PECS learners, however, are able to advance through all six phases (Preston & Carter, 2009; Schlosser & Wendt, 2008).

Research shows PECS is successful in promoting functional communication skills, specifically requesting (Lancioni, O'Reilly, Oliva, & Coppa, 2001; Schepis, Reid, Behrman, & Sutton, 1998; Sigafoos, O'Reilly, Seely-York, & Edrisinha, 2004; Son, Sigafoos, O'Reilly, & Lancioni, 2006). Increases in social–communicative behaviors and speech have also been reported in several PECS studies (Charlop-Christy, Carpenter, Le, LeBlanc, & Kellet, 2002; Yoder & Stone, 2006). It is widely reported that individuals with autism prefer visual stimuli over auditory stimuli; thus, PECS may be advantageous and cost-effective for use with these individuals (Hodgdon, 1995, 1996; Miranda & Schuler, 1988; Schuler & Balwin, 1981). Individuals with autism, however, are heterogeneous, and careful consideration should be taken when selecting an appropriate intervention based solely on the intervention's primary use of visual or auditory stimuli. As Lancioni et al. (2007) reported, most participants demonstrated a preference in visual-based or auditory-based AAC strategies.

A speech-generating device (SGD) is an electronic communication aide that produces digitized or synthesized speech upon activation by individuals with little to no functional speech (Lloyd et al., 1997). SGDs vary greatly in terms of features, cost, and appearance, and are viable alternatives to exchange-based approaches. Similar to PECS, most SGD research with the autism population focused on requesting (Durand, 1993; Schlosser et al., 2007; Sigafoos, Didden, & O'Reilly, 2003; Sigafoos et al., 2004). Lancioni et al. (2007) reviewed 16 studies investigating the efficacy of SGDs among individuals with autism and other developmental disabilities. From a combined participant total of 39 (one to five participants per study), 36 were successful in requesting via SGDs. Research also shows SGDs to be successful in increasing communicative interactions (Schepis et al., 1998), social interactions (Sigafoos et al., 2009), and speech production (Dyches, 1998; Olive et al., 2007; Parsons & La Sorte, 1993; Schlosser et al., 2007) for children and adolescents with autism and limited functional communication skills.

One of the more notable benefits of SGDs over PECS and other graphic symbol based systems is the additional speech feedback they provide for the learner. This extra speech modeling may help promote faster skill acquisition (Romski & Sevcik, 1988, 1993). Additionally, SGDs facilitate more independent communication across various environments (Miranda, 2001; Schepis, Reid, & Behrman, 1996). Similar to natural speech production, the speech signal from the SGD is immediately made available to anyone within hearing distance. Unlike with picture exchange systems, there is no training required from the communication partner to comprehend the communicative message. As a result, the user achieves greater communicative independence and untrained communicative partners can comprehend the message.

Recently, a new type of SGD was developed to closely follow the principles of PECS while adding new elements that may potentially improve communication and social skills beyond PECS. ProxTalker[®] is an electronic aide that uses digitized speech to provide a verbal model of selected picture cards. Up to five picture cards can be combined to create novel messages following the traditional PECS protocol. This new approach is an important development as it uses the same principles of the widely used and successful PECS approach. Additionally, the ProxTalker has the potential to increase the speed of acquisition for communication and social interaction skills due to its added speech output capability. However, empirical data is unavailable in terms of (a) its efficacy in promoting functional communication and social skills, and (b) its efficacy compared to PECS or other SGDs.

Given the popularity of PECS and the plethora of SGDs available, practitioners and other stakeholders often request specific AAC strategies that promote faster and/or easier skill acquisition. Unfortunately, few comparative efficacy studies exist to make specific AAC recommendations. A recent search of the literature yielded two studies comparing PECS to an SGD (Bock, Stoner, Beck, Hanley, & Prochnow, 2005; Beck, Stoner, Bock, & Parton, 2008). However, other studies were found comparing SGDs with general, exchange-based communication strategies (Dyches, Davis, Lucido, & Young, 2002; Sigafoos et al., 2009; Son et al., 2006; Soto, Belfiore, Schlosser, & Haynes, 1993). Bock and colleagues (2005) assessed the effectiveness of PECS and an SGD in developing requesting behavior for children diagnosed with developmental delay who did not have spoken language. Results indicated participants learned to use both AAC strategies even though preferences in strategies were seen. Beck and colleagues (2008) conducted a follow-up study with 4-year-old participants with autism. Results were similar to Bock et al. in that participants successfully requested items using both AAC strategies. Yet, preferences for one strategy over the other were noted regardless of the participants' performance. Beck et al. also reported PECS to be physically easier to use than the SGD as participants were required to grab the SGD handle prior to activating it. In both of these comparative studies, a couple of limitations were noted. First, both AAC strategies were not systematically compared. Second, follow-up and maintenance phases, two important phases in single-subject research, were not implemented.

In an effort to extend the existing literature and to guide educators and clinicians during the AAC selection process, this study aimed to (1) evaluate the efficacy of the ProxTalker when compared to the traditional PECS intervention in developing

requesting skills for children with autism; and (2) to validate a modification of the PECS protocol for infusing speech output technology in the PECS instructional framework.

2. Materials and methods

2.1. Participants

With institutional review board (IRB) approval, three elementary-age children with severe autism were recruited through a university-based speech-language clinic, a parent autism support group, and word-of-mouth. Participants met the inclusion criteria of: (a) autistic disorder according to the DSM-IV-TR (2000) diagnostic criteria, (b) were between the ages of 4–12 years, (c) had adequate visual and auditory perception for learning novel skills, (d) demonstrated adequate hand and eye coordination for activating the SGD, (e) had limited unaided communication skills (defined as pointing, some gestures, fewer than five manual signs, and fewer than ten functional words/word approximations), and (f) were not current users of any speech-output technology.

To assess language and communication skills, the MacArthur-Bates Words and Gestures Communication Development Inventory (CDI; Fenson et al., 2007) was completed for each participant. The MacArthur CDI is a norm-referenced checklist widely used in clinical and research literature to identify current vocabulary among toddlers. Heilman, Weismer, Evans, and Holler (2005) found high correlations between the MacArthur CDI and direct language measures.

Participants received their diagnosis of autism from outside neurologists or developmental pediatricians more than two years prior to the start of the study. To verify the autism diagnosis, the first author administered the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1993), a norm-referenced diagnostic tool. CARS is comprised of 15 items scored on a scale from 1 (no impairment) to 4 (severe impairment) and has a high test-retest reliability, interrater reliability, internal consistency, and criterion-related validity (Mayes et al., 2009; Ozonoff, Goodlin-Jones, & Solomon, 2005).

Table 1 summarizes the participant characteristics for Christian, Nadia, and Zeth (pseudo names were used to maintain participant confidentiality). All the participants had very limited functional communication skills and displayed problem behaviors. Christian, a 6-year-old boy, engaged in tantrums, hitting, screaming, running away, and some self-injurious behavior (SIB). At the time of the study, he lived at home with his mother and younger brother. Nadia, a 7-year-old girl, had no functional speech but typically hummed, moaned, and occasionally elicited squeal-like sounds. According to teacher and parent reports, she followed one-step commands in both English and Spanish. However, no formal assessments had been conducted to assess her language skills. Nadia's parents reported she sometimes displayed SIB, especially when told "no" and when upset. Nadia lived in a Spanish-speaking environment with both parents, two younger siblings, and an older brother. Zeth, a 10-year-old boy, engaged in hitting, hair pulling, shirt grabbing, head-biting, eloping, and SIB (e.g., biting and hair pulling). He also exhibited difficulties transitioning to novel environments, especially upon entering small rooms similar to standard size therapy rooms. Zeth lived with his parents and an older brother.

2.2. Setting

For Nadia and Zeth, intervention sessions were carried out in a therapy room at the university's speech clinic. The therapy room was equipped with a wall-mounted video camera, a 6 in. × 3 in. table, adult-size chairs, and materials necessary for the

Table 1
Participant characteristics.

	Participant		
	Christian	Nadia	Zeth
Age (years)	6	7	10
Gender	Male	Female	Male
Race	Caucasian	Hispanic	Caucasian
CARS score (autism severity)	37 (moderate-severe)	42 (severe)	51.5 (severe)
Receptive language (<i>MacArthur CDI</i>)	Understands 19 phases and 53 words	Understands 15 phases and 52 words	Understands 12 phases and 27 words
Expressive communication	Speaks 8 words; uses 1 manual sign	No speech; uses some gestures but no manual signs	No speech; uses 3 manual signs
Prior experience with PECS	Exposure to picture-based system but not PECS	Exposure to picture symbols but not PECS	No exposure to PECS
Adaptive skills	Eats and drinks independently; dresses with assistance	Toilet trained; eats and drinks independently; dresses with assistance	Eats & drinks independently
School placement	Half-day special education classroom	Full-day special education classroom	Full-day special education classroom with 4 h of ABA therapy per week

Note: Applied behavior analysis (ABA); Childhood Autism Rating Scale (CARS); MacArthur-Bates Words and Gestures Communication Development Inventory (MacArthur CDI); Picture Exchange Communication System (PECS).

study (e.g., reinforcers, PECS materials, SGD, etc.). For Christian, intervention sessions were carried out at home (in the kitchen) due to a conflict in schedule which prevented the parent from bringing him to the clinic. To minimize distractions and setting variations, the setting was arranged to closely resemble a therapy room. The kitchen was equipped with a video camera on a tripod, a 4 in. × 3 in. table, chairs, and intervention materials. All sessions were conducted two to three times per week. A typical session lasted about 20–30 min and included either PECS or SGD intervention.

2.3. Materials

A standard 5-button Logan ProxTalker device without its shoulder straps or mounting unit was used for the SGD intervention condition. A standard-size PECS communication book obtained from the manufacturer was used for the PECS intervention condition. For both conditions, laminated Picture Communication Symbols printed in color and measured 1.25 in. × 1.25 in. were used to ensure consistency of size, symbolic representation, and overall appearance. A corresponding label was printed directly above the image on each picture card. Picture cards for the SGD condition were recorded in English by the first author. The device emitted digitized speech corresponding to the picture card. Picture cards varied by participant and closely reflected each participant's food preferences. Only food items were used as reinforcing stimuli due to their motivating value. This technique helps avoid latency of trial transitions and decreases the duration of each session. A minimum of four preferred food items were used per treatment and served as reinforcers, equaling at least eight different reinforcers per participant.

2.4. Design

A multiple baseline design across participants (MBD; Baer, Wolf, & Risley, 1968) was combined with an alternating treatment design (ATD; Barlow & Hayes, 1979). The MBD permitted the analysis of treatment effects across the three participants while each participant served as the baseline for the next participant (Barlow, Nock, & Hersen, 2009). The design is meant to introduce treatment variables in a temporal sequence to behaviors, subjects, or settings in order to demonstrate changes in behavior (Barlow et al., 2009). To minimize carryover effects, the sequence of treatment conditions was randomly chosen and counterbalanced for each participant. This arrangement allowed the comparison of two intervention conditions and their relative effects on developing requesting skills. The PECS condition followed the traditional PECS protocol. The SGD condition consisted of the ProxTalker and used a protocol similar to PECS. However, appropriate modifications were used to infuse the SGD (see Tables 2–4).

2.5. Response measurement and timeline

Requesting was selected as the dependent variable based on research and recommendations in the PECS manual. In addition to PECS guidelines specifying this skill be taught first, requesting has often been targeted in early instruction of individuals with developmental disabilities due to motivational considerations (Reichle & Sigafos, 1991). Requesting was defined as independently initiating a request by activating the SGD or exchanging a picture card with the trainer to obtain a preferred food item. Requesting was recorded using event recording procedures, and each independent request was counted as a single occurrence (Kennedy, 2005). Data were collected continuously during and between baseline, intervention, and follow-up phases. Data for the maintenance phase was collected eight weeks after the last follow-up session.

2.6. Procedures

2.6.1. Preference assessment

According to the traditional PECS protocol, a preference assessment is a critical step prior to intervention (Frost & Bondy, 2002). Replicating the process demonstrated by Schlosser et al. (2007), a stimulus preference assessment was conducted to systematically select eight items of high interest for each participant. The preference assessment included three stages that

Table 2
Phase I protocol.

Phase I – Physical exchange ^a
While directly across the child, trainer 1 entices while:
Step 1: Providing an open hand cue and placing the picture card [PECS] in front of the child or on the device button [SGD]
<i>Mastery criterion:</i> Child exchanges picture with trainer 1 [PECS] or activates the device [SGD] with 100% accuracy for two consecutive trials.
Step 2: Fading the open hand cue and placing the picture card on the book [PECS] or on the device book [SGD] in front of the child
<i>Mastery criterion:</i> Child exchanges picture with trainer 1 [PECS] or activates the device [SGD] with 100% accuracy for two consecutive trials.
<i>Error correction:</i> If the child reaches for the snack first, trainer 2 prompts the child to grab the picture and place it in trainer 1's hand (or place it on the button and activate it) through backwards chaining.
<i>Overall phase criterion:</i> Child requests snack with 80% accuracy for two consecutive sessions across two communicative partners and three reinforcers.

^a Adapted from Frost and Bondy (2002).

Table 3
Phase II Procedures.

Phase II – Distance and persistence ^a
Trainer 1 entices while situated: Step 1a: Halfway across the room from the child (PECS book/SGD is next to the child) <i>Mastery criterion:</i> Child exchanges picture with- [PECS] or activates the device near [SGD] trainer 1 with 100% accuracy for two consecutive trials.
Step 1b: Across the room from the child (picture card/book is next to the child) <i>Mastery criterion:</i> Child exchanges picture with- [PECS] or activates the device near [SGD] trainer 1 with 100% accuracy for two consecutive trials.
Step 2a: Next to the child (picture card/book is halfway across the room away from the child) <i>Mastery criterion:</i> Child exchanges picture with- [PECS] or activates the device near [SGD] trainer 1 with 100% accuracy for two consecutive trials.
Step 2b: Next to the child (picture card/book is across the room from the child) <i>Mastery criterion:</i> Child exchanges picture with- [PECS] or activates the device near [SGD] trainer 1 with 100% accuracy for two consecutive trials.
Step 3: Various distances away from the child (picture card/book placement also varies) <i>Mastery criterion:</i> Child persists to exchange a picture with- [PECS] or activate the device near [SGD] trainer 1 at any distance with 100% accuracy for 2 consecutive trials.
Error correction: If the child reaches for the snack, trainer 2 will use backwards chaining as needed to assist the child in retrieving the picture card or SGD and requesting the snack by exchanging the picture card or activating the SGD.
<i>Overall phase criterion:</i> Child requests snack with 80% accuracy for two consecutive sessions across two communicative partners and three reinforcers.

^a Adapted from Frost and Bondy (2002).

Table 4
Phase III procedures.

Phase III – Discrimination between picture cards ^a
While directly across the child, trainer 1 entices between: Step 1: Preferred versus distractor items <i>Mastery criterion:</i> Child selects the preferred picture card from the book and (a) exchanges it with trainer 1 [PECS] or (b) places it on the button and activates it [SGD] with 100% accuracy for two consecutive trials.
Step 2: Preferred versus non-preferred items <i>Mastery criterion:</i> Child selects the preferred picture card from the book and (a) exchanges it with trainer 1 [PECS] or (b) places it on the button and activates it [SGD] with 100% accuracy for two consecutive trials.
Step 3: Two preferred items <i>Mastery criterion:</i> Child selects one preferred picture card from the book and (a) exchanges it with trainer 1 [PECS] or (b) places it on the button and activates it [SGD] with 100% accuracy for two consecutive trials.
Step 4: Three preferred items <i>Mastery criterion:</i> Child selects one preferred picture card from the book and (a) exchanges it with trainer 1 [PECS] or (b) places it on the button and activates it [SGD] with 100% accuracy for two consecutive trials.
<i>Error correction:</i> Trainer 1 follows the 4-step error correction illustrated in Frost and Bondy (2002).
<i>Overall phase criterion:</i> Child requests a snack with 80% accuracy for two consecutive sessions across two communicative partners and three reinforcers.

^a Adapted from Frost and Bondy (2002).

followed a combination of guidelines set forth by Pace, Ivancic, Edwards, Iwata, and Page (1985) and Sigafos and Reichle (1992). The *parent interview* (first stage) identified a list of four to six potential reinforcers. These potential reinforcers were then presented individually in a *trial based assessment* (second stage). Items consumed 80% of the time were selected as reinforcers. To minimize carryover effects between intervention conditions, the reinforcers used during PECS was different than the reinforcers used in the SGD condition. The *forced-choice assessment* (third stage) identified two equally motivating reinforcer sets by (a) pairing and presenting all food items with each other, (b) calculating the mean percentage of preference for each item, (c) ranking the mean percentage scores in order of preference, and (d) creating two sets of food items with similar reinforcing attributes. At the beginning of each session and every five trials thereafter, brief preference assessments were conducted to minimize satiation.

2.6.2. Baseline

The SGD and the PECS book were available and within reach of the participant. Verbal and physical prompts were not used; however, visual cues (i.e., giving an expectant look) were used. Specific procedures included (1) presenting the reinforcer within view but out of reach (such as in a closed, clear container), (2) waiting 5–10 s to give the participant time to request, and (3) providing the reinforcer and pairing it with a label (e.g., “yum, gummy bear”). All attempts to obtain the reinforcer (e.g., reaching, grabbing, pointing, etc.) were honored whether or not the participant successfully requested using either AAC strategy.

2.6.3. Intervention

Three trainers took turns serving as communication partners and prompters throughout the intervention conditions to encourage participants to communicate across trainers. A variety of reinforcers were also used to expose participants to

request different food items. Trainers who had completed both basic and advanced PECS training were present throughout each intervention phase. Trainer 1 served as the communicative partner during all communicative exchanges and was responsible for presenting and delivering reinforcers. Trainer 2 served as the physical prompter during all initial stages within each treatment condition as needed. As the participant's independent requesting increased, prompts were faded and then eliminated.

2.6.3.1. Mastery criterion. The number of sessions implemented for each participant was based on the mastery criterion (see Tables 2–4). If mastery was achieved in one intervention condition but not the other, the participant continued to be exposed to the mastered condition until mastery was achieved under the second condition. This procedure was used to maintain experimental control within the alternating treatment portion of the design. Additionally, if the participant did not show potential in reaching mastery criterion (i.e., five consecutive sessions of 40% accuracy or less per session), then the protocol was re-evaluated to determine whether modifications were needed.

2.6.3.2. Training protocol. Participant training was conducted in phases. For the SGD intervention condition, a modified PECS training protocol was used. The PECS intervention condition followed the training guidelines set forth by Frost and Bondy (2002). Table 2 shows Phase I procedures used in teaching participants to request a preferred item with a single picture card. Phase II procedures are presented in Table 3. In this phase, participants were taught to expand their spontaneity during communicative interactions. Table 4 illustrates the procedures used in Phase III in which participants were taught to discriminate between picture cards. The training protocol outlined in Tables 2–4 is abbreviated. For a complete training protocol, see Boesch (2011).

Another phase used in the training protocol was Phase III-modified. In this phase, the goal was to assist participants in reaching overall mastery criterion if it could not be met at the 3-picture card level. For example, if participants advanced to the 3-symbol level as described in Phase III but were unable to master the phase according to criterion, then Phase III was terminated and the modified Phase III was introduced. Phase-III-modified entailed re-exposing participants to *discrimination between two preferred items*. Mastery criterion remained the same as in the non-modified Phase III. In other words, participants had to obtain 80% accuracy at the 2-picture card level for two consecutive sessions. Furthermore, to maintain experimental control, participants did not have access to either AAC strategy outside the training sessions for the duration of this study.

2.6.4. Follow-up

After the conclusion of the intervention phases, each participant continued to receive the intervention condition that yielded more favorable results, while the other condition was discontinued. Three sessions were required for each participant. Follow-up differs from the maintenance phase in that follow-up is an added measure used in single-subject research to validate that one intervention condition does not have an effect on the other intervention condition (Gast, 2010). In this study, follow-up was used to show experimental control by using the intervention which yielded more favorable results while eliminating the other intervention. For Christian, only two follow-up sessions were conducted.

2.6.5. Maintenance

To assess maintenance of skills, participants were not exposed to the PECS or SGD conditions for approximately eight weeks after the follow-up phase. This allowed for the measurement of the AAC strategies in producing lasting effects of requesting behavior even after non-exposure in any setting. The maintenance condition is important as it informs educators and parents about the longevity of the initial training (Schlosser & Lee, 2000).

2.7. Interobserver agreement

All sessions were video recorded with 33% randomly selected for analysis by two independent observers. Observers were graduate and undergraduate students majoring in special education or in speech-language pathology with experience in data collection procedures (e.g., through an undergraduate research trainee program). Interobserver agreement (IOA) was calculated using a frequency ratio. The smaller frequency total was divided by the larger frequency total and multiplied by 100 (Kazdin, 2011). Mean agreements were reported for requesting across conditions for each treatment modality. IOA was 100% across all conditions for Christian and 99% for Nadia and Zeth.

2.8. Treatment integrity

Treatment integrity (TI) was assessed for both intervention conditions by two independent raters. Raters were graduate or advanced undergraduate students who were majoring in special education or speech-language pathology and had completed official PECS training. Treatment protocol checklists were created for each phase and intervention conditions, and for both trainer roles (e.g., trainer 1 and 2). These checklists were used to document the occurrence or non-occurrence of specific training techniques based on a task analysis for each phase and trainer (see Boesch, 2011, for all TI checklists used in this study). Sessions for TI evaluation were randomly selected and represented 33% of all video recorded sessions for each intervention phase. TI was calculated by dividing the total number of correctly performed steps by the total number of steps

and multiplying by 100. TI for trainer 1 was an average of 98% across all conditions and participants. Overall agreement between observer 1 and 2 was 99%. For trainer 2, TI average was 94% and overall agreement between observers was 98%.

2.9. Data analysis techniques

2.9.1. Visual analysis

Visual analysis was used to identify interaction effects between intervention conditions throughout the study so modifications could be made if necessary (Kennedy, 2005). To assess the effects within the single-case design, six features were used to examine within- and between-phase data patterns: (1) level, (2) trend, (3) variability, (4) immediacy of the effect, (5) overlap, and (6) consistency of data patterns across similar phases (Fisher, Kelley, & Lomas, 2003; Hersen & Barlow, 1976; Kennedy, 2005).

2.9.2. Statistics

To further support the visual analysis, the Wilcoxon signed pair test (Wilcoxon, 1945) was applied to compare the data from both intervention conditions. This test is used to compare two data sets derived from the same participant (Field, 2005). For this experiment, it was used to detect differences in performance between PECS and SGD conditions.

2.9.3. Effect size metrics used

Effect size estimation was also used to quantify the treatment effects. The non-overlap of all pairs (NAP; Parker & Vannest, 2009) and the percentage of non-overlapping data (PND; Scruggs & Mastropieri, 1998; Scruggs, Mastropieri, & Casto, 1987) were calculated to provide information about the magnitude of treatment effect. However, in light of the recent criticisms of PND (Parker, Hagan-Burke, & Vannest, 2007), only the NAP scores are reported; PND scores are available upon request.

NAP calculates the number of comparison pairs that do not overlap and divides it by the total number of comparisons. In essence, NAP compares each baseline data point with each treatment data point. Guidelines for interpreting scores are offered as follows: 0–65% indicates weak effects, 66–92% indicates medium effects, and 93–100% indicates large or strong effects (Parker & Vannest, 2009).

3. Results

As per the research design, AAC strategies were counterbalanced to ensure participants were exposed to each treatment equally. However, the number of sessions for each phase varied per participant as progression between phases was dependent on the participants reaching the mastery criterion and not a predetermined number of sessions (see Section 2.6.3.1).

3.1. Christian

Christian participated in 52 sessions in total. During five baseline sessions, Christian requested an average of 0.8 times in the PECS condition and 0 in the SGD condition. In Phase I, there were three sessions in each condition with the average requesting behavior increasing to 15.7 with PECS and 15 with the SGD. Visual inspection of the graphed data (see Fig. 1) revealed that Christian appeared to be equally successful with both intervention conditions. In Phase II, there were five sessions per condition with Christian requesting more with PECS. The mean per session was 16 with PECS and 9 with the SGD. Low response rates occurred in the first few sessions with the SGD condition due to failure of carrying the device prior to activating it near trainer 1. However, he frequently activated the SGD independently. During 10 Phase III sessions per condition at the 3-symbol level, Christian did not reach mastery criterion. He had a mean of 11.4 independent requests in the PECS condition and 10 in the SGD condition. Consequently, discrimination at the 2-symbol level was reintroduced. In Phase III modified, Christian participated in three sessions per condition. He requested an average of 16 times per session in the PECS condition and 17.3 times in the SGD condition. Based on the modified Phase III results, the SGD was selected for follow-up. In the two follow-up sessions, Christian requested an average of 16 times per session. During the three sessions in the maintenance phase, Christian requested an average of 16.3 times.

There were no statistically significant differences between AAC strategies for any phase (Phase I: $z = -.45, p > .01$; Phase II: $z = -1.48, p > .01$; Phase III: $z = -1.13, p > .01$; Phase III modified: $z = -1.07, p > .01$). In other words, Christian requested similarly in both PECS and SGD conditions.

NAP scores for PECS were 100% across conditions. Scores ranged from 96% to 100% across SGD conditions. These scores suggest both AAC strategies produced strong effects.

3.2. Nadia

Nadia participated in 67 sessions throughout the study. During the nine baseline sessions, a mean of 1.4 requests per session were displayed with PECS and 0 with the SGD. Nadia completed Phase I within four training sessions per condition. The mean was 13.8 with PECS and 9.5 with the SGD. Phase II was mastered within 12 sessions per condition. Nadia requested a mean of 11.3 times with the SGD and 8.9 with PECS. During Phase III, Nadia demonstrated difficulties discriminating

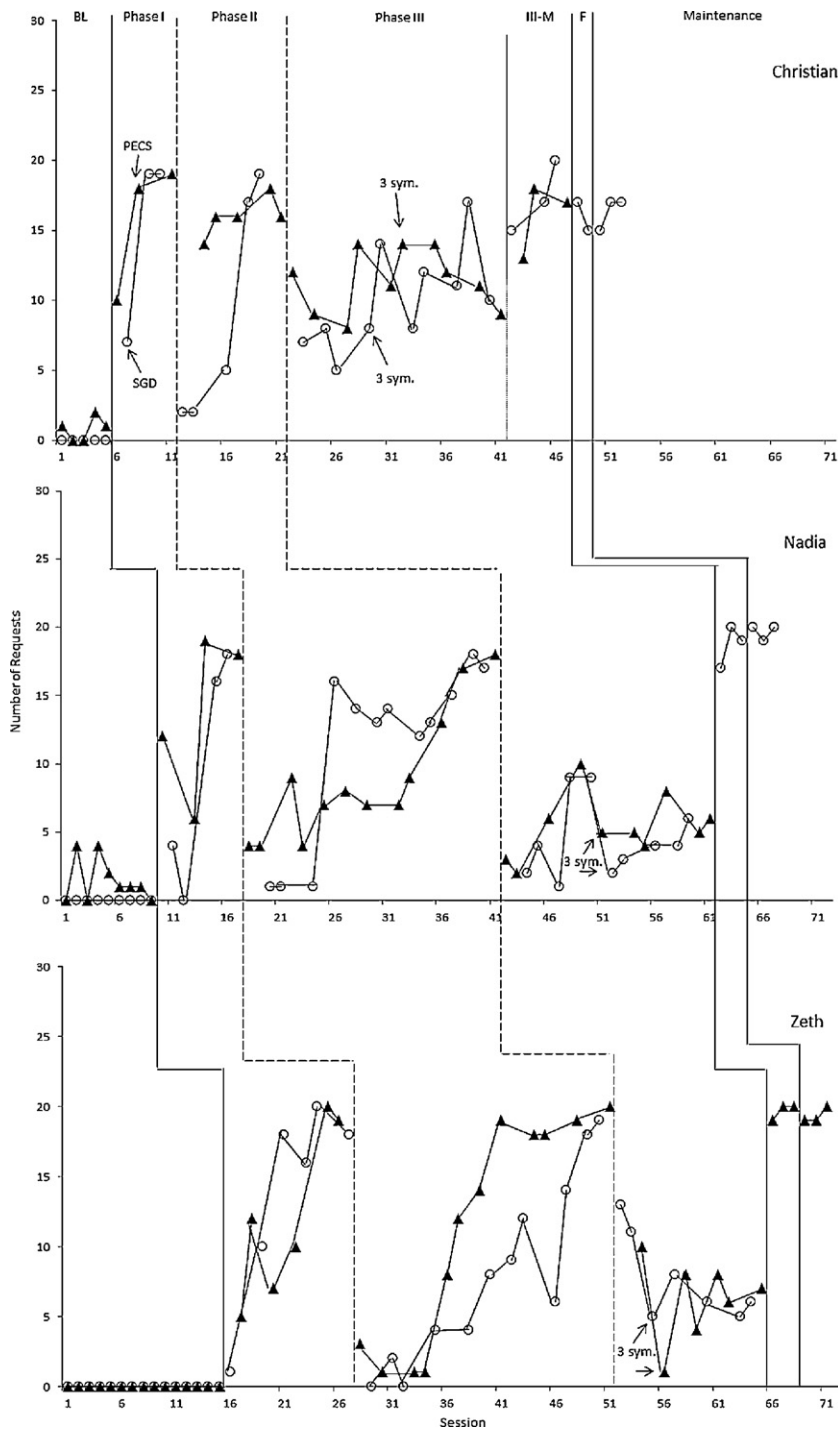


Fig. 1. Total number of correct requests per session for each condition across participants. PECS use is represented in the figure by triangles and SGD use is represented by circles. Discrimination between three picture-symbols in Phase III is denoted by “3-sym”.

between picture cards (i.e., reaching for food items that did not correspond to the selected picture cards and displaying problem behaviors when blocked from obtaining the non-corresponding food items). Thus, Nadia failed to reach mastery criterion within 10 sessions per condition. Requesting behavior decreased to a mean of 5.4 with PECS and 4.4 with the SGD. Phase III was discontinued for ethical purposes after Nadia (a) failed to demonstrate at least 10 successful requests per session for 5 consecutive sessions and (b) continued to engage in problem behavior. Visual inspection of the graphed data in Fig. 1 suggested Nadia was more successful with the SGD than with PECS in Phase II (last mastered phase). Therefore, the SGD

was selected for three follow-up sessions which yielded a mean of 18.67 per session. During the three maintenance sessions, the mean was 19.6 requests per session.

Similar to Christian's results, there were no significant differences between intervention conditions for any phase (Phase I: $z = -1.6, p > .01$; Phase II: $z = -1.37, p > .01$; Phase III: $z = -1.2, p > .01$).

For Nadia, effect size measures supported visual and statistical analyses. NAP scores for the PECS condition ranged from 94% to 100% across phases (strong effect) and from 88% to 100% (medium to strong effect) for the SGD condition.

3.3. Zeth

In total, Zeth participated in 71 sessions. During the 15 sessions in the baseline condition, Zeth did not request independently with either AAC strategy. In Phase I, Zeth was exposed to six training sessions with each AAC strategy. The mean for both strategies was similar; with PECS yielding a mean of 12.2 and 13.8 for the SGD. Phase II was mastered within 12 sessions per intervention condition with PECS yielded a higher mean of 11.2 while the mean for the SGD was 8. Zeth participated in seven training sessions per intervention condition but did not master Phase III. The mean for PECS was 6.3 requests per session and 8 for the SGD condition. Similar to Nadia, Zeth demonstrated non-mastery and displayed an increase in problem behavior including aggression toward others, SIB, and screaming; therefore, Phase III was discontinued. During the follow-up condition, PECS in Phase II was selected as the target intervention as it was the last successfully mastered phase. Zeth's mean requesting was 19.6 during the three follow-up sessions and 19.3 during the three sessions of the maintenance phase.

The Wilcoxon test indicated no significant differences between intervention conditions in any phase (Phase I: $z = -.40, p > .01$; Phase II: $z = -2.45, p > .01$; Phase III: $z = -.59, p > .01$). Thus, Zeth performed similarly in the PECS and SGD conditions.

NAP scores across all phases for the PECS condition were 100%, suggesting strong effects. For the SGD condition, NAP scores ranged from 92% to 100% across phases, which demonstrated medium to strong intervention effects.

3.4. Rate of acquisition

Table 5 shows the number of intervention sessions participants received to achieve mastery criterion. Phase I required the fewest number of sessions for participants to reach mastery (PECS = 4.3; SGD = 3.7) while Phase II took the longest (PECS = 8; SGD = 9.7). Comparison across participants indicates Christian reached mastery criterion in the fewest number of sessions for all phases. Nadia and Zeth reached mastery criterion within a similar number of sessions across conditions. Comparing intervention conditions across all mastered phases (Phase I and II for all participants, and III-modified for Christian only) reveals that the rate of acquisition was comparable (PECS = 5.7; SGD = 6.1).

3.5. Social validity

To assess treatment acceptability, all parents and Zeth's behavior therapist completed a modified Treatment Acceptability Rating Form – Revised (TARF-R; Reimers & Wacker, 1988). The original survey consists of 17 acceptability items with an internal consistency reliability ranging between .69 and .95 (Finn & Sladeczek, 2001; Reimers, Wacker, Cooper, & De Raad, 1992a; Reimers, Wacker, Cooper, & De Raad, 1992b). However, the TARF-R was modified by the primary author to include 12 Likert-type questions and one open-ended question. These questions pertained to the respondents' perceptions of treatment effectiveness, acceptability, and any associated negative side effects. All respondents agreed the intervention strategies were "very acceptable" and perceived no disadvantages to using them. Respondents also believed the intervention strategies were "very likely" to make permanent improvements to the child's communication skills, and were confident the strategies would make a meaningful change in their child's communicative behavior. Due to their child's lack of functional communication skills, the respondents believed there was an urgent need to obtain AAC intervention. When asked if their child demonstrated a preference for a particular AAC strategy, all respondents said yes and suggested preferences were related to specific features of the AAC strategy selected. Features mentioned included the SGD's auditory output and the portability of PECS. Two respondents believed their child preferred the SGD while the other respondent selected PECS as the child's preferred AAC strategy.

Table 5
Number of sessions to reach mastery criterion for each intervention condition.

	Intervention phases							
	Phase I		Phase II		Phase III		Phase III-M	
	PECS	SGD	PECS	SGD	PECS	SGD	PECS	SGD
Christian	3	3	3	5	–	–	3	3
Nadia	4	4	12	12	–	–	NA	NA
Zeth	6	4	9	12	–	–	NA	NA

Note: Phases not mastered are denoted with "–" and phases not introduced are denoted with "NA."

4. Discussion

This study was designed to assess the comparative efficacy of two AAC strategies in increasing functional communication skills for three elementary-age children diagnosed with severe autism. The PECS protocol and an adaptation of the PECS protocol for infusing the ProxTalker SGD were experimentally evaluated to determine if either strategy had a stronger impact on increasing requesting skills. Results demonstrated that participants were able to rapidly learn to request desired items by exchanging or activating a single picture card. Given the results in the current investigation and previous studies suggesting the effectiveness of PECS (Angermeier, Schlosser, Luiselli, Harrington, & Carter, 2008; Charlop-Christy et al., 2002; Ganz & Simpson, 2004; Ganz, Parker, & Benson, 2009; Tincani, Crozier, & Alazetta, 2006) and SGDs (Dyches, 1998; Olive et al., 2007; Parsons & La Sorte, 1993; Schepis et al., 1998; Schlosser et al., 2007) for children with autism who have limited functional communication, it is highly likely individuals with similar characteristics will also learn to request with either AAC strategy.

Two of three participants performed better with PECS than with the SGD during Phase II. During the first sessions of SGD training, all participants had difficulty picking up the device, carrying, and handing it to trainer 1. Although the participants independently activated the device, no attempts were made to take the device to trainer 1. Occasionally, the participants attempted to repair communication breakdowns by grabbing the picture card from the device and giving it to the trainer when their first communicative attempt was unsuccessful. After a few sessions with trainer prompts, participants were able to independently request at various distances. It is possible the difficulty seen in Phase II is due to features of the SGD. Its size and weight make it heavier for younger AAC users when compared to PECS. It should be noted that the training protocol entailed the participants to carry the SGD and activate it near trainer 1. This was done for two reasons. First, it was important to maintain consistency between the training protocols to minimize confounding variables when comparing both AAC strategies. Second, in more naturalistic settings, it cannot be assumed the communicative partner will always be within hearing range. Therefore, it is important to teach individuals to carry and activate the SGD near the communication partner to ensure it is heard. As with natural speech, SGDs can be heard from afar in ideal environments. However, when someone requests an item in a noisy environment or from across a room, it cannot be assumed the intended communicative partner heard the request. When the environment impedes the message, the speaker, whether using natural speech or via an SGD, needs to repair the communication breakdown by moving closer to the communicative partner and/or repeating or rephrasing the message.

In Phase III, difficulties discriminating between picture symbols were noted for all the participants. Specifically, when more than two picture symbols were available, success was not noted with either AAC strategy. This result suggests that the discrimination task required in Phase III as per the original PECS protocol may have been beyond the participants' current symbolic communication skills. Cummings, Carr, and LeBlanc (2012) investigated the training structure of the PECS protocol and concluded participants with discrimination difficulties during PECS Phase III also had prior matching-to-sample difficulties. As such, participants in this study might have had difficulties prior to training which directly affected the acquisition of discrimination skills during Phase III. Therefore, protocol modifications may be needed for users showing non-mastery with either AAC strategy during phases requiring discrimination skills.

4.1. Advantages and disadvantages of PECS versus SGD

The SGD used in this study had several key features of an ideal device based on the 18 specified features mentioned in Lloyd et al. (1997). The SGD advantages include (1) digitized speech for recording in a variety of voices and dialects to meet the needs of the user, (2) durability and ease of maintenance minimize damage from moisture, accidental or intentional falls, and other daily wear and tear, and (3) a simplistic design and features to create low mental and linguistic demands. Evident in Phase I, the SGD was easily learned by all three participants regardless of intellectual capacity, preference, or autism severity. However, two main disadvantages of some SGDs include (1) the high cost when compared to PECS and (2) the lack of portability due to weight and bulkiness, especially for young children or individuals with physical limitations.

The main advantages of PECS include low cost, ease of maintenance, and portability. Participants were able to easily carry and handle the picture cards. For advanced PECS users, however, portability may become an issue as more picture cards are added to the PECS book (same with the SGD). On several occasions, the PECS picture cards had to be re-created due to excessive wear and tear. A major disadvantage to using PECS is that it does not offer speech output capability. AAC strategies lacking speech output capabilities rely on the communicative partner to be within close proximity, thus limiting the AAC user's independence.

Professionals and families should consider the AAC user's intellectual functioning, school, family, and community contexts, as well as visual and auditory strengths prior to selecting a specific AAC strategy. These considerations are critical as the AAC user advances to the symbol discrimination level. In this study, difficulties with symbol discrimination were evident for all participants. For Nadia and Zeth, problem behavior increased when the food reinforcer was delayed due to discrimination errors. Therefore, after several sessions of non-mastery and increased problem behavior, Phase III was discontinued. Christian also had difficulties with picture symbol discrimination, but showed promising results and refrained from displaying severe problem behavior. Thus, Phase III was modified, and discrimination at the 2-symbol level was reintroduced.

Additionally, prior to selecting an AAC strategy, educators need to consider the cost (monetary and time) the AAC system will require if malfunctions occur or if it stops meeting the needs of the user. For low technology, these considerations may

not be as critical due to the low cost. Some high technology systems, however, can be very costly and, if selected, should adapt to the changing needs of the user.

For parents and educators unsure which AAC strategy is superior, selecting a multimodal AAC intervention may offer the most benefits. By using a combination of low technology with mid to high technology, users have the opportunity to optimize their communication abilities. In essence, potential shortcomings associated with one strategy may be addressed by another one. For example, if a high tech device breaks or the battery is depleted, the low tech strategy can support the users' communication needs until the device is functioning properly. Likewise, if a user is unable to use a picture-based strategy with a person with visual difficulties, then the device with speech capability can provide the means to communicate. As such, AAC interventions can be complementary to each other and can offer far greater benefits when a multimodal approach is selected (Lloyd et al., 1997).

4.2. Practical implications

For educators and other professionals, the results of this study provide practical information related to (a) skill acquisition rates and (b) considerations for AAC selection. For professionals in search of suitable interventions for individuals with limited expressive language skills, the AAC strategies assessed in this study provide support as to their utility in acquiring these skills in a relatively short amount of time. As illustrated in Fig. 1, individuals identified as slow learners may learn to request with continued intervention exposure as long as an increasing trend is noted. For individuals not reaching mastery criterion, professional judgment should be used to re-evaluate the intervention and make appropriate modifications as needed.

This study sheds light on the efficacy of ProxTalker, a mid-range technology, as it compares to a widely used exchange-based communication system. Results suggest the ProxTalker device can be a suitable alternative to PECS. It provides similar benefits to the traditional approach; however, it has the added benefit of speech output. Although PECS does not have speech output capabilities, it is an affordable AAC strategy and can be used as a back-up strategy for SGDs. These findings also provide a solid foundation for future research on the adaptability of the PECS protocol for use with other SGDs and allow practitioners to make more definite recommendations regarding the use of both AAC strategies.

4.3. Limitations and future research directions

Several shortcomings of this study need to be recognized. First, generalization across settings was not investigated. Doing so would have allowed others to determine whether the AAC strategies can be learned within the contexts of different environments. This is especially important as communication occurs in many settings and environments. Therefore, generalization should also be studied under contexts outside the clinic setting (Schlosser, 2003) as it is necessary to help educators with decision-making. For Christian, results might have differed had treatment occurred in a more structured environment such as at the clinic. At home, many distractions occurred at the beginning of the intervention phase and required constant redirection and prompting. For Nadia and Zeth, intervention might have resulted in better outcomes had treatment been provided in a more naturalistic setting such as a home or in the classroom. Because motivation is often linked to behavioral treatment outcomes, studies using behavioral treatments might encounter problems with participant motivation when opportunities to request are artificially created and may not be truly motivating to the participant.

In Phase III, participants were systematically taught to discriminate between graphic symbols; however, graphic symbol iconicity was not assessed. Some literature suggests the degree of iconicity affects the learnability of the graphic symbol (Fuller, 1997; Goossens, 1983; Koul, Schlosser, & Sancibrian, 2001; Nail-Chiwetalu, 1991). Yet, Angermeier et al. (2008) found no differences when graphic symbol iconicity was assessed during PECS. Because it is not clear how much symbol iconicity affects PECS learning and given that participants in this study had difficulty discriminating between several picture symbols, it is possible that picture iconicity affected learning and should be investigated further.

Although the PECS protocol was successfully modified to teach participants how to request a mid-technology device (ProxTalker SGD), future investigators need to ask "Can the traditional PECS protocol be modified adequately to accommodate the instruction of high technology devices?" At the present time, there is a lack of information on the transition from low and mid-technology to high technology. With the introduction of the Apple iPad[®] and other similar tablet devices, professionals and families are asking if these are alternative options for AAC intervention and how to incorporate them into the intervention process.

As more individuals from linguistically and culturally diverse backgrounds require AAC services (Bridges, 2004), future research should empirically evaluate the degree to which a diverse background affects performance during AAC intervention. As with Nadia, teacher and parent reports indicated that she understood English and Spanish. Because comprehension skills were not thoroughly assessed prior to treatment, however, it is possible that discrimination difficulties were related to language comprehension. In this study, English was used for all spoken (e.g., praise, verbal prompts, instruction, etc.) and written language (e.g., label printed directly above all picture cards). On many occasions, Nadia showed signs of frustration with picture discrimination, but it is unclear if some frustration was due to difficulties with comprehension. As a result, future research should focus on comprehension and diversity as it relates to increasing functional communication skills with AAC strategies.

In the present study, participants were exposed to Phases I through III. However, Phases IV through VI were not evaluated. The PECS protocol is designed to increase language skills by teaching users to construct sentences and to comment during later phases. However, the literature on these later phases is negligible (Charlop-Christy et al., 2002). As such, assessing the efficacy of these later stages is essential to guide professionals working with advanced users.

Furthermore, there is a need to investigate the speech component in SGDs as no attempts were made to control for the participants' exposure to extra auditory feedback provided with the SGD condition. Studies by Parsons and La Sorte (1993) and Schlosser, Blischak, Belfiore, Bartley, and Barnett (1998) indicate that speech output facilitates skill acquisition. These findings, however, are not conclusive, and future research should aim at isolating speech as an independent variable (with and without speech).

The behavioral teaching strategies inherent in the PECS protocol are perhaps the greatest contributing factor to the success of the participants in learning to request under several treatment conditions. Koul et al. (2001) provided an overview of the differences between clinician-directed and child-centered approaches and their associated advantages and disadvantages for encouraging communication skills. Thus, research is needed to compare the traditional PECS protocol against an alternative instructional approach while maintaining the intervention variables constant. There is also merit in comparing AAC technologies; however, to investigate two important areas efficiently, research should examine the efficacy and effectiveness of a single AAC strategy under two teaching conditions. An appropriate extension to this current study is to infuse the ProxTalker SGD with two instructionally different approaches (i.e., the behaviorally oriented, clinician-directed PECS protocol and the Milieu/incidental teaching approach; Hart & Risley, 1975) to assess their effects on increasing functional communication skills. It is not sufficient to evaluate AAC strategies based on their features; it is also equally important to understand how a specific teaching strategy affects the usefulness of the strategy in promoting functional communication skills. Findings from this type of experimentation may have far-reaching implications for the field, as they might shed light on the relative contributions of the different instructional paradigms and theoretical underpinnings.

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