Speech Associated with the Use of Speech Generating Devices with Children with Autism Spectrum Disorder: A Comparison of Two Treatment Conditions

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Abstract

Augmentative and alternative communication (AAC) systems are commonly used by children with autism spectrum disorder (ASD) and communication impairments. Some AAC systems, such as the Picture Exchange Communication System (PECS; Bondy & Frost, 1994), have been associated with increased speech. Although the exact mechanism of change is unknown, the creators of PECS (Bondy & Frost, 2004) suggest the use of a time delay when “reading” the sentence strip may be associated with increases in speech. The current study evaluated the effects on speech of two approaches to communication training using the PECS IV+® App as a speech generating device (SGD): (a) SGD speech output without a time delay, and (b) SGD speech output with a 3-second time delay. An adapted alternating treatment design (AATD) across three participants with ASD was used. Results suggest that the influence of the two teaching strategies on speech was different for each participant. For one participant, time delay prompting may have been beneficial in increasing the complexity or length of utterance of her speech. For a second participant, time delay prompting may have been beneficial in increasing vocal speech in the form of word approximations. For the remaining participant, there appeared to be no visible benefit for speech for either teaching strategy (with or without time delay prompting).

Implications for selecting and training SGDs are discussed.

Keywords: autism spectrum disorder, communication, speech, speech generating devices
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Speech Associated with the Use of Speech Generating Devices with Children with Autism Spectrum Disorder: A Comparison of Two Treatment Conditions

Autism spectrum disorder (ASD) is a pervasive developmental disorder characterized in the Diagnostic and Statistical Manual of Mental Disorders (5th edition; DSM-5; American Psychiatric Association, 2013) by impairments in social communication and social interaction, and by restricted patterns of behaviour, interests, or activities. In individuals with ASD, impairments in social communication and interactions commonly include deficits in social reciprocity, nonverbal communication and establishing and/or maintaining relationships with others. Some individuals will also display restricted or repetitive patterns of verbal or nonverbal behavior (American Psychiatric Association, 2013).

While most children learn to communicate with speech, an estimated 30% of individuals diagnosed with ASD fail to develop speech (Wodka, Mathy, & Kalb, 2013). For individuals with ASD who have yet to develop functional speech, or have unintelligible speech, such that they cannot meet their communication needs, augmentative and alternative communication systems (AAC) are often recommended (Sigafoos, Schlosser, & Sutherland, 2010). AAC interventions are designed to increase functional communication by replacing or supplementing an individual’s speech (Schlosser, & Wendt, 2008). Interventions utilizing AAC systems, such as picture exchange and speech generating devices (SGD) have been shown to be effective in teaching individuals with ASD to acquire a communicative repertoire (Mirenda, 2003; Schlosser & Wendt, 2008).

Within the literature, numerous potential AAC systems for individuals with ASD exist. These systems can be divided into two broad categories, aided and unaided AAC systems (Mirenda, 2003). Unaided AAC systems do not utilize any equipment external to a person’s body
and include approaches such as manual signing and gestures. Aided AAC systems utilize some form of external material or device and include approaches such as picture-point systems, the Picture Exchange Communication System® (PECS; Bondy & Frost, 1994) and SGDs (Mirenda, 2003).

**The Picture Exchange Communication System®**

The Picture Exchange Communication System® (PECS; Bondy & Frost, 1994) is one AAC system that has been extensively researched and is considered evidence-based practice (EBP) for individuals with ASD (Wong et al., 2013). Developed by Bondy and Frost (1994), PECS is a protocol based on evidence-based procedures from the field of applied behavior analysis (ABA), which uses behavioral teaching strategies such as reinforcement, prompting, and chaining, to systematically teach functional communication. PECS training teaches individuals to communicate by exchanging pictures with a communication partner, to access preferred items or activities. PECS is unique amongst other aided/unaided communication systems in that it does not require prerequisite skills such as eye contact, matching, or verbal or fine motor imitation; skills which are often lacking for individuals with ASD. As well, PECS was designed to address social and motivational challenges common to individuals with ASD. As many individuals with ASD have relatively weak motivation for social interaction with others, PECS training begins by teaching users to exchange a single picture for a highly preferred item or activity. The communicative behavior produces a highly motivating result for individuals with ASD, unlike interventions that first teach expressive or receptive identification maintained by social reward such as praise (Bondy & Frost, 1994).
Phases of PECS Training

The PECS training protocol is divided into six chronological phases, in which a single picture request for highly preferred items is first taught, followed by phases designed to increase learner’s vocabulary and mean length of utterance. Table 1 provides a summary of each phase of training in the PECS protocol.

**Phase I: Requesting via picture exchange.** Phase I is designed to teach learners to request a desired item from a communication partner, using a single picture card. In his analysis of Verbal Behavior, Skinner (1957), first described this behavior (i.e., requesting preferred items) as a mand. Skinner defined the mand as “a verbal operant in which the response is reinforced by a characteristic consequence and is therefore under the functional control of relevant conditions of deprivation and aversive stimulation” (Skinner, 1957, pp. 35–36), for example, saying “water” and receiving a glass of water.

To teach manding in Phase I of PECS training, a trainer presents a preferred item within view of the child. A second trainer then physically guides the child to pick up a corresponding picture of the item and release it into the first trainer’s hand. The item is delivered to the child immediately upon the exchange. Often, the name of the item is spoken by the trainer, exposing learners to the relevant verbal stimuli associated with each picture. Physical prompts are faded over time. By the end of this phase the child can independently pick up a picture and exchange it with a trainer for a desired item.

**Phase II: Increased spontaneity, moving to the trainer and to the communication book.** Phase II is designed to teach the child to locate his or her communication book and approach a communicative partner, to initiate a picture exchange. The trainer gradually moves away from the child, as well as moves the child’s communication book, to teach the child to...
travel and to persist in order to complete a communicative exchange. Multiple trainers are used to promote generalization.

**Phase III: Discrimination of pictures.** Phase III is designed to teach the child to discriminate amongst multiple pictures in order to make a specific request. Initially, a preferred and a non-preferred item are placed within view of the child, and corresponding pictures for each item are placed on the child’s communication book. Upon the child exchanging the correct (preferred) picture, tangible (i.e., the item) and social reinforcement are provided. If the picture of the non-preferred item is exchanged, an error-correction procedure is implemented in which the child is given the non-preferred item, and then, taught to exchange the correct (preferred) picture, using prompting and differential reinforcement. Gradually, the number of pictures is increased to teach the child to discriminate amongst multiple pictures.

**Phase IV: Requesting with the phrase “I want ____.”** Phase IV is designed to teach the child to construct a sentence and request using the phrase, “I want ____.” Using physical prompting and backward chaining, the child is taught to construct the sentence on a sentence strip, and then exchange the entire sentence strip with a communication partner. The full sentence is then spoken by the trainer (e.g., “I want cookie”), exposing the learner to the relevant verbal stimuli associated with each picture on the sentence strip. Once the child independently constructs and exchanges the sentence strip, physical prompting is used to teach the child to point to the picture cards, as the communication partner reads the sentence (i.e., the learner points to each picture, and pointing to the picture then results in a stimulus change in the environment in which the trainer reads each picture as it is pointed to). Once the child has mastered pointing to the pictures, a constant time delay prompt is then used. The trainer reads the sentence starter “I want”, then inserts a pause (e.g., 3-5 seconds), before saying the rest of the
sentence. This pause gives the opportunity for the child to emit the name, or a vocal approximation, of the reinforcer. Differential reinforcement is applied, in which greater reinforcement is provided for exchanges in which the child displays vocal behaviour.

Phase V: Answering “What do you want?” Phase V is designed to teach the child to request items in response to the question, “What do you want?” A progressive time delay prompt procedure is used to teach the child to independently respond to the question.

Phase VI: Commenting. Phase VI is designed to teach the child to use pictures to label or comment on objects and events within their environment, using phrases such as “I see,” “I have,” or “I hear,” among others. In his Analysis of Verbal Behavior, Skinner (1957), first described this behavior (i.e., labeling stimuli) as a tact. Skinner described the tact as a verbal operant evoked by “a particular object or event or property of an object or event (p. 82).” This verbal operant is more commonly referred to as labeling or commenting. As in Phase V, a time delay prompt is used to teach the child to independently respond to a question, such as “what do you see?” (Bondy & Frost 1994; Frost & Bondy, 2002).

Table 1

Phases of the Picture Exchange Communication System® (PECS)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Skills taught</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I</td>
<td>Manding via single picture exchange.</td>
</tr>
<tr>
<td>Phase II</td>
<td>Increasing spontaneity and persistence; moving to the communication partner and the book.</td>
</tr>
<tr>
<td>Phase III</td>
<td>Vocabulary development; discrimination amongst a variety of pictures.</td>
</tr>
<tr>
<td>Phase IV</td>
<td>Sentence structure; manding with the phrase “I want”.</td>
</tr>
<tr>
<td>Phase V</td>
<td>Responding to the question “what do you want?”</td>
</tr>
<tr>
<td>Phase VI</td>
<td>Tacting.</td>
</tr>
<tr>
<td>Additional skills</td>
<td>Use of attributes, manding for help, etc.</td>
</tr>
</tbody>
</table>

Note: Skills taught during each of the phases of the Picture Exchange Communication System® (PECS).
Bondy and Frost (1994) first reported on the impact of PECS on the communication skills of individuals with ASD, describing group outcomes for 85 preschool and school-aged children who were introduced to PECS. It was reported that almost all students learned to exchange a single picture within the first month of being introduced to PECS, and over 95% of students eventually learned to request using a short sentence (i.e., composed of two or more pictures). Additionally, 76% of children eventually used some form of speech, either to augment their picture-based communication system, or as their sole communication system (Bondy & Frost, 1994). Since this report, numerous descriptive (Schwartz, Garfinkle, & Bauer, 1998) experimental or quasi-experimental (Carr & Felce, 2006, 2007a; Howlin, Gordon, Pasco, Wade, & Charman, 2007; Magiati & Howlin, 2003; Yoder & Stone, 2006), and single-subject design studies examining the impact of PECS on the communication skills of people with ASD have been conducted (Charlop-Christy, Carpenter, Le, Le Blanc & Kellet, 2002; Kravits, Kamps, Kemmerer & Potucek, 2002; Ganz & Simpson, 2004; Ganz, Simpson, & Corbin-Newsome, 2008; Jurgens, Anderson & Moore, 2009; Tincani, Crozier & Alazetta, 2006; Travis & Geiger, 2010).

Results from these studies have shown that PECS can be used effectively to teach people with ASD a functional communication system (Carr & Felce, 2007a, b; Charlop-Christy et al., 2002; Ganz & Simpson, 2004; Magiati & Howlin, 2003; Schwartz et al., 1998; Tincani et al., 2006; Travis & Geiger, 2010). In some individuals, PECS has also been associated with increases in the use of spontaneous speech, vocabulary size, and complexity of statements (Carr & Felce, 2007a; Charlop-Christy et al., 2002; Ganz & Simpson, 2004; Jurgens et al., 2009; Kravits et al., 2002; Travis & Geiger, 2010; Yoder & Stone, 2006). Additional benefits of PECS use, such as increased social communicative behaviour, including improvements in joint attention (Charlop-
Christy et al., 2002), and reductions in problem behaviour (Charlop-Christy et al., 2002; Magiati & Howlin, 2003; Tincani et al., 2006) have also been demonstrated.

Several meta-analyses have provided further support for the use of PECS (Flippin, Reszka, & Watson, 2010; Preston & Carter, 2009; Sulzer-Azaroff, Hoffman, Horton, Bondy & Frost, 2009; Tincani & Devis, 2010). Across these studies, comparable results were found, and revealed that PECS training, on average, is an effective intervention to teach individuals with ASD a functional communication system.

**Speech Generating Devices**

Although there is substantial support for the effectiveness of PECS in teaching a functional communication system to individuals with ASD, including identification of PECS as an EBP/emerging EBP in large-scale research reviews (NAC, 2015; Wong et al., 2013), as well as emerging evidence for its positive impact on speech, there has recently been an increase in the use of other AAC systems, specifically SGDs. These devices, including easily accessible systems available for use on tablets (i.e., Proloquo2Go™), are becoming increasingly popular. Inherent to the device, SGDs significantly differ from PECS and other AAC systems, as they have built-in technology to generate an intelligible audio output. This feature is hypothesized to offer several benefits. First, given the vocal output, the individual using the system is not required to first gain the visual attention of their communication partner in order to communicate (Lancioni, O’Reilly, Cuvo, Singh, Sigafoos, & Didden, 2007). Additionally, the auditory output of many SGD devices can be clearly understood by a listener (Lorah, Parnell, Whitby, & Hantula, 2015).

Two recent reviews have summarized the research pertaining to the use of SGDs and other speech output technologies (e.g., talking word processors) for children with ASD (Lorah et al., 2015; Schlosser & Koul, 2015). The use of SGDs has been investigated in terms of
acquisition of communication skills such as manding (e.g., Sigafoos et al., 2013; Ward, McLaughlin, Neyman, & Clark, 2013), strategies for teaching communication using SGDs (Lorah et al., 2015), and comparisons to other AAC systems (e.g., Beck, Stoner, Bock, & Parton, 2008a, b; Sigafoos, Green, Payne, Son, O'Reilly, & Lancioni, 2009; Son, Sigafoos, O’Reilly, & Lancioni, 2006). Comparisons of SGD and other AAC approaches in terms of the acquisition of a mand repertoire, have yielded mixed or inconclusive results. For example, Sigafoos and colleagues (2009) compared acquisition rates of a mand repertoire with a SGD, to acquisition rates of a mand repertoire with a picture-exchange (PE) system and found comparable rates across systems with an adolescent boy with ASD and Down syndrome. Son and colleagues (2006), however, found that in comparison to PE training, fewer trials to criterion were required for acquisition of manding behavior using a SGD for one participant. Yet, comparable acquisition rates across modalities for the two remaining participants were found. Beck and colleagues (2008a, b) adapted the PECS protocol for use with a Voice Output Communication Aide (VOCA) as a SGD. Using a single-subject alternating treatment design, the use of the Picture Exchange Communication System® (PECS) and a Voice Output Communication Aide (VOCA) were compared. In comparison of modalities, a quicker rate of acquisition was reported with PECS, than with the VOCA, across four participants.

Within the literature, a multitude of strategies for teaching communication using a SGD have been reported (Lorah et al., 2015). As well, a range of devices (e.g., iPad®, iPod®, tablets) and software applications (e.g., Proloquo2Go™, Go Talk Now) have been used. For example, Sigafoos and colleagues (2013) investigated the acquisition of a mand repertoire in two boys diagnosed with ASD. The participants were taught to use an iPad® with the application Proloquo2Go™ as a SGD using a least-to-most physical prompting procedure. Both participants
acquired the ability to mand for continuation of play with a preferred toy shortly after the intervention was introduced. Ward, McLaughlin, Neyman, and Clark, (2013) also investigated the acquisition of a mand repertoire using the iPad® with the application Go Talk Now Free, as a SGD, using a model, lead, test prompting strategy. An ABA single case design that included baseline, training, and independent (baseline two) phases was used to investigate the acquisition of a mand repertoire with a 5-year old boy diagnosed with ASD. Results showed an increase in independent requests following training. Independent requests maintained during a return to baseline.

In a review, Lorah and colleagues (2015) indicated that, to date, there is no clear teaching method that is preferred, or has been shown to be more effective within the literature (Lorah et al., 2015). Despite the limited empirical evidence to support specific teaching strategies over others, both Lorah and colleagues (2015) and Schlosser and Koul (2015) assert that the literature suggests that speech output technologies such as SGDs may offer a new avenue of AAC system to effectively teach communication to individuals with ASD.

To date, a limited number of studies have evaluated the effects of speech output technologies such as SGD, on the speech of children with ASD (e.g., Beck, Stoner, Bock, & Parton, 2008a, b; Boesch, Wendt, Subramanian, & Hsu, 2013; Kasari et al., 2014; Parsons, & La Sorte, 1993; Roche et al., 2014; Schlosser et al., 2007; Sigafoos, Didden, & O'Reilly, 2003). Some authors have suggested that utilizing SGDs as AAC systems may provide advantages for increasing speech, compared to AAC systems without speech output (Blischak et al., 2003; Kasari et al., 2014; Schlosser, & Wendt, 2008). However, mixed results have been shown in studies of SGD interventions that do not include procedures to specifically target (e.g., prompt and reinforce) vocalizations (Gevarter et al., 2016; Schlosser, & Wendt, 2008). For example,
Gevarter and colleagues (2016) investigated whether AAC intervention using vocal instruction, or vocal instruction with the addition of differential reinforcement, prompting, and reinforcement delay could increase speech while using a SGD, in four individuals with ASD. Three participants began to emit vocal word approximations with SGD responses following the introduction of vocal instruction. For two of the participants, mastery criteria for the vocalization target was achieved using a reinforcement delay and differential reinforcement procedure. For one participant, criterion for vocalizations was achieved after the addition of an echoic prompt (vocal model), and time delay procedure. In another study, Schlosser and colleagues (2007) investigated the role of digitized speech output on the maintenance of manding using a SGD, and the frequency of vocalizations in five children with ASD. Participants were taught to request access to preferred items using a SGD. Using an adapted-alternating treatment design, rates of SGD requests and vocalizations were compared across two conditions: SGD speech output on, and SGD speech output off, to compare the relative effectiveness of each condition. In terms of requesting, results showed that two participants requested more effectively with the speech output on, while one participant requested more effectively without the speech output. For the remaining two participants, there was no difference, and results showed frequent requesting under both conditions. In terms of vocalizations, only one participant showed improvement in vocalizations. For this participant, slight improvement in vocalizations was shown in the speech-output condition, while there was no change from baseline in the no speech output condition.

These results highlight the idiosyncratic nature of speech production associated with SGDs and the speech output feature. Despite these mixed results, this author’s experience indicates that many practitioners believe the speech output feature inherent to SGDs may facilitate speech for users. However, these assertions have not been consistently born out in the
literature (Blischak et al., 2003; Kasari et al., 2014; Lancioni et al. 2007; Schlosser, & Wendt, 2008).

**PECS and Speech**

Bondy and Frost (1994) first documented that although speech development was not a specific aim of PECS, some children trained in PECS did develop speech. Additionally, for those individuals who did develop speech, they often did so in the later phases of PECS training (i.e., Phases IV to VI; see Table 1 for a summary). While changes in speech during PECS training have been reported (Charlop-Christy et al., 2002; Ganz & Simpson, 2004; Tincani, 2004; Tincani, Crozier, & Alazetta, 2006; Yoder & Stone, 2006), the specific impact of PECS on speech is still unclear, with meta-analytic studies reporting variations in outcomes across group and single-subject design studies (Flippin, Reszka, & Watson, 2010; Tincani & Devis, 2010).

Comparison of speech outcomes between phases of PECS training have also shown the greatest magnitude of gains during Phase IV of the protocol, suggesting that characteristics of Phase IV may be particularly important for the development of speech in children with ASD (Flippin, Reszka, & Watson, 2010). Similarly, results from several single-subject studies indicate that those children who did develop speech during PECS training, did so during later PECS phases (i.e., Phase IV and beyond; Charlop-Christy et al., 2002; Ganz & Simpson, 2004; Tincani, 2004).

**Hypotheses of speech development**

While processes underlying the development of speech in individuals using PECS are not yet fully understood, it has been suggested that characteristics of Phase IV of the PECS protocol may be particularly important for the development of speech in children with ASD (Flippin, Reszka, & Watson, 2010; Tincani, Crozier, & Alazetta, 2006). Frost and Bondy (2002) describe
the use of a constant time delay prompting procedure with differential reinforcement as a means to provide the opportunity for children to emit speech in Phase IV of the PECS protocol (see Table 1 for description of Phase IV). According to the creators, the time delay prompting procedure with differential reinforcement in Phase IV of the PECS protocol is designed to provide the learner with the opportunity to speak during a communicative exchange, “[taking] advantage of many students’ desire to see familiar routines completed” (Frost & Bondy, 2001, pp. 165). Flippin, Reszka, and Watson (2010) discussed two strategies introduced in Phase IV (i.e., verbal modeling and time delay prompting) as possible influences on speech acquisition; however, whether the documented increases in speech production in Phase IV were related to the introduction of verbal modeling, time delay, or some combination of the two strategies remains a point of question in the literature (Ganz & Simpson, 2004; Flippin, Reszka, & Watson 2010).

Hypothesis

The relationship between speech and characteristics of PECS® Phase IV teaching protocol is not well understood (Ganz & Simpson, 2004; Flippin, Reszka, & Watson 2010). In consideration of operant mechanisms that might underlie the development of speech Phase IV, I hypothesize that as communication is taught as a chained response throughout PECS training, the time delay prompting procedure introduced in Phase IV of the PECS protocol could function as a transitive conditioned motivating operation (CMO-T) In individuals with a history of reinforcement for speech, and a history of exposure to verbal stimuli during PECS training (i.e., when the communication partner “reads” the communication exchange), the time delay prompting procedure may contrive a CMO-T for speaking the target word, during the pause of the time delay. The use of differential reinforcement further increases speech production.
Skinner (1957) first described the conditions of deprivation and aversive stimulation under which mands are emitted. This was further described by Michael (1988), in his analysis of the establishing operation (EO), which he defined as “an environmental event, operation, or stimulus condition which affects an organism by momentarily altering (1) the reinforcing effectiveness of other events, and (2) the strength of that part of the organism’s repertoire that has been reinforced by those other events” (Michael, 1988, pp. 3). Michael described two types of establishing operations: conditioned establishing operations (CEOs), EOs whose value-altering effects are dependent on an individual’s past learning histories, and unconditioned establishing operations (UEOs), EOs that do not have a prior learning history. Michael (1988) defined the mand as being under the control of both types of establishing operations, in addition to the specific consequences linked to the relevant request. More recently, Laraway, Snycerski, Michael, and Poling (2001) suggested that the term motivating operation be adopted in lieu of establishing operation.

Michael (1988) first described the transitive CEO, later termed CMO-T (Michael, 1993), as a motivating operation in which one stimulus increases the reinforcing value of a second stimulus. Contriving CMO-Ts has been shown to be an effective strategy for teaching manding skills in individuals with developmental disabilities (Hall & Sundberg, 1987). One procedure, known as a behavior chain interruption procedure (Hall & Sundberg, 1987), involves contriving a situation so that part of a behavior chain is interrupted “and cannot be completed unless a mand occurs, thereby creating the relevant conditions of deprivation. In other words, the inaccessibility of an item needed to complete a chained task creates conditions under which the needed item increases in value, thus making a mand for that item more probable” (Rosales & Rehfeldt, 2007, pp106). In a behavior chain interruption procedure, learners are taught to mand for missing
items, necessary to complete a behavior chain. Individuals are taught to complete an invariable chain of behavior, contacting a specific reinforcer when the chain is completed. This strategy functions to establish the objects, environmental changes, or a combination of the two, as conditioned reinforcers and strengthens the sequence of responses within a specific behavior chain. Once this history is established, it is possible to manipulate CMO-Ts by removing item(s) necessary for completion of the chain, establishing the momentary effectiveness of the missing item(s) as reinforcers, and allowing a trainer to prompt behaviour (e.g., exchange of a picture) to obtain the missing object (Hall & Sundberg, 1987).

I hypothesize that in learners with a history of exposure to PECS training, the time delay prompting procedure introduced in Phase IV, similar to a behavior chain interruption procedure, may contrive a CMO-T for speech. The picture exchange procedure taught throughout the Phase IV PECS protocol exposes the learner to the repetitive completion of the picture exchange as an invariable behavior chain (i.e., the learner points to each picture, and pointing to the picture then results in a stimulus change in the environment in which the trainer reads each picture as it is pointed to). Once this sequence is completed, (i.e., following the addition of the spoken word to the environment) the learner is provided with the tangible item that was requested. Through repeated exposure, the behavior of the trainer as he or she read each picture as it is pointed to may be established as a conditioned reinforcer. Once this history is established, the time delay prompt introduced in Phase IV, which delays access to the conditioned reinforcers in the chain, may contrive a CMO-T (i.e., the pause interrupts the learner from contacting the conditioned reinforcer of the trainer reading back the second picture card, and completing the chain, whereby the learner can access the terminal reinforcer, or the requested item).
Unlike in a behavior chain interruption procedure, PECS users are not prompted to complete the chain with another mand or picture exchange; instead the pause, which immediately precedes the stimulus change in the environment of the communicative partner speaking the target word, allows the learner the opportunity to wait for the chain to be completed (i.e., for the communicative partner to say the target word), or to engage in another response. It is likely that many learners exposed to the PECS protocol would have some history of reinforcement for speech production, and that they may engage in such behaviour in an attempt to complete the remaining steps in the chain (i.e., speaking the target word in the pause, and thus gaining access to the terminal reinforcer). By analyzing the location in the sequence in which individuals speak the target word in this response chain, the effects of the time delay procedure on a person’s speech can be investigated. The temporal location of the target word within this behaviour chain might suggest the functional control of a person’s speech (i.e., echoic-mand, intraverbal-mand).

**Purpose**

If contriving CMO-Ts through the use of time delay prompting is important for speech, there are important, possibly negative, implications for speech development using SGDs, as the majority of devices and applications used today do not allow for the use of time delay prompting. This study attempted to test this hypothesis by comparing speech of children with ASD taught to communicate using a SGD in two conditions: 1) condition 1 (SGD), teaching communication with the SGD speech output enabled as per usual, without a time delay prompt, and 2) condition 2 (SGD + time delay), teaching communication with the SGD speech output and a constant time delay prompting procedure (i.e., a 3 s pause) between the SGD speech output of the initial sentence starter (i.e., “I want”) and the target word (i.e., the requested item), similar to procedures used in Phase IV of the PECS protocol (Frost & Bondy, 2002).
Methods

Participants

Participants were three children, diagnosed with ASD, with a mean age of 5 years 3 months. Participants were recruited from an ABA clinic in Southern Ontario, where all were receiving intensive behavioural intervention (IBI). The Executive Director and Principal of the ABA clinic agreed to disseminate information about the study by placing posters in public areas in the clinic and distributing information letters to parents of potential participants. When contacted by interested parents, researchers provided additional details about the study, and answered any questions that parents had. For those parents interested in their child participating, an initial meeting was then conducted, in which written informed consent for participation in the study was obtained, and pre-experimental measures (described below) were completed to screen for suitability for the study.

Clinical file review, PECS Phase Assessment (Thompson & Koudys, 2016), and parent interview confirmed that all participants met all inclusion criteria for the study as described below:

a) Chronological age between 4 and 8 years;

b) Diagnosis of ASD, confirmed by a pediatrician or psychological report;

c) Limited speech, operationalized as no more than 10 spoken words used in a consistent, functional manner, which render it difficult to meet their daily needs via natural speech, as determined by interview of the participant’s parent(s) and IBI primary therapist;

d) Current PECS user, communicating at Phase IV of the PECS protocol, as confirmed by a PECS Phase Assessment (Thompson & Koudys, 2016). Communication at Phase
IV was defined as the ability to independently construct a sentence using two or more picture cards (i.e., a sentence starter and a picture of a preferred item) to request an item from a communication partner;

e) Adequate pointing skills to select and activate icons on a SGD, as determined through an informal interview with the participant’s IBI primary therapist, parent, and/or a retrospective review of the participant’s clinical file;

f) Former PECS training conducted by a team in which at least one member had completed a formal PECS training;

g) No greater than four-weeks prior exposure to Proloquo2Go or other SGD (e.g., child was given device for a trial period);

h) Primary language spoken within the participant’s home was English;

i) Ability to perform early learning skills necessary to participate in communication training (i.e., sit appropriately, attend to instructions/models), as determined through an informal interview with the participant’s IBI primary therapist, parent, and/or a retrospective review of the participant’s clinical file;

j) No significant problem behavior (e.g., significant self-injury or aggression) that may have interfered with communication training, as determined through an informal interview with participants’ IBI primary therapist, parent, and/or a retrospective review of the participant’s clinical file.

Karen. Karen was a four-year-old girl who had been diagnosed with ASD and who had been reported to have no functional speech. Karen was reported to make some vocalizations; however, these vocalizations were primarily stereotypical in nature and consisted primarily of unintelligible sounds. Karen’s IBI primary therapist reported that she had been introduced to
PECS with her current team approximately 12 months prior to data collection for this study. Karen was reported to use PECS within the clinic environment; however, parents reported that Karen did not use PECS at home, and instead used primarily gestural communication within this environment. Karen used PECS to request a variety of preferred toys, TV shows, and edible items. Karen started PECS Phase IV training five months prior to data collection for this study. Fidelity of PECS IV implementation was monitored as a component of another study (Koudys & Thompson, 2018), and fidelity was reported to be very high, with a range of 92% to 100% and a mean of 98%.

John. John was a five-year-old boy who had been diagnosed with ASD and who had been reported to have no functional speech. Caregiver report indicated that John experienced in utero drug exposure. John’s IBI primary therapist reported that he had been introduced to PECS with his current team approximately 14 months prior to data collection for this study. John was reported to use PECS within the clinic environment; however, caregivers reported that PECS was not used within the home environment, and instead John used primarily gestural communication at home. John used PECS to request a variety of preferred toys, activities, school environments (e.g., gym, playground), and edible items. John started PECS Phase IV training five months prior to data collection for this study. Fidelity of PECS IV implementation was monitored as a component of another study (Koudys & Thompson, 2018), and fidelity was reported to be very high, with a range of 81% to 100% and a mean of 95%.

Kyle. Kyle was a six-year-old boy who had been diagnosed with ASD and who had been reported to have no functional speech. Kyle’s IBI primary therapist reported that he had been introduced to PECS with his current team approximately 18 months prior to data collection for this study. Kyle was reported to use PECS across both the clinic environment and the home
environment. Kyle used PECS to request a variety of preferred toys, activities, edible items, and actions of other individuals. Kyle started PECS Phase IV training two months prior to data collection for this study. Fidelity of PECS IV implementation was monitored as a component of another study (Koudys & Thompson, 2018), and fidelity was reported to be very high, with a range of 98% to 100% and a mean of 99.6%.

**Setting and Experimenter**

The study took place within the participant’s ABA clinic. Each child was seated at a small rectangular table facing the researcher, in a designated research room, outside of his or her primary work area. The room contained a bookshelf and a table and was separated from other areas of the clinic by a closed door. Two video camcorders were attached to the wall to capture both the researcher and the participant, including the SGD screen. Specific reinforcer items were present but were not readily accessible to participants. Research sessions occurred twice-per-day, and on average, three days per week (i.e., six sessions per week).

The author of this paper, who completed PECS Level 1 Basic Training and PECS Level 2 Advanced Training, conducted all sessions and was the primary data collector. Trained research assistants who were graduate students studying ABA, or therapists working in ABA clinics, collected procedural integrity data, and interobserver agreement (IOA). Research assistants were formally trained to a pre-specified mastery criterion of greater than 90% IOA across three sets of 5-trial probes, that were selected from participant data for training.

**Materials**

**Speech Generating Device (SGD).** All participants used an iPad®, with the PECS IV+® application, as a SGD. Prior to training, each participant’s SGD was individualized. This included programming the application with pictures of each child’s identified reinforcers, as
determined by a stimulus preference assessment (described below). The PECS IV+® application was chosen because it allows the user to manipulate the SGD’s speech output to include a time delay prompting procedure for any programmed words. This feature was not available with other SGD applications available at the start of the study.

**Measures**

**Pre-experimental measures.** Prior to SGD teaching, an informal interview was conducted with each participant’s parents and IBI primary therapist to gain information about each participant’s communication history, including information related to PECS training and other communication and AAC modalities previously used.

**PECS Phase Assessment.** To confirm participant’s current skill level with PECS (i.e., PECS phase), a PECS Phase Assessment (Thompson & Koudys, 2016) was administered by a research assistant (see Appendix 1 for PECS Phase Assessment Protocol). Several reinforcing items or activities were placed within each child’s view but were not freely available. The child’s PECS communication binder was easily accessible. The child’s performance at Phase IV was systematically tested. No prompts or assistance were provided. The assessment was developed by Thompson and Koudys (2016) and piloted in a prior research study.

**Experimental Measures.** Measures of SGD requests and speech were obtained throughout all phases of this study. Trained research assistants watched sessions on video and recorded data using data sheets created specifically for this study.

**Speech.** The primary dependent measure was the percentage of trials with the occurrence of speech. Speech included three types of vocalizations: vocal approximations, full words, and full sentences (described below). Measures of speech were collected across all phases of this study using a data sheet created specifically for this study (see Appendix 3). When scoring these
data, vocalizations were mutually exclusive, that is, the most complex vocalization observed within each trial was scored. The percent of trials with the following responses was determined in order to monitor the effects of each intervention on participants’ speech:

_Vocal approximations._ Vocal approximations were scored if the participant’s vocalization had at least one sound from the target word (i.e., reinforcer label) or at least one sound from the sentence starter (i.e., “I want). For example, “c” or “o” would be acceptable approximations for “cookie,” but “b” would not. Vocal approximation did not include stereotypy, moans, forced exhalations, or sneezes. For Karen, the operational definition for vocal approximation was individualized to exclude sounds and sound combinations associated with vocal stereotypy.

_Full word vocalizations._ Full word vocalizations were scored if the participant’s vocalization included all the same sounds and number of syllables as the target word, in the exact order of the target word.

_Full sentence vocalizations._ Full sentence vocalizations were scored if the participant’s vocalization included the sentence starter (i.e., “I want”) and the full target word (i.e., reinforcer label). Full sentence vocalizations were only scored if the participant’s vocalizations had all the same sounds and number of syllables as the target sentence, in the exact order of the target sentence.

_Temporal location of speech._ For one participant, with whom full word vocalizations and full sentence vocalizations were observed in the time-delay condition, temporal location of speech was also analyzed by recording the temporal location of the full word vocalization (as defined above). These data were analyzed to monitor for effects of each intervention on participants’ speech. By analyzing the location in the sequence in which the participant first spoke the full word vocalization, effects of the time delay procedure (i.e., CMO-T) could be
investigated and might suggest the functional control of the participants speech (i.e., echoic-mand, intraverbal mand). For responses that met criteria for a full sentence vocalization, the temporal location of the full word vocalization within the sentence was scored.

During SGD teaching (SGD + human-voice) and condition 1 (SGD), full word vocalizations were scored as either (a) initiated, (b) during the human-voice model or SGD speech output, or (c) following the human-voice model or SGD speech output. During condition 2 (SGD + time delay), these measures of temporal location were scored, as well as (d) during or following the pause of the time delay. Table 2 lists examples.

Initiated. Full word vocalizations that first occurred within 5s of the presentation of an item, but before the beginning of either: (a) a vocal model spoken by the research assistant (during SGD teaching), or (b) speech output of the SGD device (During condition 1 and condition 2), were scored as vocal initiations.

During the human-voice model or SGD speech output. Full word vocalizations that first occurred during either: (a) a full vocal model spoken by the research assistant (during SGD teaching), or (b) speech output of the SGD device, were scored as occurring during the vocal model or SGD speech output. Full word vocalizations during the speech output or full vocal model did not include vocalizations that occurred during the pause of the time delay procedure (i.e., in condition 2 [SGD + time delay]).

Following the human-voice model or SGD speech output. Full word vocalizations that occurred within 5s of either: (a) the cessation of a full vocal model spoken by the research assistant (in SGD teaching), or (b) the cessation of the SGD speech output (during condition 1 or condition 2), was scored as occurring following the speech output or full vocal model.
During or after the pause of the time delay. Full word vocalizations that first occurred at any time during or after the pause of the time delay prompting procedure, but before the SGD output ceased, were scored as vocalizations during or after the pause of the time delay.

Table 2

Examples of temporal locations of target speech responses

<table>
<thead>
<tr>
<th>Type of vocalization</th>
<th>Example</th>
<th>Temporal location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full word</td>
<td>“cookie” [I want cookie]</td>
<td>Initiation</td>
</tr>
<tr>
<td>Full word</td>
<td>[I want cookie*] “cookie**” (* occurring simultaneously)</td>
<td>During SGD speech output</td>
</tr>
<tr>
<td>Full word</td>
<td>[I want cookie] “cookie”</td>
<td>Following SGD speech output</td>
</tr>
<tr>
<td>Full word</td>
<td>[I want] “I want” [cookie] “cookie”</td>
<td>Following SGD speech output</td>
</tr>
<tr>
<td>Full word</td>
<td>[I want] pause [cookie] “cookie”</td>
<td>Following SGD speech output</td>
</tr>
<tr>
<td>Full word</td>
<td>[I want] “cookie” [cookie]</td>
<td>During or following pause of time delay prompt</td>
</tr>
<tr>
<td>Full word</td>
<td>[I want] pause [cookie*] “cookie**” (* occurring simultaneously)</td>
<td>During or following pause of time delay prompt</td>
</tr>
<tr>
<td>Full sentence</td>
<td>[I want] “I want cookie” [cookie]</td>
<td>During or following pause of time delay prompt</td>
</tr>
<tr>
<td>Full sentence</td>
<td>[I want] “I want” [cookie] “cookie”</td>
<td>Following SGD speech output</td>
</tr>
</tbody>
</table>

Note: Examples of temporal locations of target speech responses. SGD model is denoted by square brackets (e.g., [I want]), while example vocalizations are bold font (e.g., “cookie”).

SGD request. In addition to the primary dependent measure, independent use of the SGD was also monitored, and data of independent and prompted steps to complete an SGD request was recorded, and the percentage of independent steps of SGD requests was calculated. A task-analysis for SGD requests was created. The sequence included four steps: (1) select the sentence starter (i.e., “I want”) icon; (2) select the icon corresponding to the presented item; (3) tap the sentence starter icon on the sentence strip to activate the SGD speech output (i.e., “I want”); (4) tap the icon of the presented item on the sentence strip to activate the SGD speech output (e.g., “reinforcer label”). An independent step was recorded if within 5 s of the presentation of a preferred item, the participant completed the step in the sequence of responses necessary to
complete a SGD request using the PECS IV+ ® application, without gestural or physical prompts. A prompted step was recorded if physical or gestural prompting was required to complete a step.

The percentage of independent steps of SGD requests were collected across all phases of the study, using a data sheet created specifically for this study (see Appendix 2). The (a) total percentage of independent steps in the SGD request response chain, (b) percentage of prompted steps, and (c) number of sessions to criterion, were analyzed to monitor progress with the SGD during SGD teaching and to ensure mastery, then to monitor use of the SGD during both comparison conditions.

**Interobserver agreement.** All sessions were videotaped, and approximately 33% of sessions for each participant were selected for interobserver agreement. Independent, trained research assistants watched sessions and collected data on all measures. For all measures, trial-by-trial agreement was determined. An agreement was scored if both observers scored the same response within a trial. A disagreement was scored if both observers scored a different response within a trial. Agreements were calculated for each session by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100 to convert the result into a percent score.

**Procedural integrity.** A procedural integrity checklist was created for each condition (SGD teaching, condition 1 and condition 2; see Appendix 4). Independent, trained research assistants watched randomly selected sessions on video and used the checklists to score the researcher’s behaviour, including appropriate use of materials, prompting, modeling, time delay prompting, and reinforcement delivery (see Appendix 4 for a definition of each). Procedural integrity data were collected for approximately 33% of sessions for each participant.
Experimental Design

This study used an AATD (Sindelar, Rosenberg, & Wilson, 1985) to evaluate the effects on speech of two approaches to communication training using the PECS IV+® application as a SGD: (a) SGD speech output without time delay prompting, and (b) SGD speech output with a 3 s constant time delay prompting procedure, across three participants. During SGD teaching, participants were taught to request preferred items using the PECS IV+® application as a SGD. Speech output of the SGD device was disabled during SGD teaching, and a human-voice vocal model was used. Following SGD teaching, the two teaching conditions were compared. Researchers maintained a minimum of two hours’ time between sessions, the sequences of conditions were randomized, and comparison conditions were counterbalanced across participants to minimize carryover effects.

Procedures

Systematic preference assessment. A three-part preference assessment was conducted to determine items to be used in SGD communication training. This included an interview with each participants’ IBI primary therapist and two-part systematic preference testing.

In the interview, participants’ IBI primary therapists were asked to identify each participants’ preferred items/activities from across categories (e.g., leisure items, food, drink). Items identified during this interview were then used in subsequent preference testing.

During the first part of the systematic preference assessment, items identified in the interview were offered to participants, one item at a time, for 5 s. Each item was presented five consecutive times. The researcher recorded which items were selected. Selection was defined as taking the item from the tray and consuming it if edible, or if non-edible, selecting the item and engaging with it (e.g., manipulating the item) for at least 5 s. Items selected, and consumed or
manipulated, on 80% or more opportunities were defined as preferred and were used in the subsequent preference testing (Pace, Ivancic, Edwards, Iwata, & Page, 1985).

For the final part of preference testing, a multiple-stimulus without replacement preference assessment (MSWO; DeLeon & Iwata, 1996) was conducted. Separate MSWO preference assessments were completed for leisure and edible items. The results of the MSWOs provided a rank of participant’s preferences. The six highest ranked items, including a combination of edible and leisure items, were selected for SGD communication training.

The six items obtained from the MSWO were divided into two sets of three items each, and one set was randomly assigned to each comparison condition. To ensure that sets were comparable for use within an AATD, objects were matched on two variables: (a) participants’ preference for the items and (b) complexity of the word using a combination of expert-opinion, and a logical analysis. Results of MSWO preference assessments (above) were used to balance sets in terms of preference. A Communication Disorders Assistant (CDA) who was also a Board-Certified Behaviour Analysts (BCBA) with over five-years’ experience providing and supervising communication training, including speech, AAC and SGD training and transitioning, rated words in order of complexity by evaluating: (a) difficulty of speech sounds, (b) number of syllables, (c) configuration of words and sound placement, (d) initial consonants, (e) any redundant letters across words, and (f) number of syllables in each word. For John, sets were also balanced to include the target sound “m” once in each set; as “m” was a stereotypical sound that he frequently emitted. Once hierarchies of preference and word complexity were established, two individual raters, the author and her research supervisor independently created two sets of reinforcers for each participant, balancing preference and complexity. Once these sets of reinforcers were independently created, the sets were compared. For all three participants, 100%
agreement was found between raters. The six items selected for a participant were then used in the SGD teaching phase.

**Target words.** For Karen, the target words selected for Set 1 were “cheesy”, “cookie”, and “squishy toy”, the target words selected for Set 2 were “iPad”, “smarty”, and “chip”. For John, the target words selected for Set 1 were “iPad”, “smarty”, and “pop-up”, the target words selected for Set 2 were “cheesy”, “marble”, and “bubble”. For Karen and John, a second iPad was in a different case (i.e., not the SGD) was used as a reinforcer, in order to access preferred videos, accessible online. For Kyle, the target words selected for Set 1 were “bean”, “open”, and “candy”, the target words selected for Set 2 were “toys”, “wagon”, and “cookie”. For Kyle, “open” was used to request a water-bin being opened.

**SGD Teaching (SGD + human-voice model).** The SGD teaching phase was designed to obtain a measure of each participant’s speech when introduced to a new SGD without the influence of the device speech output (i.e., the speech output of the device was disabled, and a human-voice model of the sentence was provided by the research assistant), consistent with procedures used with PECS communication. For each participant, data were collected on independence of SGD requests, and speech (i.e., including speech and temporal location of speech). During SGD teaching and all subsequent phases, the participant’s PECS communication binder and an iPad displaying a preprogrammed PECS IV+® application screen were placed directly in front of the participant. A highly preferred target item was presented in front of the participant. The item was placed just beyond reach of the participant so that the researcher could block any attempts by the participant to take the item. When the participant reached for his or her communication binder the researcher physically prompted the participant to perform a SGD request. Using a backward chaining procedure, and most-to-least prompting, prompts were faded
across successive communication opportunities. Access to the item was provided immediately following any prompted or independent SGD requests. If the participant made an incorrect response (e.g., attempting to grab the item), a SGD request was physically prompted. A trial was ended after the delivery of reinforcement. Participants were given approximately 20s to interact with the item, or in the case of an edible item, until the item was consumed. Trials were only started if the relevant EO was in place (i.e., there were behavioural indicators that the participant was interested in the target item). If the relevant EO was not in place (e.g., the participant walked away or sought out other items), or if the participant made no response during the initial presentation (i.e., there were no behavioural indicators that the participant was interested in the target item) within 30 s, the researcher selected a different item and restarted the procedure.

Differential reinforcement was applied, in that a greater magnitude of reinforcement was provided for spoken full words and full sentences. The same magnitude of reinforcement was provided for full words as was provided for full sentences. Differential reinforcement was not provided for vocal approximations. A total of 30 trials (i.e., 5-trials per item) were run per session. Sessions were completed twice daily, and three days per week, on average. SGD teaching continued until the participant achieved mastery criteria for independent use of the SGD, defined as using the SGD to request preferred items with 90% or greater independence across five SGD teaching sessions, and stability of vocalization data was observed.

**Comparison phase.** The purpose of the comparison phase was to compare the effects of two teaching strategies: SGD speech output and SGD speech output with time delay prompting on participants’ speech.

**Condition 1 (SGD).** Procedures for condition 1 (SGD) were identical to the SGD teaching phase with the following exceptions: a) prior to beginning each session, the researcher
enabled the speech output function of the participant’s SGD, b) only items from Set 1 were presented during this condition, and c) for each item, the corresponding SGD speech-output “read” the sentence. A total of 15 trials (i.e., 5-trials per each of three items) were conducted each session.

**Condition 2 (SGD + time delay).** Procedures for condition 2 (SGD + time delay) were identical to condition 1 (SGD), with the following exceptions: a) only items from Set 2 were presented during this condition, and b) the use of time delay prompting was included by programming the corresponding SGD speech output for each item to include a 3 s pause, that is, between the SGD speech output that “read” the sentence starter (“I want”) and the SGD speech output that “read” the item name (e.g., “I want – 3 s pause - cookie”). A total of 15 trials (i.e., 5-trials per each of three items) were conducted each session. For each participant, data were collected on SGD requests, and speech, including temporal location of speech for Karen.

**Results**

**Speech**

**Percentage of trials with occurrence of any vocalizations.** Figure 1 shows the percentage of trials with occurrence of any vocalizations (i.e., vocal approximations, or full word vocalizations, or full sentence vocalizations) for Set 1 (SGD) and Set 2 (SGD + time delay) across the SGD teaching phase (SGD + human-voice), and when introduced to the comparison phase (i.e., condition 1 [SGD], and condition 2 [SGD + time delay]). During the SGD teaching phase (SGD + human-voice), the level of any vocalizations was low and variable for all participants. For Karen, a decreasing trend in vocalizations was observed across the SGD teaching phase, for both sets. Based on visual analysis there was no evident differentiation in
level of any vocalizations between Set 1 and Set 2 during the SGD teaching phase, across all participants.

For Kyle, after the first few comparison sessions, the level of any vocalizations was greater in Set 2 (SGD + time delay), than the level of any vocalizations, for Set 1 (SGD). During the final two sessions, the level of vocalization for Set 2 decreased and was comparable to that of Set 1. For Kyle, these vocalizations were primarily vocal approximations.

For John, vocalizations remained relatively consistent with the SGD teaching phase when the comparison phase was introduced. There appeared to be no visible benefit for vocalizations for either teaching strategy (with or without time delay prompting), for John.

For Karen, an immediate increase in level of any vocalizations was observed in both sets when the SGD voice output was introduced in the comparison phase. Initially, the level of any vocalizations was greater in Set 2 (SGD + time delay). Overtime, the level of any vocalizations also increased in Set 1 (SGD). Based on differential responding across comparison conditions, in which full sentence vocalizations were only observed in condition 2 (described below in Figure 3), the decision was made to apply condition 2 (SGD + time delay), to Set 2 (i.e., originally exposed to condition 1 [SGD]). Vocalizations were reliably observed on 100% of trials when both sets were moved to include time delay prompting.
Figure 1. Percentage of trials with occurrence of any vocalizations (i.e., vocal approximations, or full word vocalizations, or full sentence vocalizations). This figure depicts the percentage of trials with occurrence of any vocalizations for Set 1 (SGD) and Set 2 (SGD + time delay), for three participants across the SGD teaching phase (SGD + human-voice), and comparison phase. For Karen, condition 2 (SGD + time delay) was eventually applied to both sets.
Percentage of trials with occurrence of full word or full sentence vocalizations.

Figure 2 shows the percentage of trials with full word or full sentence vocalizations for Set 1 (SGD) and Set 2 (SGD + time delay) across the SGD teaching phase (SGD + human-voice), and when introduced to the comparison phase (i.e., condition 1 [SGD], and condition 2 [SGD + time delay]). For John and Kyle, both full word and full sentence vocalizations remained consistent with the SGD teaching phase at relatively stable zero-levels. For Kyle, full word vocalizations were observed in three sessions. Full word vocalizations were observed in one session for John. There was no visible benefit for full word or full sentence production with either teaching strategy (with or without time delay prompting), for both John and Kyle.

For Karen, an increase in full word vocalizations was observed in both sets when the SGD speech output was introduced in the comparison phase. There was variability in the percent of trials with full words and full sentences in condition 2 (SGD + time delay). In condition 1 (SGD), full word vocalizations increased overtime. Although full words were observed in both sets, full sentence vocalizations only occurred during condition 2 (SGD + time delay). Therefore, the decision was made to apply condition 2 (SGD + time delay), to Set 1 (i.e., originally exposed to condition 1 [SGD]). When time delay prompting was applied to both sets, full-sentences were more reliably observed across both sets.
Figure 2. Percentage of trials with occurrence of full word and full sentence vocalizations. This figure depicts the percentage of trials with occurrence of full word and full sentence vocalizations for Set 1 (SGD) and Set 2 (SGD + time delay), for three participants across the SGD teaching phase (SGD + human-voice), and comparison phase. For Karen, condition 2 (SGD + time delay) was eventually applied to both sets.
**Frequency of target speech responses for each temporal location.** Figure 3 depicts the frequency of full word vocalizations for Karen, across each temporal location: (a) initiated, (b) during the human-voice model or SGD speech output, (c) following the human-voice model or SGD speech output, for both Set 1 (SGD) and Set 2 (SGD + time delay), and (d) during or following pause of the time delay, for Set 2, across the SGD teaching phase, and the comparison phase. As full word vocalizations were only reliably produced by Karen, temporal location data were not analyzed for John or Kyle.

For Karen, during the SGD teaching phase there were limited occurrences of full word vocalizations across temporal locations, for both Set 1 and Set 2. Once introduced to the comparison phase, full word vocalizations occurring as either vocal initiations or during the SGD output, remained at stable zero-levels across both sets, with the exception, of sessions 13, 24, and 27 of condition 1. Vocalizations were only observed during the time delay pause during three sessions across both conditions (i.e., sessions 33 and 34 for Set 2, and session 36 for Set 1). The majority of vocalizations occurred following the full vocal model for both Sets 1 and 2, with greater stability in vocalizations following the model in Set 1 once the time delay was applied to this set.
Figure 3. Frequency of occurrence of full word vocalizations for each temporal location (i.e., initiation, during SGD speech output or human-voice model, following SGD speech output or human-voice model, and during or following the pause of a time delay prompt). This figure depicts frequency of occurrences of full word vocalizations for each temporal location for Set 1 (SGD) and Set 2 (SGD + time delay), for Karen, across the SGD teaching phase (SGD + human-voice), and comparison phase. Set 2 (SGD + time delay) was eventually applied to both sets.
Independent SGD Requests

Figure 4 shows the percent of independent SGD requests. All three participants acquired the ability to request preferred items using an iPad® with the PECS IV +® application as a SGD, achieving greater than 95% independence within three sessions (approximately 90 trials), and reaching mastery criterion (i.e., 90% or greater independent responses across five SGD teaching sessions) within six sessions (i.e., approximately 180 trials). When introduced to the SGD speech output in the comparison phase, John and Kyle’s performance decreased as both participants required prompting to wait for the SGD speech output to finish generating the speech output “I want” before selecting the reinforcer icon (i.e., both boys selected the icons in rapid succession which interfered with the speech output of the device). However, John’s performance steadily improved to criterion within eight sessions. Kyle’s performance improved to criterion within 22 sessions. Karen’s performance maintained above criterion across both comparison conditions.
Figure 4. Percentage of independent steps in the SGD requests task analysis. This figure depicts the percentage of independent SGD requests for three participants across the SGD teaching phase, and comparison phase.
Reliability. IOA was assessed on approximately 33% of sessions across the SGD teaching phase and both comparison conditions to obtain a measure of reliability for the dependent measures. For SGD requests, IOA ranged from 98% to 100%, with a mean of 99%, in the SGD teaching phase, ranged from 76% to 100%, with a mean of 95% in condition 1 (SGD), and from 88% to 100%, with a mean of 98%, in condition 2 (SGD + time delay), across participants. For vocalizations, IOA ranged from 87% to 100%, with a mean of 99%, in the SGD teaching phase, ranged from 87% to 100%, with a mean of 93%, in condition 1 (SGD), and ranged from 80% to 100%, with a mean of 96%, in condition 2 (SGD + time delay), across both participants. For temporal location, IOA was 97%, in the SGD teaching phase, ranged from 87% to 100%, with a mean of 93% in condition 1 (SGD), and ranged from 93% to 100%, with a mean of 95%, in condition 2 (SGD + time delay).

Procedural Integrity. Procedural integrity ranged from 97% to 100%, with a mean of 99% in the SGD teaching phase, ranged from 94% to 100%, with a mean of 99% in condition 1 (SGD), and was 100% for condition 2 (SGD + time delay), across all participants.

Discussion

In this study, all three participants quickly learned to use an iPad® with the PECS IV +® application as a SGD to request six preferred items. Participants requested items using the SGD with greater than 95% independence within three sessions (approximately 90 trials). These results are consistent with previous research supporting the use of SGDs as AAC systems to teach communication to children with ASD (Ganz et al., 2014; Lorah et al., 2015; Schlosser & Koul, 2015). It is possible that the rapid acquisition of the SGD request could have been facilitated by participant’s prior exposure to PECS training and use, as supported by Frost and McGowan’s (2012) recommendations on transitioning children from PECS to SGDs, once
children had demonstrated mastery of Phase IV of the PECS protocol. It is unknown if this rate of acquisition would be the same for children introduced to SGDs without the advantage of prior PECS training and use.

For John and Kyle, independence of SGD responses declined following the addition of the SGD speech output. It was observed that both participants selected the sentence starter and the reinforcer picture in rapid succession. This had negative implications for the SGD speech output. Specifically, the PECS IV+® application immediately generates speech upon selection of each icon. Therefore, when the sentence starter icon was selected, the corresponding SGD speech output was produced (i.e., “I want”). However, as soon as the participant selected the reinforcer icon, the output for the reinforcer icon would start – effectively “cutting off” the speech output of the sentence starter. Therefore, the full SGD speech output (i.e., “I want reinforcer”) was not produced. With additional prompting, both participants learned to wait for the SGD speech output to speak the sentence starter, before selecting the reinforcer icon to activate the SGD speech output of the reinforcer. Interestingly, during the time-delay condition, both participants were also observed to repeatedly select the reinforcer icon during the time delay. While it was hypothesized that the time delay prompt might create a CMO-T for speech, these two participants were observed to engage in a second SGD response rather than produce speech. To address this, developers of the PECS IV+® app have suggested that when using time delay prompting, a drag-and-drop activation of the SGD speech output could be programed, which would naturally increase the latency from the activation of the SGD speech output for the sentence starter and the SGD speech output for the reinforcer. Future research should investigate the use of the drag-and-drop response when using time delay prompting with the PECS IV+® application.
The primary purpose of the current study was to monitor the effects on speech production of two approaches to teaching SGD device use (i.e., SGD speech output without time delay prompting and SGD speech output with time delay prompting). The results suggest that the influence of the two teaching strategies on participant’s speech was different for each participant. For John there was no visible benefit for speech with either teaching strategy. For Kyle, an increase in the level of vocal approximations was observed in Set 2 (SGD + time delay); however, during the final 2 sessions, the level of vocalization for Set 2 decreased and was comparable to that of Set 1. These results suggest that for Kyle, time delay prompting may have been beneficial in increasing vocal approximations. For Karen, an immediate increase in level of any vocalizations was observed in both sets when the SGD voice output was introduced. Initially, the level of any vocalizations was significantly greater in Set 2 (SGD + time delay); however, overtime the level of any vocalizations also increased in Set 1 (SGD). Full word vocalizations were observed to increase in both sets when the SGD voice output was introduced. Although full words were observed in both sets, full sentence vocalizations only occurred during condition 2, which included a three-second time delay prompt. When time delay prompting was applied to both sets, full sentences were more reliably observed across both sets. These results suggest that for Karen, time delay prompting may have been beneficial in increasing the complexity or length of utterance of her speech. Kyle and Karen’s results, which show differential responding in the time-delay teaching condition demonstrate experimental control for this study.

In terms of functional control of speech, as assessed by the temporal location of full word vocalizations, for Karen it is likely that target speech responses were multiply controlled (i.e., echoic-mands). First, her target speech responses appeared to be under the functional control of motivating operations. As an EO to request an item was in place, target speech responses
initiated before the human-voice model in the SGD teaching phase, or before the SGD speech output, may have been primarily under the control of motivating operations (Charlop, Schreibman, & Thibodeau, 1985). However, when Karen was introduced to the two teaching strategies, target speech responses were more frequently observed following the SGD speech output during both comparison conditions (i.e., Set 1 and 2). This suggests that target speech responses were likely also under echoic (imitative) control (Gevarter et al., 2016). Skinner (1957) defined the echoic as a verbal operant that occurs when a speaker imitates the verbal behaviour of another speaker. An echoic verbal operant is functionally controlled by a verbal discriminative stimulus that has formal similarity and point-to-point correspondence with the response. In comparison to the SGD teaching phase, Karen imitated the SGD speech output more frequently than the human-voice model. Given that this child could produce some limited verbal speech before the onset of the study, the advantage of the SGD speech output over a human voice model could be due to the consistent auditory model provided by the SGD (Lorah et al., 2015).

In terms of the operant mechanisms underlying speech production during AAC training, for Karen, there was no increase in target speech responses (i.e., the reinforcer label) during the pause of the time delay prompt, as hypothesized. One interpretation of this is that for Karen, time delay prompting procedures might not have contrived a CMO-T for speaking the target word during the pause of the time delay prompt. In fact, it is possible that a new behaviour chain was created whereby Karen engaged in echoic behaviour, imitating each vocalization produced by the SGD, (i.e., the stimulus control for Karen’s vocal behaviour was the speech output of the device, and the SGD speech output for the terminal reinforcer reliably occurred following Karen’s production of the phrase “I want”). However, as data on the temporal location of speech is only presented for one participant at this time, more research is needed to make any definitive
conclusions on this hypothesis and to further inform practice related to the use of time delay prompting with SGDs.

A limitation in the interpretation of these results is that the focus of analysis was on the timing of the production of the reinforcer label. An analysis of the production of the sentence starter “I want” was not conducted. Also, temporal location data were scored mutually exclusively (i.e., the temporal location of the first occurrence of a full word vocalization was scored each trial), and thus, these data do not allow us to analyze if speech occurred across more than one temporal location of the response chain. Future research should use a more sensitive measure of temporal location, to more accurately analyze temporal characteristics of speech and interpret functional control.

Interestingly, for Karen, time delay prompting was associated with increased length of utterance of speech, which was not hypothesized. While formal data were not collected on the temporal location of the sentence starter, Karen was observed to speak the sentence starter during the pause of the time delay. As her speech was likely partially under echoic control, the time-delay may have allowed Karen the opportunity to imitate the sentence starter, which could explain the increased length of utterance under these conditions. Future analyses of these data will be conducted, to confirm this hypothesis. Although this appears to be a beneficial outcome, if the hope is that children will go on to produce sentences that are not echoic in nature, then additional teaching strategies or manipulations of the SGD speech output may be required to transfer the stimulus control of speech.

Recently, Gevarter (2018) used a behavioral intervention package to increase target mand vocalizations produced by minimally verbal children with ASD who used a SGD. The use of differential reinforcement procedures in which target vocalizations were reinforced with a highly
preferred target item and responses that did not include vocalizations produced a distractor trial and access to a lesser-preferred item, was shown to be effective in promoting target speech responses for three of the six participants. For two of the participants, the addition of echoic prompts, and rapid fading of these prompts, which involved modelling approximations and full words of the target responses, in addition to differential reinforcement of successive approximations, was required to increase target mand vocalizations. The addition of echoic prompting, as well as differential reinforcement procedures, may be necessary for some children, and may have been beneficial for John and Kyle, for whom stable increases in speech were not shown with time delay prompting alone.

The results of the present study should be evaluated in the context of at least four limitations. First, at this time, analyses are limited to a small, potentially non-representative sample, with data reported on only three participants. As this small sample may be non-representative of the population, it limits our ability to make any definitive conclusions regarding treatment effects and to generalize results to the greater population. This small sample may also limit our ability to make any definitive conclusions regarding differential treatment effects between the two interventions using an AATD.

Another limitation is that measurement on a third, control set of reinforcers was not conducted, and could not be included in analyses. Due to participants limited and restrictive preferences, establishing a third reliable set of stimuli was not possible, as consideration was made to the importance of retaining a set of reinforcers that were not used in research sessions, and could continue to be used during the participant’s involvement in IBI. Without a control set, it is impossible to detect threats to internal validity, such as whether a participants’ history or
maturation influenced their performance. This is a concern as communication training continued for several weeks (Kazdin, 2011).

Previous research of children with ASD has suggested that children’s vocal imitation abilities, prior to intervention, may influence the success of interventions targeting speech. In particular, gains in speech may be less likely when children lack sufficient vocal imitation skills (Ganz et al., 2014; Gevarter et al., 2013a; Schlosser & Wendt, 2008). This represents an additional limitation as this study did not include formal measures to assess participant’s vocal imitation skills prior to the SGD teaching phase. While data of vocal imitation skills have not typically been included in similar studies of SGDs and speech in the past (Gevarter et al., 2013a; Schlosser & Wendt, 2008), two recent studies of SGDs and speech (i.e., Gevarter, 2018 and Gevarter et al., 2016) and several recent vocal language intervention studies (that did not involve to use of SGDs) have included these data (Carroll & Klatt, 2008; Esch et al., 2005; Miguel et al., 2002; Normand & Knoll, 2006). Future research should include a measure of participant’s vocal imitation skills prior to introduction to the SGD.

Further, for children with ASD, oral-motor skills, such as a child’s ability to pucker their lips, or protrude their tongues has been shown to be associated with speech production, and fluency of their speech (Amato & Salvin, 1998). This study did not include a formal assessment of participant’s oral-motor skills prior to the SGD teaching phase. Future research should include a measure of participant’s oral-motor skills prior to introduction to a SGD, and to determine appropriate target words.

Though limited, the findings regarding the emergence of speech with the use of a SGD under different teaching conditions provide important suggestions for research, as well as for clinical practice. First, there was no notable reduction in speech for any participant following
introduction to the SGD with speech output. These findings are consistent with prior findings in the literature (Geverter, 2018; Geverter et al., 2016). In fact, for one participant, speech production increased under the time delay teaching condition, and for a second participant, speech production increased under both teaching conditions when SGD speech output was introduced. As such, concerns that communication using a SGD may delay or prevent the development of speech can be eased. For Karen, differential responding was observed when comparing teaching strategies. From a clinical perspective, these results provide evidence for the importance of individualizing teaching strategies when training SGD device use. Practitioners should also consider the available features of different AAC systems (Frost & McGowan, 2011), such as the ability to program a pause to use time delay prompting procedures, when selecting communication systems. Additionally, these results highlight the importance of collecting appropriately sensitive data when transitioning individuals from one AAC system to another (Frost & McGowan, 2012). Without the degree of sensitivity of the data collected in this study, changes in complexity of vocalizations (e.g., changes from full word to full sentence vocalizations) may not have been detected, and more effective teaching strategies may not have been adopted.

Although there was no formal measure of social validity, results were shared with all three participant’s families and clinical team, to aid in clinical decision-making and treatment planning. All participant’s families, and clinical teams reported that this information was helpful to them. Following completion of the study, Karen fully transitioned to an SGD. John and Kyle, on the other hand, are in the process of transitioning to full SGD device use.

At this time, the active recruitment for a fourth participant is ongoing. Data from future participants will be included in this study once data collection is complete.
References


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Appendix 1

PECS Phase Assessment Protocol

PECS ASSESSMENT PROTOCOL

ASSESSMENT GUIDELINES

1. Assessment will begin by testing the participant’s performance at Phase IVb/c.
2. High-preferred items identified in the MSWO preference assessment will be used as reinforcers for this assessment.
3. If on the first trial of the PECS assessment the child reaches for an item without utilizing their PECS book, give one prompt - "Use your words" and point to the book. Then record the prompt by circling P* on the data sheet. Data of correct or incorrect should still be recorded.
4. After item is presented deliver item to learner within 3 seconds for any appropriate behavior. If inappropriate behavior attempt to delay until calm (within 10 seconds is ideal; clinical judgement is warranted). It is acceptable to use a time delay prompt (max 3 seconds) prior to delivering an item.
5. If child gives a picture of an item that is not available, respond by saying "Take it" and offering available items; grant access to selected item and record performance; if child does not take an item and you believe they want another item, say “Sorry we don't have that...but you can chose one of these” (or something along those lines). Then repeat trial.
6. Document any spontaneous PECS use in comments on page 3 of data form.
7. If no indication of interest in reinforcer, end trial and try a new item identified from MSWO preference assessment. “Interest” is defined as looking at item, approaching item, reaching towards or attempting to access the item. If necessary, a “freebie” may be given to clearly ascertain interest.
8. Do not use differential reinforcement. All correct or incorrect responses should result in access to the reinforcer and the item being labelled and/or praise delivered.

ADVANCE CRITERIA
If participant reaches criteria at identified phase (3Ys in a row), advance and test next phase.

REVERSE CRITERIA
If participant does not meet criteria at identified phase (3 Ys in a row), return to prior phase (if it has not already been tested); if achieve success on that phase, STOP (do not return to higher phases)

DISCONTINUE CRITERIA
If participant does not meet criteria at identified phase, and previous phase has already been tested (or if met at Phase I), discontinue assessment. For phases greater than IIb, test for phase II (distance) prior to ended assessment.
PECS ASSESSMENT PROTOCOL

ASSESSMENT PROCEDURES

PHASE I (Single Picture)

CRITERIA FOR SUCCESS (Y)
Upon seeing and wanting a particular item, and with a picture of that item in reach, participant picks up a picture, reaches to RA and releases the picture into that person’s hand (no picture discrimination required; any single picture exchange is scored as "+").

Procedures
1. Sitting at table
2. Offer participant top item from PA (One item offered)
3. Affix corresponding picture on cover of binder (no array, single picture)
4. Entice child with item. Do not prompt child (*N/A if this is initial start phase. Only one initial prompt to be given (see Guideline 2).
5. Upon exchange, deliver reinforcer within ½ second of exchange.
6. Label item and/or offer praise.
7. Allow participant to consume or interact with item. (<30 seconds ideal)
8. Return picture to binder
9. Conduct 5 trials.
10. Record whether trial was correct (Y) or incorrect (N) on data form.
11. Determine appropriate advance, or discontinue criterion.
   a. If 3 Y’s in a row, advance to Phase II
   b. If do not get 3 Y’s in a row, STOP (Assessment Complete)

PHASE II (Distance & Persistence)

CRITERIA FOR SUCCESS (Y)
Upon seeing and wanting a particular item, and with a picture of that item alone on a communication book, participant will go to the book, carry picture or book to RA and give picture (no picture discrimination required; any single picture exchange is scored as "+")

Procedures
1. Sitting at table
2. Affix corresponding picture on cover of binder (no array, single picture)
3. Move binder 5 ft away from participant
4. Move self to other side of room (between 5-9 ft away) from participant
5. Offer one item (#1 from PA)
6. Upon exchange, deliver reinforcer within ½ second of exchange.
7. Label item and/or offer praise.
8. Allow participant to consume or interact with item. (<30 seconds ideal)
9. Return picture to binder.
10. Conduct 5 trials.
11. Record whether trial was correct (Y) or incorrect (N) on data form.
12. Determine appropriate advance, reverse, or discontinue criterion.
   a. If 3 Y’s in a row during 5 trials, **advance to Phase IIIb (Front of binder)**
   b. If do not achieve 3 Y’s in a row, **reverse to Phase I** (if not previously tested)
   c. If do not achieve 3 Y’s in a row, and Phase I previously tested, **discontinue**.

**PHASE III (Front of Binder)**

**CRITERIA FOR SUCCESS (Y)**
Upon seeing 3-5 reinforcing items and with the PECS book available with those pictures on it, participant will give RA one picture and then select corresponding item when told “Go ahead,” or “Take it,” or similar phrase.

**Procedures**

1. Sitting at table
2. Multiple items available
3. Multiple corresponding pictures on front of binder (if only known items are identified in PA, then just use child’s pictures); if unknown was a high preferred (i.e., in top 3 in PA), then place corresponding picture on binder, on the front page while participant watches
4. After participant exchanges picture, say “**take it**” and offer the items, allow participant to take an item.
5. Label item and/or offer praise
6. Record whether participant exhibited correct (C) or incorrect (I) correspondence on data form
7. Allow participant to consume or interact with item. (<30 seconds ideal)
8. Return picture to binder
9. Conduct 5 trials.
10. Record whether trial was correct (Y) or incorrect (N) on data form.
11. Determine appropriate advance, reverse, or discontinue criterion.
   a. If 3 Y’s and correct discrimination in a row during 5 trials **advance to Phase IIIb (Inside binder)**
   b. If do not achieve 3 Y’s in a row and correct discrimination, **reverse to Phase II** (if not completed previously)
   c. If do not achieve 3 Y’s in a row and correct discrimination, and Phase II previously completed, **discontinue**

**PHASE III (Inside Binder)**

**CRITERIA FOR SUCCESS (Y)**
Upon seeing 3-5 reinforcing items and with the PECS book available with those pictures inside of it, participant will give RA one picture and then select corresponding item when told “Go ahead,” or “Take it,” or similar phrase.

**Procedures**

1. Sitting at table
2. Multiple items available
3. Multiple corresponding pictures in binder (if only known items are identified in PA, then just use child's pictures); if unknown was a high preferred (i.e., in top 3 in PA), then place corresponding picture in binder, on the front page while participant watches
4. After participant exchanges picture, say "take it" and offer the items, allow participant to take an item.
5. Label item and/or offer praise.
6. Record whether participant exhibited correct (C) or incorrect (I) correspondence on data form
7. Allow participant to consume or interact with item. (<30 seconds ideal)
8. Return picture to binder
9. Conduct 5 trials.
10. Record whether trial was correct (Y) or incorrect (N) on data form.
11. Determine appropriate advance, reverse, or discontinue criterion.
   a. If 3 Y's in a row and correct correspondence during 5 trials advance to Phase IVa
   b. If do not achieve 3 Y's and correct correspondence in a row, reverse to phase IIIb (front of binder) (if not completed previously)
   c. If do not achieve 3 Y's in a row and correct correspondence, and Phase IIIb previously completed, discontinue

PHASE IV ("I want" on Sentence Strip)

CRITERIA FOR SUCCESS (Y)
Given PECS book with a variety of pictures and a Sentence Strip with an "I want" picture attached to Sentence Starter location on it, participant will request a desired item by attaching picture of item following "I want" picture on Sentence Strip and giving strip to RA.

Procedures
1. Sitting at table
2. Multiple items available
12. Multiple corresponding pictures in or on binder depending on parental report or success/failure at prior step (if only known items are identified in PA, then just use child's pictures); if unknown was a high preferred (i.e., in top 3 in PA), then place corresponding picture on binder, or in the binder on the front page while participant watches
3. "I want" picture affixed to sentence strip
4. Upon exchange, deliver reinforcer within ½ second of exchange.
5. Label item and/or offer praise.
6. Allow participant to consume or interact with item. (<30 seconds ideal)
7. Return picture to binder
8. Conduct 5 trials.
9. Record whether trial was correct (Y) or incorrect (N) on data form.
10. Determine appropriate advance, reverse, or discontinue criterion.
   a. If 3 Y's in a row during 5 trials advance to Phase IV b/c
   b. If do not achieve 3 Y's in a row, reverse to phase IIIb (inside of binder or on cover) depending on parental report or success/failure at prior step (if not previously tested)
   c. If do not achieve 3 Y's in a row, and phase IIIb previously tested, discontinue (Test Phase II if necessary)

PHASE IV B/C ("I want" Inside or on top of Binder)
CRITERIA FOR SUCCESS (Y)
Given PECS book with a variety pictures of available items, an “I want” picture, and a Sentence Strip, participant will request desired items by placing “I want” picture and picture of item in correct order on Sentence Strip, and giving entire Sentence Strip to RA.

**Procedures**

1. Sitting at table
2. Multiple items available
3. Multiple corresponding pictures in or on binder depending on parental report or success/failure at prior step (if only known items are identified in PA, then just use child’s picture); if unknown was a high preferred (i.e., in top 3 in PA), then place corresponding picture in binder, on the front page while participant watches
4. “I want” available inside or on binder depending on parental report or observations during MSWO preference assessment
5. Upon exchange, deliver reinforcer within ¾ second of exchange.
6. Label item and/or offer praise.
7. Allow participant to consume or interact with item. (<30 seconds ideal)
8. Return picture to binder
9. Conduct 5 trials.
10. Record whether trial was correct (Y) or incorrect (N) on data form. *(Continued on page 5)*
11. Determine appropriate advance, reverse, or discontinue criterion.
   a. If 3 Y’s in a row during 5 trials move on to **Phase V**
   b. If do not achieve 3 Y’s in a row, and phase IVa previously tested, **discontinue (Test Phase II if necessary)**

**PHASE V (Responding to “What do you want”)**

CRITERIA FOR SUCCESS (Y)
When asked, “What do you want?” or upon wanting an item, participant will construct sentence (two-word minimum) and exchange strip.

**Procedures**

1. Sitting at table
2. Multiple items available
3. Multiple corresponding pictures in or on binder depending on parental report or success/failure at prior step (if only known items are identified in PA, then just use child’s picture); if unknown was a high preferred (i.e., in top 3 in PA), then place corresponding picture in binder, on the front page while participant watches
4. “I want” available inside or on binder depending on parental report or observations during MSWO preference assessment
5. Ask participant “What do you want?”
6. Upon exchange, deliver reinforcer within ¾ second of exchange.
7. Label item and/or offer praise.
8. Allow participant to consume or interact with item. (<30 seconds ideal)
9. Return picture to binder
10. Conduct 5 trials.
11. Record whether trial was correct (Y) or incorrect (N) on data form.
12. Determine appropriate advance, reverse, or discontinue criterion.
   a. If 3 Y’s in a row during 5 trials **advance to Attributes**
   b. If do not achieve 3 Y’s in a row, and phase IVb previously tested, **discontinue (Test Phase II if necessary)**
ATTRIBUTES

CRITERIA FOR SUCCESS (Y)
Given PECS book with multiple attribute icons, and shown multiple preferred examples of a desired item varying by one attribute, participant will construct and exchange a Sentence Strip using an attribute icon in correct sequence ("I want" - attribute - reinforcer) and then when told, “Take it,” etc., will take the corresponding item (i.e., correct item and attribute). Only exchanges with correct correspondence will be scored as correct.

Procedures

1. Sitting at table
2. Corresponding attribute pictures provided on activity board with “I want” and picture for “candy” (or other appropriate known reinforcer).
3. Show participant options (i.e. colours, sizes); offer child “freebie”; offer two types of candy or other reinforcer (skittles, smarties to gauge interest)
   a. if child accepts/consumes – proceed;
   b. if child does accept/does not consume – discontinue and test Phase II
4. Ask participant “Tell me what colour or size candy/reinforcer you want?”
5. Allow participant to construct sentence
6. Tell participant to “take it”
7. Label item and/or offer praise.
8. Allow participant to consume or interact with item. [<30 seconds ideal] (Continued on page 6)
9. Return picture to activity board
10. Conduct 5 trials.
11. Record whether trial was correct (Y) or incorrect (N) on data form. (Only exchanges where correct correspondence is present will be scored as correct.)
12. Advance to phase VI

PHASE VI (Commenting)

CRITERIA FOR SUCCESS (Y)
Given access to activity board with only comment Sentence Starter icon and pictures of objects, and asked corresponding comment question, ("What do you see?") participant will construct sentence with comment Sentence Starter and object picture OR single object picture and exchange with RA.

Procedures

1. Sitting at table
2. 5 pictures
3. Corresponding vocabulary pictures provided on activity board with “I see”
4. Show participant picture (one at a time)
5. Ask participant “What do you see?”, “What is it?” or something similar
6. Upon correct exchange label picture and offer praise
7. Return picture to activity board
8. Repeat with 5 pictures
   a. If 3 Y’s in a row during 5 trials discontinue, test Phase II
   b. If do not achieve 3 Y’s in a row, discontinue, test Phase II
## Appendix 2

### SGD request data sheet

| Participant Behaviors | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|-----------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1. Participant taps “I want” picture to move it to the sentence strip |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 2. Participant taps reinforcer picture to move it to the sentence strip |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 3. Participant taps “I want” picture on the sentence strip |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 4. Participant taps reinforcer picture on the sentence strip |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

**TOTAL NUMBER CORRECT STEPS**

<table>
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<th>Comments</th>
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</table>

**TOTAL PERCENT INDEPENDENCE:**

\[
\text{(Correct steps / 120) x 100}
\]

**Master Criteria Met?**

Yes  No

**Data collection completed by:**

______________________________

**Video Code:**

______________________________

**PRIMARY IOA IOA Score:**

_______

**Appendix 2**

SGD request data sheet

**PECS to SGD Research Study**

SGD Intervention: SGD Response Data

Date: ________________  Participant# : ______  Researcher: ______  Session #: ______
## Speech data sheet

### SGD Intervention

**Vocalization Scoring Data Sheet**

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<th>Response</th>
<th>Timing</th>
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#### First Condition:

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1. VA FW FS NV I D P F
2. VA FW FS NV I D P F
3. VA FW FS NV I D P F
4. VA FW FS NV I D P F
5. VA FW FS NV I D P F
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11. VA FW FS NV I D P F
12. VA FW FS NV I D P F
13. VA FW FS NV I D P F
14. VA FW FS NV I D P F
15. VA FW FS NV I D P F

#### Second Condition:

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1. VA FW FS NV I D P F
2. VA FW FS NV I D P F
3. VA FW FS NV I D P F
4. VA FW FS NV I D P F
5. VA FW FS NV I D P F
6. VA FW FS NV I D P F
7. VA FW FS NV I D P F
8. VA FW FS NV I D P F
9. VA FW FS NV I D P F
10. VA FW FS NV I D P F
11. VA FW FS NV I D P F
12. VA FW FS NV I D P F
13. VA FW FS NV I D P F
14. VA FW FS NV I D P F
15. VA FW FS NV I D P F

**Vocal approximation (VA)**  **Full word (FW)**  **Full sentence (FS)**  **No vocal response (NV)**

**Vocal Initiation (I)**  **During SGD (D)**  **During or following pause (P)**  **Following SGD (F)**

**Trials with vocalizations:**

<table>
<thead>
<tr>
<th>VA</th>
<th>FW</th>
<th>FS</th>
<th>NV</th>
<th>I</th>
<th>D</th>
<th>P</th>
<th>F</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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<table>
<thead>
<tr>
<th>Set 1 %</th>
<th>Trials</th>
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</thead>
<tbody>
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<table>
<thead>
<tr>
<th>Set 2 %</th>
<th>Trials</th>
</tr>
</thead>
<tbody>
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Data scoring completed by:  PRIMARY IOA

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Appendix 4

Procedural integrity data sheets

<table>
<thead>
<tr>
<th>Video Code: ____________________</th>
<th>Procedural Integrity Data Sheet</th>
<th>TOTAL PERCENT ACCURACY OF IMPLEMENTATION: ____________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date: ________________________</td>
<td>Participant# : _______</td>
<td>Instructor# : _______ Session#: _______</td>
</tr>
</tbody>
</table>

**Researcher Behaviors**

1. Participant’s PECS communication book is placed within the participant’s reach.
2. The researcher places the SGD in front of the participant.
3. Presents items in front of the participant if they may be used.
4. Entices the participant with items using no or limited speech.
5. If participant requires prompting to construct sentence and make communication request, physical or gestural prompting is provided, as necessary.
6. When participant completes taps pictures on sentence strip of SGD, the researcher “reads” the sentence then the student points to each picture.
7. Does not delay in “reading” sentence strip (i.e., between “I want” and reinforcer name).
8. Reinforces an exchange by delivering the designated item within 1 to 2 seconds.
9. If participant makes no response within approximately 20s (i.e., no behavioral indicator of interest), the researcher offers the participant with a different item.
10. If the participant requests an item that is not available, the researcher states “sorry, we don’t have that right now, but we have these”, or something similar.
11. Does the participant approximately 20 seconds to interact with the item, or in the case of an edible item, when the item is consumed, or in the case of a set of items, approximately 20 seconds is given with the set.
12. Differentially reinforces if student speaks.
13. Does not insist on or drill speech initiation/production.

<table>
<thead>
<tr>
<th>Trial</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<th>16</th>
<th>17</th>
<th>18</th>
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<th>20</th>
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</thead>
</table>

**TOTALS ( # of +/total behaviors scored)**

**PERCENT CORRECT**

Procedural Integrity completed by: ____________________ PRIMARY IOA IOA Score: _______
### PECS to SGD Research Study

#### Procedural Integrity Data Sheet

**SGD ALTERNATING CONDITIONS**

<table>
<thead>
<tr>
<th>Date: __________________</th>
<th>Participant#: ____________</th>
<th>Instructor #: ________</th>
<th>Session #: ________</th>
</tr>
</thead>
</table>

| Trial | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|-------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| **Researcher Behaviors** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Participant’s PECS communication book is placed within the participant’s reach. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| The researcher places the SGD in front of the participant. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SGD speech output is enabled. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Presents item(s) in front of the participant (a tray may be used). | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Entices the participant with item(s) using no or limited speech. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| If participant requests prompting to construct sentence and make communication request, physical or gestural prompting is provided, as necessary. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Following cessation of SGD speech output reinforce an exchange by delivering the designated item within 1 to 2 seconds. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| If the participant makes no response within approximately 20 s (i.e., no behavioral indicator of interest), the researcher entices the participant with a different item. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| If the participant requests an item that is not available, the researcher states “sorry, we don’t have that right now, but we have these”, or something similar. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| If the participant speaks the target word during the speech output of the device, or during the pause of the BCIS, the reinforcer is immediately delivered. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Differentially reinforces if student speaks. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Does not insist on or drill speech imitation/production. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**TOTALS** ( # of + / total behaviors scored) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**PERCENT CORRECT**

Procedural Integrity completed by: ___________________  PRIMARY IOA IOA Score: ________
Appendix 5

Certificate of Ethics Clearance

Social Science Research Ethics Board

Certificate of Ethics Clearance for Human Participant Research

DATE: 10/19/2015

PRINCIPAL INVESTIGATOR: KOUDYS, Julie - CADS

FILE: 15-038 - KOUDYS

TYPE: Faculty Research

STUDENT: Kryssten Thompson

SUPERVISOR: Julie Koudys

TITLE: Transition from the Picture Exchange Communication System (PECS) to Speech Generating Devices (SGDs)

ETHICS CLEARANCE GRANTED

Type of Clearance: NEW  Expiry Date: 10/31/2016

The Brock University Social Science Research Ethics Board has reviewed the above named research proposal and considers the procedures, as described by the applicant, to conform to the University's ethical standards and the Tri-Council Policy Statement. Clearance granted from 10/19/2015 to 10/31/2016.

The Tri-Council Policy Statement requires that ongoing research be monitored by, at a minimum, an annual report. Should your project extend beyond the expiry date, you are required to submit a Renewal Form before 10/31/2016. Continued clearance is contingent on timely submission of reports.

To comply with the Tri-Council Policy Statement, you must also submit a final report upon completion of your project. All report forms can be found on the Research Ethics web page at http://www.brocku.ca/research/policies-and-forms/research-forms.

In addition, throughout your research, you must report promptly to the REB:

a) Changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;

b) All adverse and/or unanticipated experiences or events that may have real or potential unfavourable implications for participants;

c) New information that may adversely affect the safety of the participants or the conduct of the study;

d) Any changes in your source of funding or new funding to a previously unfunded project.

We wish you success with your research.

Approved:

[Signature]

Kimberly Maich, Chair
Social Science Research Ethics Board

Note: Brock University is accountable for the research carried out in its own jurisdiction or under its auspices and may refuse certain research even though the REB has found it ethically acceptable.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of research at that site.