Effects of PECS Phase III Application Training on Independent Mands in Young Children with Autism

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EFFECTS OF PECS PHASE III APPLICATION TRAINING ON INDEPENDENT MANDS IN YOUNG CHILDREN WITH AUTISM

By

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Bachelor of Arts Psychology
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2006

Master of Arts in Psychology
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ABSTRACT

Effects of PECS Phase III Application Training on Independent Mands in Young Children with Autism

by

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Children with autism may use challenging behavior as a means to request or reject (Chiang, 2008). One way to alleviate problem behavior is through functional communication training. Previous research on Functional Communication Training indicates success with replacing various problem behaviors (Dolezal & Kurz, 2010; Davis et al., 2009; Franco, Lang, O’Reilly, Sigafoos, & Rispoli, 2009; Falcomata, Roane, Feeney, & Stephenson, 2010; Hagopian, Contrucci Kuhn, Long, & Rush, 2005; Horner & Day, 1991; Olive, Lang, & Davis, 2008; Padilla Dalmau et al., 2011; Wacker et al., 1998; Wu, Mirenda, Wang, & Chen, 2011). Picture Exchange Communication System training in Phases I through III can help reduce problem behavior that functions to produce desired items or activities through teaching the exchange of an icon as a replacement behavior.
All previous studies on PECS training in Phases I-III have evaluated the use of paper icons (Ali et al., 2011; Angermeier et al., 2008; Barnes et al., 2011; Carré et al., 2009; Chambers & Rehfeldt, 2003; Dogoe et al., 2010; Frea et al., 2001; Kravitz et al., 2002; Lund & Troha, 2008; Park et al., 2011; Rehfeldt & Root, 2005; Rosales & Rehfelt 2007; Tincani 2004; Ziomek & Rehfeldt, 2008). Currently, there are no prior studies that have been conducted to evaluate the efficacy of PECS Phase III training with a PECS Phase III application. Therefore, the purpose of this study was to examine the effects of PECS phase III application training on independent mands in young children with autism.

Participants were five children with autism ranging from ages 2 to 4 years old. A multiple baseline across participants was used to evaluate acquisition of independent correct mands across baseline and treatment conditions during training with the PECS Phase III iPad™ application. Data for Participant Four did not demonstrate experimental control directly, as he showed high levels of mands during baseline. The functional relationship for Participant One is questionable as she too likely learned to mand by contacting the contingency during baseline procedures. Participant Three successfully acquired all skills taught during training with the PECS Phase III iPad™ application and his data suggested experimental control. Two participants (Participant Two and Participant Five) were unable to complete the study within its time frame, but their data also suggest a functional relationship. Data for Participant Five suggested a delayed, but beneficial treatment effect.

For all participants who completed the study, mands generalized at moderate to high accuracy (60% to 100%) in a novel setting across all generalization probes. Maintenance measures indicated moderate to high durability of treatment effects (70% to
Mand preference assessments were also conducted to evaluate participant preference between paper icons and the iPad™. All participants indicated a preference for mands using the iPad™. Parent report indicated that four out of five parents of study participants felt that the iPad™ would be easier to use in their daily routine. Parents were also confident that they would be able to use the iPad™ to support their child’s communication (if given training).
ACKNOWLEDGEMENTS

This project is dedicated to all those who have helped me grow over the many years in which I had the privilege to be a student. If it were not for the support and mentoring of my current advisors, previous advisors, parents, husband, friends, the UNLV/CSUN preschool, Southwest Autism Behavior Solutions, and doctoral colleagues, none of my successes in this program would have been possible.

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DEDICATION

With love and admiration to:

My parents, Olivia and Herbert Love. My siblings, Aaron, Rachel, and David.

My husband, Matthew Dolan.
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CHAPTER 1
INTRODUCTION

Language is consistently embedded within daily human interaction. Skinner (1957) defines language or “verbal behavior” as any behavior that is reinforced through the mediation of another person or organism in the verbal community. In a general sense, it gives a person the power to affect the actions of others in his/her environment. From a life-long perspective, it may also affect a person’s ability to successfully navigate the social community.

Language especially has notable implications in the field of early childhood education. Every day, bustling preschools are filled with chatter among the pupils, teachers, and classroom assistants. The preschoolers are able to share and gain information by talking with the various people around them. Some children, however, do not have the same command of language as others. These children may need more support in the practice of language through specialized interventions; others may need assistive technology devices in order to fully participate in the early childhood setting. Thus, the purpose of this study was to examine the effects of PECS phase III application training on independent mands in young children with autism.

Assistive Technology

As cited in The Assistive Technology Act of 1998, assistive technology devices (ATDs) are defined as "any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities” (p. 6). Assistive technology can help people better live their daily lives, function on the job, improve their educational experiences, or even improve their health (Seelman, 1993). Assistive
technology can include both low tech and high tech devices. Low tech devices may require little to no battery power and may include crutches, ramps, or modifications to everyday objects such as using a special pencil grip to help improve handwriting. Higher tech devices may include hearing aids or augmentative or alternative communication devices such as computerized voice output machines.

Access to assistive technology is now considered a legal right, but was not always mandated by law. The Americans with Disabilities Act (ADA, 1990) and the Individuals with Disabilities Education Improvement Act (IDEA, 2004) laid the groundwork for civil rights among people with disabilities. The Americans with Disabilities Act created the legal right for such populations to have access to national, state, and local programs, and to be reasonably accommodated in employment, education, and other public settings. Examples of accommodations included simple physical modifications such as ramp access in buildings that had stairs, however, other accommodations included more extensive modifications such as phone accommodation services for people who had hearing deficits. The right to fully participate in the community also extended to people with communication or speech deficits (U. S. Department of Justice, 2009/2012).

In school settings, the Individuals with Disabilities Education Improvement Act (2004) represented a reauthorization of previous legislation known as the Education for All Handicapped Children Act of 1975 (i.e., PL 94-142). In its most current version, IDEA mandates that children with disabilities have a free appropriate public education, individualized education plan, and that a group of experts and the student’s caregivers will make team-based decisions along the course of a student’s academic career (Hallahan, Kauffman, & Pullen, 2009; U. S. Department of Justice, 2009/2012).
A law that more specifically mandates the use of technology to aid people with various disabilities is The Technology-Related Assistance for Individuals with Disabilities Act (“Tech Act”) of 1988 (i.e., P.L. 100-407). This law provided the first legal definition of assistive technology (Oklahoma Assistive Technology, n.d.). The law was enacted to provide funding to state and federal programs to provide financial assistance to purchase assistive technology for all individuals with disabilities, regardless of age (Title I). Under Title 2, part C, funding was also provided to universities to train professionals in assistive technology. The most current version of this law is The Assistive Technology Act of 2004, P.L. 108-364.

**Assistive Technology for Communication**

Because of these laws, people with disabilities now have access to technology that can help them better participate in daily life, school, and the community. The inability to produce vocal speech can hinder a person’s ability to fully participate if they do not have some alternative means to convey their needs or ideas. One type of assistive technology can help people who cannot produce vocal speech by speaking for them. This type of assistive technology is commonly referred to as assistive or augmentative communication (AAC). Mirenda (2003) states that AAC is divided into two categories: aided and unaided. Unaided AAC is when the person uses alternative communication that does not require any external device to create a message. This includes manual signs, gestures, or miming. In contrast, aided AAC is when the individual requires some type of external object or device in order to communicate a message. Some examples include symbols of language such as printed words, line drawings, or photographs (Mirenda, 2003). Other
examples that may be considered “higher tech” include voice output devices, microswitches, and even computers (Wehmeyer, 1999).

Such devices, when used in conjunction with behavioral interventions, have produced positive outcomes for people with communication deficits. Specifically, functional communication training is a technology that encourages efficient communicative responses to indicate wants or needs to replace challenging behavior (e.g., hitting, throwing objects).

**Functional Communication Training**

Functional Communication Training (FCT) was developed to alleviate problem behavior and encourage appropriate communicative responses (Carr & Durand, 1985). Its procedures were created based upon principles of Applied Behavior Analysis (ABA). Specifically, these interventions are designed to directly benefit the speaker (Carr & Durand, 1985). During functional communication training, problem behaviors are reduced or eliminated by teaching an individual to use a functionally equivalent, appropriate communicative response as a replacement for the problem behavior. Functions of problem behavior (and selection of appropriate communicative responses) are often guided by a functional analysis (Iwata, Dorsey, Slifer, Bauman, & Richman, 1994).

The efficacy of functional communication training (FCT) has been supported by previous research and found to be effective for replacing problem behaviors such as elopement (Falcomata, Roane, Feeney, & Stephenson, 2010; Olive, Lang, & Davis, 2008), excessive protesting (Davis et al., 2009), noncontextual speech (Franco et al., 2009; Wu, Mirenda, Wang, & Chen, 2011), self-injurious behavior (Hagopian, Contrucci
Kuhn, Long, & Rush, 2005; Horner & Day, 1991) and aggression (Dolezal & Kurz, 2010; Padilla Dalmau et al., 2011; Wacker et al., 1998). Functional Communication Training has also been designated an established (evidence-based) behavioral treatment package by both the National Autism Center (2009) and the National Professional Development Center for Autism (n.d.).

**Previous Response Topographies**

Alternative responses to challenging behavior range from vocal responses (Durand & Carr, 1991), voice output communication aids (Olive, Lang, & Davis, 2008), and sign language (Fisher et al., 1993), to simple cards with printed words (Matson, LoVullo, Boisjoli, & Gonzales, 2008). Recent developments in assistive technology devices have also included small, portable tablets or touch-screen computers. These devices provide additional options of communication topographies for people with communication deficits.

Skylar (2008) discussed the implications of touch screen, portable computers (e.g., iPod touch) in terms of better differentiating instruction for students. Portable computers have also been discussed as a tool for supporting universal design for learning (Schweder & Wisick, 2011). Applications for communication (e.g., Proloquo2Go, Grace) have been developed to provide a portable, lightweight alternative to larger voice-output devices (Menard, 2011; Sennott & Bowker, 2009).

Some noted advantages of using portable computers are the “cool factor” (Menard, 2011) and the ability to customize the images for each user (Fried-Oken, Beukelman, & Hux, 2012). In addition, access to the tablets allows the person to
participate in common activities that peers are already using such as interacting through social forums (AAC-RERC, 2011).

**Implications of Tablet Response Topographies**

There are also several potential advantages for using tablet devices for communicative purposes with young children who have autism. For example, previous researchers have found that young children with autism exhibit gross motor delays, fine motor delays, or both (Matson, Mahan, Fodstad, Hess, & Neal, 2010; Provost, Lopez, & Heimerl, 2007). Fine motor delays may potentially limit the ability of a young child with autism to use certain AAC devices. For example, in the traditional Picture Exchange Communication System (PECS), the person must be able to grasp and pull an icon off of a Velcro strip.

The physical picture icons can be customized based on size, but grasping and pulling with hands and fingers still remains a prerequisite skill for the communicative response. Fine motor skills may also preclude a child with autism from learning unaided AAC topographies such as sign language. Previous researchers have noted motor imitation deficits to be common in children with autism (Jones & Prior, 1985). Such deficits may become notable challenges in the acquisition of sign or gestures as a means of communication. Tablet computers in contrast, do not require grasping responses and usually require an individual to use a pointing and dragging response. Because the response requires less effort, this may help a child with autism and motor delays to more quickly acquire the use of a tablet device for generating communicative responses.

Moreover, the cost of other AAC options such as voice output devices may hinder their adoption. For example, DynaVox™ voice output devices cost between seven and
eight thousand dollars (DynaVox Mayer-Johnson, 2009). Fortunately, tablet computers such as the iPad™ cost much less. The average cost for an iPad™ ranges between 400-500 dollars, depending on the amount of memory, model type, and other characteristics (Apple Store U. S., 2012).

Hocking (1999) reviewed occupational literature on factors related to abandonment of assistive devices. Several reasons were identified as to why people typically stop using their assistive technology. The main reasons were that (a) the person’s needs changed, (b) the device was challenging to use or was not reliable, (c) the person did not receive enough training, and (d) the appearance or size of the assistive technology was problematic. The tablet computer may alleviate some of these problems for those who are looking for an augmentative or alternative communicative device. As previously noted, most tablet communication applications can be changed or customized to each user and updated as the user’s needs change. In addition, because of the tablet’s popularity and the popularity of “smart” phones, many people already have some experience with operating them. Sales in 2012 of the iPad™ alone were 15.4, 11.8, and 17 million for their respective first, second, and third quarters (Washington Post, 2012).

Building on the idea of popularity, because tablet computers are so widely purchased and commonly used in everyday life, carrying such a device on person is no longer unusual. From a perspective of including a person or child with ASD into school or the community, using a tablet device for communication or other academic tasks is less unusual than if a less-known device is adopted. In short, use of such devices does not make the person with AAC stand out from peers (Sennott & Bowker, 2009). Despite these speculated advantages in previous literature, little research is present to support the
use of the new tablet devices over more established, low tech, and low cost alternatives such as the Picture Exchange Communication System.

**Picture Exchange Communication System**

According to Bondy and Frost (1994), appropriate replacement responses selected during functional communication training are commonly a vocal speech response; however, alternative or augmentative communication (AAC) has also been used as a response topography. As previously mentioned, sign language, voice output devices, and symbols have all been used as media for communicative responses. Specifically, the picture exchange communication system (PECS) can be considered a type of AAC or assistive technology device. Bondy and Frost developed the PECS intervention procedures in 1994.

PECS approaches language acquisition from a Skinnerian perspective of verbal behavior development as opposed to teaching labels of objects or matching to sample as a foundation for further language development. PECS was developed to investigate a more efficient means for children with autism to acquire communication (Bondy & Frost, 1994). In this system, training to request a desired item is taught first (Bondy & Frost, 1994). This is based on the premise that children with autism may not share the same sensitivity to social consequences as typically developing children.

During the use of PECS, a tangible, desired consequence is paired with a social interaction. The child learns to use communication to alter the behavior of another person and to achieve a goal (i.e., to produce the desired object or activity). As the child continues through the six phases of PECS, the consequences become less direct and more social in their characteristics. If they complete all phases, the child finishes the program.
with the ability to describe characteristics of items or events through the use of a picture and word strip.

**Statement of the Problem**

Recent technological advancements have made portable technology more accessible and affordable to the general public. Because of this, applications are now emerging for persons with communication disabilities. The Rehabilitation Engineering Research Center on Communication Enhancement (AAC-RERC, 2011) published a report that states there is a significant need for quality research that examines the efficacy of these new AAC applications. Such research should evaluate application effects on both “functional communication and quality of life” for people with communication deficits (p. 4).

Currently, a picture exchange communication system application has been developed for Phase III of PECS (A. S., Bondy, personal communication, April 16, 2012). A review of the literature on PECS interventions indicated that there are no studies on tablet applications of PECS. Furthermore, additional studies on PECS are needed in order to clarify its role as an evidence-based practice. According to the NAC (2009) PECS is an emerging practice for individuals with autism. Flippin, Reszka, and Watson (2010) conducted a review of literature and identified PECS as a “promising but not yet established evidence-based intervention” (p. 178). The efficacy of PECS as a language intervention will be discussed with more depth in Chapter 2.
Research Questions

Based upon previous literature on PECS efficacy, the following research questions were generated:

1. Does training with a PECS phase III iPad™ application increase the frequency of independent mands among young children with autism spectrum disorder?

2. Does training with a PECS phase III iPad™ application result in similar levels of independent mand performance among young children with autism spectrum disorder within an alternate setting?

3. Will the effects of PECS phase III iPad™ application training maintain after the intervention is withdrawn?

4. Will participants indicate a preference for requests using the iPad™ over requests using PECS paper icons?

5. After viewing a brief video clip or live demonstration of their child using the PECS phase III iPad™ application, will parents perceive it as feasible to use with their children at home or in the community?

To answer the first research question in this study an investigation of the effects PECS phase III application training had on the frequency of participants’ independent, discriminated mands was required. This question was based on previous studies that have evaluated the frequency of mands both before and during PECS training. Studies increased independent, discriminated mands after PECS training in phases I through III with participants of varying diagnoses such as Autism, Down Syndrome, or Intellectual Disability (Ali, MacFarland, & Umbreidt, 2011; Angermeier, Schlosser, Luiselli, Harrington, & Carter, 2008; Barnes, Dunning, & Rehfeldt, 2011; Carré, Grice, Blampied,
To answer the second and third research questions independent mands made by participants within an alternate setting and over time was required. The inclusion of this question was supported by findings from Dogoe, Banda, and Lock, (2010). Their findings indicated that among three preschool-aged children with autism, all of them demonstrated generalization of PECS use across settings and people, but only two out of three participants demonstrated generalization of PECS use to new stimuli.

The second research question specifically involved an investigation of the efficiency of the intervention procedures in producing novel requesting behavior with different people and settings. In addition, these data were collected to serve as a measure of social validity related to the intervention. The ability to request across novel settings is an essential component of the participant obtaining a generalized communicative repertoire. It was deemed if the intervention failed to produce generalization to an alternate setting, then such information would be valuable feedback for modifications of future studies or clinical evaluations of the PECS phase III application.

The third research question specifically involved an evaluation of the durability of treatment effects from PECS phase III iPad™ application training. Maintenance measures were included to address the limitations of some studies on PECS (e.g., Chambers & Rehfeldt, 2003; Cihak, Smith, Cornett, & Coleman, 2012) that did not include the collection of maintenance measures.
The fourth research question was created in order to assess participant preference related to high and low-tech PECS and to provide a direct observation of the social validity of the iPad™ intervention. There were two primary rationales for this question. First, Hawkins (1991) suggests using not only participant verbal behavior to assess the value or actual usefulness of an intervention, but to also measure behaviors that can be directly observed. Second, this research question resulted in a systematic way to identify which modality of communication is preferred by the participant. Such information may help the family or teacher with future decisions on which modality would be best to continue using.

To answer the fifth research question, caregiver perceptions of the iPad™ application intervention were evaluated. Specifically, this information was used to evaluate the practical use of the iPad™ application in the primary setting in which young children spend a majority of their time. Benedict, Lee, Marrujo, and Farel, (1999) strongly suggest evaluating the early childhood outcome of an assistive technology device by carefully considering both the positive and negative aspects of the experience. Due to this suggestion, each of the caregivers was asked an open-ended question about their experience (“Generally, how did participation affect your child?”) Moreover, because young children spend the most time with their parents, it was important to understand whether the parents would use the iPad™ application with their child at home or in the community. Studies have indicated that interventions that incorporate the family’s goals and opinions during the planning process tend to have better outcomes for both the parent and the child (e.g., Brookman-Frazee, 2004) and these improvements tend to last over time (Lucyshyn, Albin, & Nixon 1997; Lucyshyn et al. 2007).
Significance of the Study

While most children develop communication or language through daily caregiver interaction, others may need more direct and systematic instruction. The chosen population for this study was young children with autism. Autism is a neurodevelopmental disorder that is characterized by delays in development of social communication skills, social interaction skills, and excesses in repetitive behavior or restricted interests (American Psychiatric Association, 2013).

With current prevalence rates of 1 in 88 children (Centers for Disease Control and Prevention, 2012), autism diagnoses are increasing. In one study, Lord and Rutter (1994) estimated that approximately 50% of children with autism were nonverbal; but other studies such as Lord, Risi, and Pickles (2004) estimated that the rate was lower, between 14% and 20% of nine year olds (as cited in Rice, Warren, & Betz, 2005). Nonverbal was defined as having 5 or fewer spoken words.

Regardless of the specific percentage, what is agreed upon in the literature is that children with autism have significant needs for communication support and instruction. Previous literature (Baker & Cantwell, 1982) suggests that children with fewer communication skills are more likely to engage in challenging behavior. Specifically, children with autism are more likely to engage in self-injury, tantrums, and aggression if they have a language impairment (Dominick, Davis, Lainhart, Tager-Flusberg, & Folstein, 2007). Larger communication deficits are often associated with increased self-injury (Baghdadli, Pascal, Grisi, & Aussilloux, 2003) as well as decreased relationship development with peers (Helmstetter, Peck, Griangreco, 1994).
Moreover, children with autism may also use challenging behavior as a means to request or reject (Chiang, 2008). Such challenging behavior can have a negative effect on a family’s quality of life (Fox, Vaughn, Wyatt, & Dunlap, 2002) and the child’s ability to successfully form relationships with others (i.e., make friends) in school or in the community (Turnbull & Ruef, 1996). This study will evaluate a method to teach children with autism to use appropriate communicative responses.

Another population that is impacted by the increased prevalence of autism and its associated communication deficits is early childhood educators. The National Association for the Education of Young Children (2009) states that children with disabilities and their families have the right to “…participate in a broad range of activities and contexts as full members of families, communities, and society” (p. 2). That is, every child has a right to be included in early childhood settings and access the same opportunities as all other young children. A 2010 report by the National Office of Special Education programs indicated that 49,213 children ages 3-5 with autism were reported to have been served under the Individuals with Disabilities Education Improvement Act (IDEA, 2004).

**Potential Benefits**

Many children with autism are included in an early childhood setting even though they still have communication deficits and/or challenging behavior. This study may provide both direct and indirect benefits for the participant. First, the procedures combined with the PECS iPad™ application may help the participant acquire the ability to communicate within their early childhood environment. Such a repertoire may increase the quality of life for the individual, as well as increase his/her independence.
In addition, some studies have shown that simple, “natural” language intervention with children of preschool age can produce an indirect benefit of reductions in problem behavior without directly targeting it (Koegel, Koegel, & Surratt, 1992). This is a potential indirect benefit for the participant receiving the PECS iPad™ application intervention. Some literature on PECS also indicates a potential collateral reduction of problem behavior. For example, Frea, Arnold, and Vittimberga (2001) found that aggressive behavior for a single participant immediately decreased when PECS was introduced within play activities. Moreover, aggressive behavior became nonexistent after only 6 days of intervention. If a participant in this study exhibits problem behavior that functions to produce preferred items or activities, the acquisition of requesting responses by using the iPad™ application may potentially reduce problem behavior as a side effect.

Besides the direct and indirect benefits for the participant, the final possible benefits are those that may affect parents or early childhood educators. It is possible that parents or the early childhood educator will find that the iPad™ application is easier to use than other previous language interventions including “low tech” paper PECS. The PECS iPad™ application may then have a positive effect of creating additional time for other teaching or planning activities (for the early childhood educator) or additional family activity time or errand time (for parents). Parents and early childhood educators may also report less confusion when learning to use the PECS™ application because they may have already had some experience with operating an iPad™.
Addition to Previous Literature

A final discussion point about the significance of this study is that there is no research that has evaluated the efficacy of the PECS iPad™ application. There are some studies that involved an evaluation of other communication applications for the iPod™ (e.g., “Pick-a-Word” and “Proloquo2Go”), but none have been conducted to evaluate the PECS application. There are, however, a large number of studies that have been conducted to evaluate traditional PECS in “low tech” paper form. Tincani and Devis, (2011) conducted a metaanalysis of these studies published between 2002 and 2009..

Currently, there are many applications for communication on tablet technology, and little research on the efficacy of each. To make an informed choice, consumers will need objective information. They will need knowledge about which application is effective, and also which is appropriate for their unique needs or abilities. The current study provides an evaluation of the effectiveness of the PECS iPad™ application, and the social validity of its potential day-to-day use in home and preschool settings.

Limitations of Study

The limitations of the study included the following: small sample size, potential maturation effects of the participants, the short duration of each intervention session, and the inability to control other language practice or programming that the participant may have received at home or school.

1. The small sample size may have affected the results and conclusions of this study. It is possible that with a larger number of participants, different conclusions would be made regarding the efficacy of training.
2. The brief duration of each session (i.e., ten trials) may have affected a participant’s ability to master PECS phase III in a timely manner. It is possible that with additional time and practice, responses using the PECS phase III application would be acquired by participants more quickly.

3. The inability of the experimenter to control the amount of practice or intervention the child received at school or home may have affected the outcome of this study. If a child’s parent increased the amount PECS iPad™ or paper icon practice at home, this may have affected the child’s results during the preference assessment or it may have accelerated progress when learning to use the iPad™.

4. The participant’s prior history with navigating or playing with a mobile device (e.g., a parent’s smart phone) may have expedited acquisition for some of the participants.
Definition of Terms

**Application (app).** For the purpose of this study, an app is defined as any software program designed to operate on a portable tablet computer, for example the iPad™. Applications have many uses including recreational activities, business endeavors, academic tasks, and organizational tools.

**Autism.** A neurodevelopmental disorder with behavior deficits in social communication and social interaction. The diagnosis also includes excesses in repetitive/stereotyped behavior, restricted interests, and unusual responses to sensory stimuli (American Psychiatric Association, 2013).

**Challenging Behavior.** For the purpose of this study, challenging behavior is any behavior which precludes a person from fully participating in family, social, school, or community activities. Examples include self-injury, aggression (e.g., hitting, kicking, spitting, pulling on people’s arms), screaming, and tantrums.

**Conditional Discrimination Training.** “A conditional-discrimination procedure defines conditional relations between stimuli: "If A1, then B1; if A2, then B2." The procedure may also generate matching to sample. If so, the stimuli will be related not only by conditionality, but by equivalence: A1 and B1 will become equivalent members of one stimulus class, A2 and B2 of another” (Sidman & Tailby, 1982, p. 5).

**Fixed Ratio One-to-One (Reinforcement Schedule).** A schedule of reinforcement delivery in which a response produces a reinforcer or the delivery of a reinforcer on a one-to one ratio. This occurs every time a response is emitted (Cooper, Heron, & Heward, 2007).
**Functional Communication Training.** An approach toward treating problem behavior that first analyzes the function of the problem behavior, and then teaches a communicative response that fulfills the same function (Carr & Durand, 1985).

**Mand.** “...a type of verbal response which is characteristically reinforced with a special consequence and is therefore under the control of the corresponding drive” (Skinner, 1957, p. 30).

**Motivating Operation.** A stimulus change in the environment that alters both the reinforcing effectiveness of a stimulus and the future probability of a behavior occurring (Michael, 1993/2004).

**Picture Exchange Communication System (PECS).** A program that functions as augmentative or alternative communication created by Andrew Bondy and Lori Frost at the Delaware Autism Program. PECS consists of seven phases beginning with the exchange of a picture to request a preferred item (Bondy & Frost, 1994).

**Preference Assessment.** A systematic evaluation “by which therapists can identify stimuli that might function as reinforcers for individuals with developmental disabilities” (Deleon & Iwata, 1996, p. 519).

**Prompt.** For the purpose of this study, a prompt is a stimulus that is added to the environment to occasion a response or increase the likelihood of its occurrence. Prompts can be gestural (e.g., pointing to the correct answer), a model (e.g., saying the correct answer or having the participant watch the correct performance of a task), or physical (e.g., guiding the participants arms or hands through the motions of the correct response).
**Reinforcer.** A reinforcer is a stimulus change in the environment that is delivered contingent upon a response and increases the future probability of the response occurring (Cooper, Heron, & Heward, 2007).

**Tact.** “... a verbal response in which the form is determined by a particular object or event which stimulates the speaker prior to the emission of the response”(Skinner, 1957, p. 58).

**Summary**

The current trend in emerging tablet technology is to create applications that are useful and inexpensive for people with communication deficits to use as augmentative/alternative communication devices. However, little research exists on the efficacy of these applications or their comparative efficacy to other more established communication devices or programs. The intent of this study was to evaluate the efficacy of an iPad™ phase III on independent mands in young children with autism. Moreover, generalization, maintenance, and participant preference of the iPad™ compared to traditional “low tech” (paper) PECS was also examined. The results of this study have practical implications for children with autism, their parents, and early childhood educators.

A review of the literature on the traditional “low tech” Picture Exchange Communication System will be presented in Chapter II, and complete methodology of this study is located in Chapter III. Finally, the study’s results will be reported in Chapter IV. Chapter V includes a discussion of results in the context of previous literature, as well as suggestions for future studies.
CHAPTER 2

REVIEW OF RELATED LITERATURE

The main purposes of this chapter are to provide an overview of the PECS protocol procedures according to Frost and Bondy (2002), and summarize existing literature on Picture Exchange Communication System (PECS). First, the procedures used to conduct PECS training are described. Second, experimental studies related to various investigations of PECS are reviewed. Finally, a synthesis and interpretation of the research on both aforementioned topics will conclude this chapter.

PECS Procedures Description

Communication training with PECS involves six distinct phases. The six phases will be discussed according to the protocol of Bondy and Frost (1994). The first phase involves teaching the child to pick up a picture from a communication board and exchange a picture for a preferred item. The second phase involves making the exchange more effortful for the child by moving the trainer or communication board farther away from the child. The third phase involves training discrimination of two pictures that are presented at the same time. Initially the two pictures may be of one preferred item and one non-preferred item. Eventually the pictures will be of equal preference. Correspondence checks are also conducted during this phase to determine whether the child chooses the tangible item that corresponds to the appropriate picture. The fourth phase involves teaching the child to request using a sentence of, “I want ____.” The fifth phase is similar to phase four, with the exception that the child learns to construct a sentence strip and give it to the communicative partner in the presence of the question,
“What do you want?” Finally, in the sixth phase, the child begins to label objects in the environment using the sentence strip, “I see ____.”

**PECS Literature Review**

**Search Procedures**

A search was conducted for literature on PECS procedures through electronic databases. The following databases were used: Education Full Text, Eric, Psyc Info, Middle Search Plus, Professional Development Collection, and PsycArticles. The search terms used were “picture exchange communication system”, picture exchange communication system, PECS, PECS AND autism, PECS review, and PECS metanalysis. Another step in the search process involved obtaining articles from the reference lists of the obtained articles. For example, some articles were identified from the reference lists of articles that conducted meta analysis or a literature review on PECS. Finally, the National Autism Center’s National Standard’s Project report was also used to identify articles on PECS.

**Inclusion Criteria**

To be included in the review, studies had to (a) be published between 1985 and 2012, (b) contain a minimum of an A-B design, (c) include data plotted in graph form if a single subject design was used, and (d) contain participants with some type of disability. Studies that were excluded from the review included descriptive research, case designs, studies with typically developing participants (e.g., only staff or parent behaviors were examined), or studies that included a picture exchange procedure, but did not explicitly state that the published PECS procedures (Frost & Bondy 1994/2002) or
modifications of these procedures (Frost & Bondy 1994/2002) were used to teach the icon exchange.

The search yielded 39 studies that met inclusion criteria. The studies were first organized according to research design and divided into review, group design, or single subject. Because of the increased number of single subject design studies, this group was divided into sub-categories according to the prominent purpose of the study. Sub-categories included generalization studies, PECS icon or procedure adaptation studies, PECS treatment package studies, collateral behavior studies, and PECS comparison studies.

The search also produced 8 additional review articles related to PECS efficacy. Reviews were included if their purpose was to evaluate the efficacy of PECS, or compare outcomes of PECS to other interventions. One article (Law, Plunkett, and Stringer, 2012) was excluded because communication interventions were the purpose of its review, but contained only a single study that involved the use of PECS as an intervention. Reviews consisted of PECS efficacy and comparisons of PECS versus other types of AAC. Other types of AAC included sign language, voice output communication aids/speech generating devices, and other picture-system methods.

**PECS Review Studies**

Literature reviews which have evaluated the efficacy of PECS for individuals with ASD have reported overall positive effects of the intervention. Tien (2008) reviewed 13 studies containing 125 participants with an autism spectrum disorder. Results indicated that sound research designs, treatment fidelity, generalization, and maintenance components of the reviewed studies supported the recommendation of PECS as an
evidence-based intervention. However, it was recommended only as evidence-based practice for individuals with autism spectrum disorders and suggestions were made to conduct additional reviews for other populations.

Preston and Carter (2009) reviewed 27 studies that specifically cited Frost and Bondy (1994, 2002) as the teaching procedures for PECS. All other studies that used similar procedures but did not cite the PECS manual as the guiding method were excluded. The studies included a variety of methods including random controlled trials, single subject designs, pre-experimental, and quasi-experimental designs. In the review, both percentage of non-overlapping data (PND) and percentage of data points exceeding the median (PEM) were calculated for the 10 single subject studies which were appropriate for that type of analysis. Three random controlled trial studies were also evaluated for quality. The three included in the review either lacked a control group (because the purpose of the study compared two interventions) or no description of treatment fidelity. The mean PND and PEM calculations for the single subject studies showed evidence for the intervention, with PND and PEM values of 78.5% and 89.1% respectively. Overall, Preston and Carter (2009) suggested that more random controlled trial studies be conducted with PECS because of the promise shown in single subject studies. They also suggested that future research address the lack of external validity associated with single subject designs.

In an earlier review that included studies published from 1992 to 2006, Lancioni and colleagues (2007) compared the efficacy of PECS and VOCAs. Their digital and hard copy search yielded 37 studies that either evaluated PECS or picture exchange-type methods, VOCA, or directly compared PECS and VOCA for teaching requesting to
participants. Their review indicated no highly noticeable differences between acquisition rates of one system versus the other, their use in daily routine, or preference by participants. The researchers suggested in the discussion that differences may not have been revealed because of the smaller number of requests taught in the reviewed studies and only with increasing the number of requests would discrepancies be revealed. In addition, clear preferences for one response modality versus another could not have been revealed because of the smaller number of participants and equivalent motor abilities of said participants. It was suggested that if motor impairments were a factor, it was possible that VOCA could have been the device of choice for participants.

Finally, the researchers hypothesized that if truly there was little to no difference between the two systems for the user acquisition (participants), then implications for the communication device selection may be related to caregiver preferences (e.g., time, resources, and budget). That is, price, ease of response interpretation, and set-up time associated with each response modality may be some of the factors affecting adoption of PECS or VOCA.

Hart and Banda (2010) evaluated 13 single subject studies conducted between 1994 and 2007. Their review covered 36 participants: 30 male and 6 female. Results indicated that 34 of the 36 participants acquired the targeted PECS phases. The two who did not both had intellectual disabilities, one of which experienced increased seizures during PECS training. For this participant, the researchers started over in phase I after the participant showed marked decreased accuracy during the increase in epileptic activity. The other participant failed to discriminate between pictures of preferred and non-preferred items in phase III.
A more objective analysis of the data included calculation of PND for all dependent measures included in each study. PND was calculated for 35 participants because one participant’s baseline data were not available. Upon further exploration of effectiveness of the PECS training, PND calculations showed that PECS training was effective for 19 participants, moderately effective for 10 participants, minimally effective for 6 participants, and had no effect for one participant. Upon review of comparison studies (PECS vs. sign and PECS vs. VOCA) PND values indicated that PECS was somewhat more effective than sign language in increasing requests for a majority of participants, and as effective as VOCA in increasing requests.

In review of generalization and social validity, 54% of the studies reported some type of generalization assessment. Reports of generalization included participants successfully requesting with new people, new settings, and new objects that were not part of the original training conditions. Only two of the 13 studies reported measures of social validity. Results were positive overall, with only one of the parents indicating that she felt that PECS did not increase her child’s communication. One study used a quantitative scale (with a score of 1 for low social validity and 10 for high social validity), and the scores were relatively high, ranging from 7 to 9.5.

The researchers stated that based on the review PECS increased manding for a majority of participants and increased speech for a few participants. Recommendations included continuing studies on PECS with treatment integrity procedures (as only 5 of the 13 studies included treatment integrity). Other suggestions included longer periods of time to assess maintenance effects, more generalization measures, and measures of social validity.
Flippin, Rezka, and Watson (2010) also conducted a review on PECS but included group and single subject designs from 1994 to 2009. Their method consisted of calculated and aggregating effect sizes across single subject studies. For group design studies, the data that were presented did not allow calculation of an effect size. Communication and speech were evaluated and reported separately. For single subject studies, the mean effect size was 0.51, indicating that participants showed improvement in communication outcomes following PECS training. Across aggregates of single subject and group effect sizes, overall the researchers reported that PECS had little to no effect on speech when looking across all of the studies.

The researchers discussed other variables that may influence children’s success with PECS such as object exploration, joint attention, and imitation. These variables have been mentioned in previous studies on PECS, and the researchers suggested continued exploration in predictor variables for success with PECS. The researchers also suggest conducting more comparison studies of PECS versus other language interventions for children with autism spectrum disorder.

Tincani and Devis (2011) conducted a meta-analysis on 16 single-subject design studies on PECS. In total, there were 44 participants across the studies. Studies evaluated requests using PECS as well as speech. All studies were also required to cite the PECS method (e.g., Frost & Bondy, 2002) as their procedures. PND was used as the unit of analysis for treatment effects for each participant. A total of 41 PNDs were calculated because of incompleteness of some participants’ data sets.

Results indicated that requests using PECS was acquired at a relatively equal rate for both males and females. Statistical analysis indicated no difference in acquisition
rates for diagnosis, gender, or training setting. Vocalization effect sizes were not aggregated. There was variability in the definitions used in each study, and participant speech acquisition was also variable. Treatment fidelity was only reported in 7 of the studies, and the degree of rigor for assessing fidelity was also lacking in some of the studies.

Overall, the PND analysis mean was 80.1, indicating that on average PECS produced a moderate improvement compared to baseline for acquisition of requests using pictures. More research for Phases V and VI were suggested, as there were not many studies that involved an evaluation of the later phases of PECs. About half of these participants in the metaanalysis had diagnoses other than autism or Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS) which led the researchers to tentatively suggest that PECS may be useful with other populations. Although some participants showed no gains in speech while others made modest to moderate gains, it was noted that the purpose of the PECS intervention is not to increase speech, and findings in lack of speech acquisition should not discredit its methods. In summary, the researchers also highlighted that the reviewed studies contained only 44 participants and cautioned against drawing definite conclusions based on such a small sample.

Finally, Ganz et al., (2012) compared the efficacy of PECS, other picture-based systems, and speech generating devices in a meta-analysis specifically for populations with ASD. The search yielded 24 articles of single subject design that met criteria. Improvement Rate Difference (IRD) was used to evaluate effectiveness of each AAC type. In total, IRD was calculated 122 times due to multiple participants in each study and multiple comparisons. After IRDs were combined, results indicated that PECS and
speech generating devices had large effects (.99 for each type). In comparison, other picture-based systems had a relatively smaller effect (.61). It was noted however, that the other picture-based system studies contained the oldest participants. It is possible that older participants’ progress may have been hindered because they had experienced a greater portion of life without learning to communicate. Ganz et al. (2012) mention that this variable may have contributed to those studies’ acquisition results.

**PECS Group Studies**

PECS has also been empirically supported through group studies. Six group studies were identified via the literature search. Schwartz, Garfinkle, and Bauer (1998) conducted two studies to examine several aspects of PECS. The first study was designed to evaluate how quickly children with disabilities are able to learn PECS. The second study was designed to investigate the effects of PECS training on the overall communicative abilities (including spoken communication) of children with disabilities. In their first study, 31 children ages 3 to 6 participated in the study. Study two contained a sample of 18 children who also participated in study one. Participants were of various diagnoses including autism, Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS), Down Syndrome, Angelman Syndrome, and other developmental disabilities. All sessions were conducted in the participants’ classrooms in a university-partnered inclusive preschool. The researchers used a descriptive design.

Data were collected retroactively by examining each child’s IEP data book records. The time it took for the child to acquire PECS was measured in weeks from the IEP data book. Children were taught to use PECS according to the published PECS manual procedures and ended on sentence building with “I want ___”. Children were also
taught to use PECS with peers according to procedures developed by Garfinkle and Schwartz (1994). Children had communication books with them during all school activities, including community outings. Teachers taught use of PECS to request across many activities throughout each day. Mastery criterion for a PECS phase was 80% accuracy for three consecutive days.

Data were analyzed by cumulatively graphing the average number of months needed to master each phase of PECS. Ranges of data were also visually examined. Results indicated that on average, it took children about two months to master the initial exchange of PECS icons for a preferred item. It took an average of three more months for children to master the ability to select the correct picture among an array of other pictures. After an average of four months, children had mastered the sentence-building phase. Finally after an average of three more months, children had mastered the use of PECS during interactions with peers. Overall, the researchers found that it took children 14 months on average (range 3 months to 28 months) to master the entire series of targeted PECS phases. The researchers concluded that PECS was acquired relatively quickly on average. A strength of this study was the large sample size, a weakness was that information on the reliability of the data or treatment integrity were not available.

During study two, Schwartz, Garfinkle, and Baer (1998) wanted to investigate the effects of PECS on other forms of communication besides requesting via PECS icons. Participants were eighteen children who were currently enrolled at the university-partnered preschool. Children were ages 4 and 5, and had the same diagnoses as mentioned for study 1. Sessions were conducted at the preschool. The study had characteristics of both within-group and within subject design. Each child was observed
once in spring, fall, and spring. Data were analyzed on the individual level, as well as comparing group averages for each observation period. Data were collected during snack and free play using event recording and direct observation. In addition, children’s vocal communicative responses were recorded verbatim and coded by function. Other communicative responses were coded by frequency, form (PECS, vocal, gesture), and function (request, label, comments). It is assumed that participants were in different phases of PECS training during the study, as the procedures were not described in study two.

Data were graphed in several ways. First, post-hoc labels were applied to children as “talkers” or “non-talkers” because a clear vocal pattern emerged for all children. Eight children were observed to be consistent talkers, and 10 children were consistent “non-talkers.” As a result, the average number of spontaneous vocalizations was graphed in line graph form with two data paths: one for talkers and one for non-talkers. Separate graphs were made and analyzed for snack and free play. Second, data on the function of vocalizations were converted to a percentage of the total number of communications. These data were graphed in bar graph form and visually analyzed. Function patterns unique to groups of children were also separately graphed in bar graph form.

Results indicated that 44% of children in the study acquired some functional speech. Some children also increased the range of functions in their communicative acts, even though they were only trained to request through PECS. The researchers concluded that possible maturation effects, participant-specific characteristics (e.g., ability to vocally imitate) may have accounted for differential results between the talkers and non-talkers. A strength of this study was that it followed the children for a relatively long
period of time (about one year) while they were learning PECS. A weakness of this study was that they did not collect baseline data.

Another group study was conducted by Magiati and Howlin (2003). The purpose of the study was to explore the efficacy of PECS implementation in the United Kingdom. Participants consisted of 34 children with autism (29 boys and 5 girls). Ages of children ranged from 5 to 12 years. About half of the children had no prior experience with PECS; however, seven children had experience with PECS ranging from Phases II to V. All children attended schools in which teachers were trained in PECS methods over a 2-day seminar and received six check-in visits with PECS consultants. The treatment consisted of training in PECS up to Phase VI (depending on their rate of learning) within their regular education classroom. Measures were collected for students, teachers and parents.

As cited in Magiati and Howlin (2003), student measures consisted of PECS level acquired, the number of different pictures learned by each participant, and the frequency of picture exchanges. It is important to note that frequency of picture exchanges was gathered using teacher report on a rating system. For example, a teacher would score a 4 to indicate that the child requested using PECS 6-10 times a day. Increases in other communication modalities (e.g., speech, pointing, manual signs, crying) were measured by a modified communication profile (Wetherby & Prizant, 1989) and other behavior changes were measured by the Vineland Adaptive Behavior Scales Interview Edition (Sparrow, Ball, & Cicchetti, 1984) and Autism Treatment Evaluation Checklist (Rimland, 2000). Data were collected 2 months before the treatment and every two months for six months.
Data were analyzed using non-parametric tests due to the nature of the data (i.e., teacher report ratings). Wilcoxon non-parametric tests were used to compare pre-post data and Friedman’s analysis of variance was used to compare repeated measures 1, 2, 3, and 4. \( P \) values were adjusted to .01 to allow for the increased number of comparisons. Results for participants without PECS experience showed significant increases in PECS level acquired and number of different pictures acquired in all time comparisons. The students also significantly increased the frequency of PECS use between pre and post measures. Upon further inspection of repeated time measures however, the only significant increase in frequency of PECS use was between time 1 and time 2. Student communication profile scores showed similar results; the only significant increase in other communication skills such as pointing, speech, or manual sign was between time 1 and time 2. Post hoc comparisons of phrase/sentence speech were found to be significantly higher in time 4 compared to time 1. Finally, a significant reduction in overall problem behavior as measured by the Autism Treatment Evaluation Checklist was also found.

For some analyses, groups were divided into those with PECS experience and those without PECS experience as well as students who were more verbally advanced or less verbally advanced. Overall, children who were more verbally advanced acquired the largest gains in PECS between times 1 and 2, and then their progress stayed at approximately the same rate. The less verbally advanced group, however, tended to make more consistent progress between all time measures.

The researchers noted that because of the lack of a control group, it was difficult to determine fully that results obtained were the product of PECS training. Maturation or
other educational activities could have affected the students’ progress. In addition, no fidelity of implementation measure was used, so there was no assessment of whether the PECS training was implemented consistently and as intended.

Limitations of this study include the aforementioned lack of comparison group and lack of treatment integrity measures. In addition, generalization across settings or persons was not directly assessed. Finally, a major limitation of the study was that although the students’ teachers reported their PECS use, number of pictures, and more--many of these data sets were rating scale based. There are many limitations to a rating scale basis of performance, especially when the system covers a wide range of behavior. For example, a score of 4 meant that the student exchanged between 6 and 10 times that day. Although this system increases the ease of data collection, it loses accuracy and may have affected interpretation of results. In addition, the researchers do not state the time of day that teachers collected data. At the end of a school day, teachers may have difficulty recalling all of the times each student used PECS; this again calls into question whether the reported data are representative of what actually occurred.

In contrast, strengths of this study were the relatively large number of participants (i.e., 59) and the variability of the participant characteristics. Although participant variability often made it difficult to conduct analyses, it is likely that groups of schools will encounter a wide variety of ability levels for students. Breaking participants into “more or less verbally advanced” and prior PECS training or no prior training, provided useful information for future studies about each type of student.

Yoder and Stone (2006) conducted a randomized control study that involved a comparison between Responsive Education and Prelinguistic Milieu Teaching (RPMT)
and PECS training methods. Participants consisted of 36 children with ASD, ages ranging from 18 to 60 months. The PECS treatment group contained 19 children, and the RPMT group contained 17 children. All children received three 20-minute sessions per week for six months in a clinic room. PECS treatment consisted of training according to Frost and Bondy (2002). Parents were also trained to support PECS at home, in school, or the community. RPMT training consisted of prompting request of an item in the context of a turn-taking activity with a highly preferred toy. Yoder and Stone reference Yoder and Warren (1998) for the full procedure description. During play, the therapist would prompt the child using as least intrusive a prompt as possible in order to ask for the toy. Once the child acquired non-verbal communication skills (e.g., pointing to an item to request it) the treatment progressed to teaching speech and procedures were modeled after Warren (1991). Parents in the RPMT group were also trained in this treatment method in order to support communication in other contexts. The average number of therapy sessions for all children was 60.

Data were collected on object exchange turns, requests, and initiating joint attention. There were two hypotheses for the study: (a) RPMT would produce better object turn-taking and joint attention than PECS and (b) PECS would produce better outcomes with requesting compared to RPMT. Data were gathered using direct observation. Data were analyzed with several statistical analyses. Results indicated that the RPMT group had a greater and significant effect on object exchange turns, and PECS did not have a significant main effect on requests. However, with children who had initially lower frequency of joint attention, PECS produced significantly greater
outcomes with manding compared to RPMT. In contrast, the RPMT treatment produced
more mands in children who had initially higher frequency of joint attention.

The researchers discussed the interesting findings of the relationship found
between a child’s skill level of joint attention and the success or non-success with either
PECS or RPMT. A limitation of the study included a lack of data on how often parents
used the treatments at home. The researchers also mentioned that parents in the RPMT
group received more training than the PECS group—which could have affected results.
For example, parents who ask for more training may have also been more likely to
practice more often at home due to pre-existing motivational differences, or they could
have felt more comfortable with the procedures. Finally, treatment integrity measures
were not fully described and appeared to be coded according to a rating scale format.
(e.g., 1 = poor, 2 = good, 3 = excellent). More highly operationalized checklists of
implementation would have increased the strength of this measure.

Strengths of the study included the relatively large number of participants,
statistical control for covariates of pre-existing group differences, and random assignment
of participants to treatment groups. The researchers also statistically analyzed whether
observer blindness affected the scoring of data. This provided greater believability of the
data scores and results of the study.

In follow-up, Yoder and Lieberman (2010) posed an additional research question
related to the same sample of participants from the Yoder and Stone (2006) study. Their
research question was whether PECS training produced response generalization for the
36 participants with ASD. Treatment consisted of the same procedures described
previously for the Yoder and Stone (2006) study. Data were collected in the context of
the Early Social Communication Scales-Abridged (ESCS-Abridged; Mundy, Hogan, & Doehring, 1996). During the ESCS, the number of icon exchanges with a novel adult, in a novel setting, and with novel items or activities was recorded. Only one picture associated with each new item was available to the participant, so picture discrimination was not required. Participants were assessed with the ESCS-abridged twice (pre and post measures).

Results of statistical analysis showed no significant difference between the groups during pre-test on icon exchanges. A significant difference was found between post measures for PECS and RPMT, with the PECS group showing a greater number of generalized exchanges than RPMT during post-test.

The researchers recognized the limitation of the method in which PECS exchange opportunities were presented during the ESCS. That is, only a single icon was available to the participant to use for exchange and no conclusion can be drawn about the participants’ abilities to discriminate among several different icons. Because of this, the measure only relates information about the participants’ number of icon exchange(s), not whether the icon(s) were accurately selected and exchanged. A strength of this study was that observers who coded the measure for this study were blind to the participant’s treatment condition.

Carr and Felce (2007) wanted to evaluate the effects of mastering PECS phases I, II, and III on the communication skills of young children with autism. Participants were 24 children with autism in the intervention group, and 17 children with autism in the control group. The age range of these participants was 3 to 7 years. All children were required to have no experience with PECS past phase I. All sessions were conducted in
the participant’s regular school, in both classrooms and quiet areas, depending on the phase they were learning.

The research question was evaluated using a between-within group design. Communicative behaviors were measured using direct observation frequency or cumulative frequency recording. Communicative behaviors were broken down into the following discrete categories: “(1) total number of child-to-adult initiations, (2) number of child-to-adult initiations with a response from the adult, (3) total number of adult initiations with opportunity for the child to respond, (4) number of adult initiations with opportunity for the child to respond and with a response from the child, (5) number of adult initiations with no opportunity for the child to respond” (Carr & Felce, 2007, p. 728). These dependent measures were collected at three times during the study: Six weeks before intervention (T₀), five weeks after starting intervention (T₁), and one week after finishing the 15 hours of intervention (T₂). Control group participants were observed using the same timing as the intervention participants. Observation sessions were two hours duration.

Participants in the PECS intervention group received 15 hours of intervention and could reach up to phase III. Protocol for teaching PECS was according to Frost and Bondy (2002). Participants in the intervention group had verified that they had only received their regular preschool programming throughout the study. Within subject comparisons of data were made by using Wilcoxon t-tests, and between subject comparisons were made using Mann–Whitney U tests. Results indicated a significant increase in number of communicative initiations made by children who received PECS training, significant increases in initiations that evoked responses from adults, and
decreases in adult-initiated communications compared to the control group. The researchers concluded that 15 hours of PECS training can result in significant increases in communicative initiations from children and can play an important role in creating spontaneous communication from children with autism.

A strength of this study was the between-within subject comparisons. The within-subject comparisons allowed the researchers to rule out maturation effects, a common threat to internal validity (especially with child participants). A weakness of this study was that the researchers did not assess maintenance for a longer period of time after treatment had ceased. The durability of effects for such a short (15 hour) intervention would be extremely valuable information for clinicians. Based on the researchers’ results, the long-term effects of a brief PECS intervention on spontaneous communication are not fully understood.

In another study, Howlin, Gordin, Pasco, Wade, and Charman (2007) evaluated the effectiveness of expert training and consultancy in PECS protocol for teachers of children with autism spectrum disorder. Their main focus, however, was the child outcomes. This was assessed in-group design fashion. Participants were 84 elementary children (average age 6.8 years) with diagnoses of autism. The teachers implemented the treatment in the child’s regular classroom. A random control between-within subject design was used. Participants were randomly designated by classroom into the following categories: Immediate Treatment Group (PECS training conducted right after baseline), Delayed Treatment Group (PECS training conducted two terms after baseline), and No Treatment. Some of the participants had minimal (phase I) exposure to PECS prior to the study.
Data were collected during Time 1, Time 2, and Time 3 using direct observation. Time 1 was before PECS training (baseline). Time 2 and Time 3 observations were conducted after PECS training (treatment group 1 and delayed treatment 2). Data were collected using direct observation and event recording on frequency of child communicative initiations, frequency of use of PECS symbols, and frequency of speech (including non-words). Frequencies were converted to rate per minute to allow comparability across varied-duration of observation sessions. The Expressive One Word Picture Vocabulary Test (EOWPVT) and British Picture Vocabulary Scales (BPVS) were also administered three times during the study to assess receptive and expressive language. Baseline consisted of the usual programming of the child’s classroom. Treatment consisted of implementation of PECS in the classroom by the children’s regular teacher. Before treatment began, teachers and parents were trained in PECS protocol by an expert from Pyramid™ (the official provider of PECS trainings) over the course of 2 days. After training, a consultant visited the school to provide further support and feedback. Consultants came to school once per month for a half day over the course of five months.

Data were analyzed using multilevel ordinal regression models. The purpose of this approach was to explore patterns between the treatment and each outcome measure. Other variables included in the model were age, domain scores on the Autism Diagnostic Observation Schedule-Generic (ADOS-G) and a nonverbal developmental composite score. Results indicated that there was a significant treatment effect on rate of communicative initiations. Specifically, there was a significant main effect of treatment on rate of PECS use. There was no significant main effect of treatment on speech or
ADOS-G scores. At 10-month follow-up, however, the immediate treatment group showed a significant effect of treatment on ADOS reciprocal social interaction scores. There was no significant effect of treatment on EOWPVT or BPVT standardized language test scores. The immediate treatment group at 10 months follow-up (after consultation was removed) showed that the positive effects of PECS ceased.

The researchers concluded that PECS training was effective for the children in increasing rate of PECS use and social initiations; however treatment integrity data were not gathered. They hypothesized that the discontinued consultations may have contributed to the decline in participant performance. A strength of this study was the presence of a control group and the collection of three measures: once before treatment and twice during treatment. One group also had follow-up data once the consultations were withdrawn. Such measures guarded against maturation as a threat to internal validity of the study. The lack of treatment integrity data was a major weakness of this study, as the decline in performance cannot be readily explained by either the PECS treatment or lack of fidelity of implementation once consultations were withdrawn. Another weakness of this study was that no information was provided as to how many phases of PECS the children were taught.

A final group study which evaluated PECS intervention in conjunction with other visual approaches was conducted by McConkey et al. (2010). The purpose of the study was to investigate the effects of an early intervention program comprised of PECS and Treatment and Education of Autistic and related Communications handicapped Children (TEACCH) on preschool-aged children with ASD and their families. Treatment was delivered to 35 participating families in the treatment group, and 26 families served as the
contrast group. Males comprised 90% of the child participants, 10% were girls. The mean age of the treatment group was 2.8 years; whereas the control group mean was 3.4 years.

Treatment consisted of 15-18 sessions of PECS training, TEACCH training, and treatment was delivered by two therapists with speech and communication training and was provided in two separate areas. Therapy was delivered over 6-9 months, depending on availability of funding, participants, and therapists. Random assignment was not used. TEACCH components included creation of a visual schedule for each child and visual supports to facilitate understanding of expectations (e.g., timers, “wait cards”, and “no cards”).

Dependent measures included several pre-post assessments for child participants: The Psychoeducational Profile-Revised (PEP-R), The Gilliam Autism Rating Scale (GARS), and Vineland Adaptive Behavior Scale (VABS). Data were analyzed using ANOVA or t-tests. When homogeneity of variance assumptions were violated, Wilcoxon Signed Ranks tests or Mann–Whitney U tests were employed.

Results of analysis for the PEP-R indicated significant increases on all subscales: imitation, perception, fine and gross motor skills, eye-hand coordination, and both non-verbal and verbal cognitive scores. Repeated measures ANOVA for the VABS indicated significant improvement in socialization, daily living skills, adaptive behavior skills, communication, and adaptive behavior. No significant differences were found for GARS scores.

Although the study did not directly measure icon exchanges, significant positive changes were found in standardized measure subtests of communication such as the PEP-R and the Vineland Adaptive Behavior Scales. This could be considered a weakness of
the study, because direct effects of PECS were not measured (e.g., correct icon exchanges, which Phase of PECS attained during the 6-9 month period). In addition, because the treatment was comprised of several components (PECS training, TEACCH, and other individualized interventions) it is difficult to attribute the overall improvements with any particular component. A strength of the study, however, was that the treatment was conducted by two separate therapists in two separate geographical areas, and no significant difference was found between the groups at post-test. Such results indicate a replication of the effect, thereby increasing the validity of the study.

**PECS Single Subject Studies**

Previous reviews on PECS have noted the importance of single subject studies in the evaluation of PECS efficacy as an evidence-based practice. Earlier studies of PECS were often descriptive case studies. Later in the 1990s single subject designs began to more systematically evaluate functional relationships between PECS procedures and gains in communication. Single subject studies were used to evaluate PECS acquisition, as well as additional research questions. The studies are discussed in terms of additional questions regarding generalization, PECS icon or procedure adaptations, PECS treatment package studies, collateral behavior studies, and comparison studies.

**Generalization Studies**

Stoner et al., (2006) sought to investigate the efficacy of PECS for increasing the communicative skills of adults with mental retardation. Four males and one female participated (ages were 22 to 30). Sessions were conducted in the participants’ group homes. A modified ABAB design was used.
Data were collected using direct observation and event recording on the number of correct PECS exchanges. Data were later converted to a percentage of correct exchanges per number of opportunities per session. During baseline conditions, the participants were seated at a table with a picture of a preferred item and the actual item in front of him/her. The preferred item was out of reach. The experimenter extended an open hand to the participant. No prompts or error correction were provided. Ten opportunities to request an item were provided. During treatment, participants were taught PECS phases 1 through 3, with mastery criteria set at 90% accuracy for three consecutive days. A summer recess provided a break between phase III and phase IV. Before phase IV began, in the fall, participants underwent a second baseline condition with procedures identical to the first baseline condition. Participants then were trained in phase IV of PECS. All PECS phases were taught according to Bondy and Frost (1994) procedures.

Data were graphed and analyzed using visual inspection. Results indicated that three out of five participants successfully acquired PECS requests up to phase IV. The remaining two participants were not able to successfully acquire phase III due to health conditions (e.g., increased seizure activity) or motor difficulties (e.g., releasing an icon into the experimenter’s hand). The researchers concluded that PECS was not functional as a communication modality for those participants. For participants who did successfully acquire all phases, the researchers concluded that PECS was functional. These participants were even able to use PECS during community activities such as ordering at a restaurant. A strength of this study was that it was conducted over a long period of time. The durability of results was supported by the participants’ ability to use
PECS even after the summer break. A weakness of this study was that no treatment integrity data were gathered.

Ganz, Sigafoos, Simpson, and Cook (2008) wanted to examine the efficacy of PECS training on the participant’s ability to generalize his use of PECS to novel people and to promote problem solving when the communication book or item was not readily available. The participant was a 12-year old boy with autism. The boy entered the study with the ability to exchange a picture for a preferred item, but only when the instructor was within arm’s reach. Sessions were conducted in the participant’s classroom. The researchers used a combination of an A-B and multi-element design.

Data were collected using direct observation and event recording for occurrences and non-occurrences of correct icon exchange. During the first baseline condition, combinations of near and far for three different instructors were examined. In other words, each instructor was placed near and far from the participant under baseline conditions. No teaching took place at this time. The experimenters were the only ones who had access to the participant’s preferred items, and the participant was seated at a table with the PECS communication binder on top of the table.

The second baseline condition used the same conditions as the first baseline, with the exception that four combinations of reinforcer and communication binder distance were examined for two experimenters. For example, experimenter A was present and the reinforcer was close to the participant, and the binder was far from the participant. Next experimenter A again was present, and the reinforcer was far from the participant, and the binder was close from the participant. The researchers also included the reinforcer or binder as out of reach or within-reach in each combination. Treatment conditions
consisted of modified versions of PECS phase II training. The modification was that the researchers used a least-to-most prompting hierarchy when the participant picked up the picture, but didn’t initiate an exchange. The researchers began with a gestural prompt, and then if the participant still didn’t exchange the icon within 10 seconds, a verbal prompt was used. If the participant still didn’t exchange the icon within 10 seconds after the verbal prompt, then a full physical prompt was used. During the third phase of the study, no instruction was given. The purpose of phase III was to examine whether the participant would problem solve to obtain a communication binder that was out of his reach. The participant began spontaneously gesturing to the experimenters to obtain his binder, so no teaching was needed.

Data were graphed and analyzed using visual inspection. Results indicated that during baseline the participant did not correctly exchange an icon when the communication binder or preferred item was out of reach. After instruction occurred in the one stimulus condition (instructor “A” far, communication binder far, item far) the participant generalized the exchange of the icon to other combinations of near/far and with different experimenters. The researchers concluded that the teaching procedures were effective, and procedural modifications to PECS protocol may be beneficial for certain participants. A strength of this study was that the researchers conducted two baseline conditions, both of which were matched to the two treatment conditions. If the researchers had obtained a single baseline condition in the beginning, this would have created ambiguity as to whether the introduction of the new conditions may have somehow evoked the response instead of the training itself. A weakness of this study was that treatment integrity data were not gathered. This provides less evidence in support of
a functional relationship between the training procedures and the observed behavior change.

Dogoe, Banda, and Lock (2010) looked at the efficacy of PECS as well as the generalization of PECS requesting for three young children with autism (ages 3-5). Sessions were conducted at a university-based autism center, in the home, and in the community. A single-subject multiple baseline across participants was used. Data were gathered using direct observation and event recording for the following variables: percentage of correct responses and number of trials to reach criterion. A social validity questionnaire was also distributed to parents to evaluate their understanding and perceptions of the treatment’s acceptability.

Baseline procedures consisted of the experimenter placing a preferred item out of the participants’ reach. An icon that corresponded to the preferred item was also present. No prompting was used. Contingent upon exchange of the icon, the preferred item was delivered to the participant. Treatment procedures were conducted according to protocol of phases 1 through 3B of the PECS published protocol. Generalization probes were conducted after participants mastered phase IIIB of PECS. Generalization probes consisted of evaluating the correct exchange of PECS icons in the presence of different people, in different settings, and using different preferred items/icons.

Data were graphed and analyzed using visual inspection. Performance on certain sessions and averages of performance per PECS phase were also visually examined. Results indicated that all three participants met mastery criterion up to phase IIIB with PECS. Generalization probes also showed that participants were requesting with PECS with new people and new settings. Only two of the three participants were observed to
request with PECS for items that were present during previous training sessions. Two of the three parents also completed the social validity questionnaire. Parents expressed that they didn’t fully understand the intervention, but felt it to be affordable to implement. Both parents felt that the intervention fit well with their family routine. The researchers concluded that participants quickly acquired communication skills with PECS, but there will always be variation in the rate of acquisition. A strength of this study was that the experimenters used siblings as novel communicative partners and explained the PECS intervention to parents. This may have helped sustain the children’s use of PECS after termination of the study. A weakness of the study was that its mastery criterion and data reporting methods were not similar to previous studies that involved investigations of similar questions. This makes it difficult to compare their data to previous works.

Carré, Grice, Blampied, and Walker (2009) wanted to better understand whether PECS training in a more isolated environment coupled with specific programming with staff would affect the generalization of PECS use in both the home and school setting. Two boys and one girl of ages 5 to 6 years were the participants. One boy and one girl had formal diagnoses of autism, and the third participant had a formal Down’s syndrome diagnosis, but had autistic-like characteristics. Training sessions were conducted in a separate room at the children’s school, but eventually moved into the regular classroom.

The study used a multiple baseline across participants design with added generalization probes. Dependent measures included percentage of correct PECS requests (to assess mastery of each phase), and frequency of other communicative responses such as gestures, grunts, and cries. Frequency of spoken words was also recorded, as well as the number of spontaneous requests made during the generalization probes in the
classroom and at home. All were measured using direct observation. In addition, a brief questionnaire was given to both parents and teachers to assess their perceptions of the study. Both were measured using direct observation and event recording.

Data were analyzed using visual analysis of a line graph and visual analysis of performance over sessions (e.g., the researchers reported frequency of requests the last ten sessions of a certain phase). Ranges of performance were also compared on certain measures. Results indicated that all participants acquired PECS requests up to phase III, but at different rates. Generalization probes showed two of three participants spontaneously requesting at home before requesting at school. The other participant requested at school before being observed to spontaneously request at home. The rate of requesting at home and school was variable. The participant who had the most exposure to phase III had the highest number of spontaneous requests in home or school settings. The other participants had low frequency of spontaneous requests: typically only one or two requests per session.

For all three participants, other modalities of communication were observed to decrease with a concomitant increase in the number of spontaneous PECS requests observed in generalization settings. One participant’s teacher reported positive effects on communication, while the other two participants’ teachers reported no effects. All three participants’ parents reported positive effects on communication at home.

The researchers concluded that PECS was quickly acquired for all the participants, but expressed that decreases in vocal behavior associated with their participants indicate a discrepancy with previous literature. They warn that PECS training could hinder long-term goals of spoken language as the primary communication
modality. They also observed that PECS requests did not generalize to the home and school setting with as high of frequency as expected.

A strength of this study was the focus on generalization of PECS requests to other meaningful settings (home and school) and its notes about any procedural changes (e.g., talking with the teachers about how to support the PECS request when they saw errors). Their additional descriptions gave important information as to how clinicians and other researchers can achieve better generalization of PECS requests. A weakness of the study is the unequal number of generalization probes at home and school; as well as the unequal amount of exposure to PECS phase III training. It is possible that all participants would have increased their number of spontaneous requests with continued exposure to the Phase III condition.

**PECS Icon or Procedure Adaptation Studies**

In addition to overall efficacy of PECS, researchers also began to explore aspects of icons to see whether acquisition rates were affected. Angermeier, et al., (2008) sought to examine whether children acquired PECS more quickly if the picture icons were of greater iconicity compared to lower iconicity. Higher iconicity meant that the symbol had greater visual similarity to the actual object or activity being requested.

Four students with either autism or pervasive developmental disorders (ages 6-9) participated. Sessions were conducted in a private assessment room at their school. The design consisted of an adapted alternating treatments design combined with a multiple baseline design across subjects. Data were collected using direct observation on percentage of correct requests during each session and number of sessions to meet the mastery criterion of each phase. Procedures included an iconicity assessment of all
symbols to be used during the study. Pictures were scored by a group of 74 high school students on their resemblance to the actual object. Based upon this assessment, a picture was categorized as either high or low iconicity. Baseline data were staggered across participants. The baseline condition consisted of presenting four preferred objects, one at a time, to the participant for 15 seconds. After the 15 seconds, the child was allowed to play with the item for 30 seconds regardless of correct/incorrect responding. PECS phases 1 and 2 were then taught with rapid alternation of the type of symbol. Visual analysis of the data in line graph form was used, as well as comparing ranges of performance during baseline and treatment conditions.

Results indicated that all participants met mastery criterion to request items with either set of icons. There was a negligible difference between the efficiency of acquiring requesting with either set of icons during phase 1 or 2. This led the researchers to conclude that at least during phases 1 and 2, icon characteristics may not impede nor facilitate acquisition of requests. They do mention, however, the potential for high iconicity pictures to possibly exert very tight stimulus control over the behavior and possibly preclude generalization related to requesting objects or activities that are not very similar to the picture.

A strength of this study is the design used to evaluate the research questions. They combined a staggered multiple baseline with rapid alternation of the two picture conditions. This provides greater demonstration of a functional relationship as opposed to a traditional alternating treatment design. Unfortunately, several of their participants went on summer vacation before completing phase III. This weakens the strength of the study conclusions because discrimination is taught during phase three. It is possible that more
errors would have been observed during this phase because of greater or lesser iconicity. This information would have been more relevant to the question of their study, because fewer errors are likely to occur during phases 1 and 2 due to the ease of the task (i.e., participant independently exchanges the picture).

Almeida, Piza, and LaMônica (2007) evaluated the effects of an adapted PECS system for a single participant. The participant was a 9-year old girl with cerebral palsy. Sessions were conducted during meal times, speech therapy, and class activities at the girl’s school. An A-B design was used. Requesting accuracy was recorded according to a point system. If the trial was unsuccessful, 0 points were awarded. Trials that required physical prompts were assigned 1 point, trials with verbal prompts were assigned 2 points, and independent responses were assigned 3 points. These were collected in-vivo by direct observation. During baseline and up to phase IIIA of PECS, the icons were 8 by 8 cm. During phase IIIB, the cards were reduced to 4 by 4 cm. During baseline, the card was placed next to the preferred item and the participant was asked if she wanted the item. The PECS adapted training phases were then introduced to teach the girl all of the skills in PECS phases 1 through 5. Procedures were taught according to the adapted procedures of Walter (2000).

Data were analyzed using visual analysis. Results indicated that the participant acquired the requesting response accurately with each phase introduction. The researchers concluded that the adapted intervention helped the participant successfully acquire all targeted phases of PECS. A strength of the study included communication of the level of prompting that the participant required. A weakness of the study is that it only contained one participant. In addition, the single-participant’s responses were
evaluated using an A-B design, which does not provide as strong evidence for a functional relationship as other design variations.

Lund and Troha (2008) conducted another single subject study to examine the effects of a modified PECS instructional protocol with use of tactile icons. Participants were two males and one female (ages 12-17). All had autism and were also blind. Sessions were conducted at the participants’ school, and a multiple baseline across participants design was used. Data were collected using direct observation and event recording for correct PECS requests. Level of prompt needed for the exchange was also coded and recorded for each trial. During baseline, the participant was seated at a table and presented with a preferred item tactile icon. The experimenter told him/her that it was “choice time”. No prompting was provided. The researchers did not relate whether the preferred item was given for correct icon exchanges. During intervention, protocol for PECS phases I-III was implemented according to Frost and Bondy (2002). The protocol was adapted for the visual impairment of the participants by only making one communication partner and one symbol available, using verbal cues to tell the participants where the communication partner was located, and using a modified least-to-most prompting hierarchy.

Data were graphed and analyzed using visual inspection. Results indicated that one of the three participants met mastery criteria for all three phases of PECS. Another participant finished the study while on phase two, and the third participant finished the study while still in phase I. All participants, however, increased independence (or needed less intrusive prompts) by the end of the study. The researchers concluded that the modified protocol was successful in teaching requests, but the 30-session limit of the
study affected their findings. They noted that participants in other PECS studies all learned at different rates. A strength of this study was the clear descriptions of the deviations of the PECS protocol and the discussion of why they were made in the context of having blind participants. A weakness was that treatment integrity data were not gathered and this may have affected differential participant performance.

In a later study, Ali, MacFarland, and Umbreit (2011) evaluated the effects of PECS with tangible symbols for four participants. Participants consisted of three girls and one boy, ages 7-14. All participants had a diagnosis of multiple disabilities that included a visual impairment. The study took place in a specialized K-12 school for children with multiple disabilities and visual impairments. The treatment setting was a room outside the participants’ regular classroom, and generalization probes were conducted in the regular classroom. A multiple probe across subjects design was used.

During baseline conditions, participants were allowed to touch or smell preferred items, and the tangible icons were available. Tangible icons were whole or parts of objects mounted on boards. The size of the icon was determined by the participant’s abilities. No measurements were given related to the size of each icon per participant. Participants were taught to request preferred items during training of phase I. The experimenter physically prompted the participant to pick up a single tangible symbol of the preferred item if he/she reached for the preferred item. Physical prompts were systematically faded and a back-step error correction procedure was used. Phase II training required the same requesting response as Phase I; however, the distance was gradually increased between the participant and the tangible icon of the preferred item. For Phase III, the participant learned to request a preferred item in the presence of two
icons (one preferred item and one non-preferred item). Data on the percentage of correct responses for baseline, treatment, and maintenance sessions were collected using direct observation during the session. In addition, a “yes or no” (correct or incorrect) response was recorded during single trial generalization probes using direct observation during the probe.

Data were analyzed by comparing averages of treatment conditions to the average of the baseline condition. Results indicated that all four participants acquired the use of requesting via PECS tangible icons with high accuracy, and maintained their skills in the absence of the PECS intervention procedures. The researchers concluded that using tangible icons when teaching PECS requesting helped their participants with visual disabilities acquire accurate requesting responses. Strengths of this study were that baseline data were stable before introduction of treatment. In addition, each introduction of treatment for participants was staggered and produced the same effect. The large increase in accurate requests was replicated across participants each time treatment was introduced.

A weakness of the study, however, is the maintenance data were collected immediately after the participant met mastery criteria for phase III. These data may not reflect the participants’ actual performance after the intervention is withdrawn for longer periods (e.g., 3 months after withdrawal). In addition, generalization probes consisted of a single trial per probe, which may not have been representative of the participant’s performance for that day. More trials included in each generalization probe may have provided a more accurate representation of participant performance.
In another study, Cummings, Carr, and LeBlanc (2012) also included modifications to icons. The purpose of their study was to demonstrate a functional relationship between each Phase of PECS and increases in independent exchanges. Seven male children (ages 4-11 years) participated in the study. All had either developmental or language disorders. All sessions were conducted at the participant’s schools, usually in existing therapy rooms. Testing sessions were conducted in a separate room similar to treatment session rooms.

The study used a multiple baseline across behaviors design. Data were collected using direct observation. Event recording was used to measure the frequency of independent exchanges within a 10-trial session (later converted to a percentage). Each phase of PECS was pre-tested during baseline. Baseline procedures consisted of six, two-minute sessions in which the experimenter placed the icon and the preferred item in front of the participant. The PECS materials corresponding to each phase were available (i.e., the icon or icon on top of the Velcro binder). If the participant exchanged the icon correctly, the preferred item was not delivered. PECS treatment phases were conducted according to protocol by Frost and Bondy (2002). However, some modifications of the icons were made during phase VI. Specifically, to facilitate discriminate between “I want” and “I see” icons, the background color for the “I see” icon was changed to blue.

Data were graphed and analyzed using visual inspection. Results indicated that for most phases, correct responses did not occur until its corresponding training phase was introduced. However, for all participants some correct responses did occur during baseline of phases V and VI. The researchers concluded that PECS protocol was effective in producing initiations, and that the carry-over effect into the baselines of phases V and
VI was the result of their similarities. For example, the only difference in the procedures between phase IV and phase V was that the experimenter asked, “What do you want.”

Additionally, in phase VI, the experimenter continued to ask, “What do you want,” which may have resulted in overlap effect. A strength of this study was that no studies on PECS to date had used a multiple baseline across behaviors (phases) to demonstrate a functional relationship. A weakness of this study was that other useful information (e.g., spontaneous speech) would have been helpful to monitor as the children went through the phases. This may help researchers pinpoint exactly when language begins to emerge during PECS training for some children.

**PECS in Treatment Packages**

In some studies, PECS has also been coupled with other interventions to examine additive effects. For example, Cihak, Smith, Cornett, and Coleman (2012) evaluated the effects of video priming on acquisition time with three boys and one girl with autism and/or developmental delays (age 3). Sessions were conducted in both special education and inclusive preschool classrooms. An alternating treatments design was used to compare PECS alone to video modeling plus PECS. Data were collected using direct observation on the number of independent initiations. Frequency of independent initiations was later converted to a percentage of opportunities. A brief social validity questionnaire was also given to the teachers.

Baseline conditions consisted of the participant sitting at a table with the experimenter and a PECS communication book. The preferred item was out of the participant’s reach. The experimenter waited 30 seconds for the participant to request the item before terminating the trial. No prompts were given. The PECS alone condition
consisted of teaching the participant to request the preferred item by exchanging the correct corresponding icon with the communicative partner. Teaching procedures were the equivalent of phase I in Frost and Bondy (2002). During video modeling plus PECS, the PECS protocol remained the same. The only difference was that the child watched one of three brief videos of a typical 4 year old girl who used an icon to request an item from the teacher.

Data were graphed and analyzed using visual inspection. Averages and ranges from baseline and treatment conditions were also compared. Results indicated that no participants initiated requests independently during baseline. For one participant, PECS and PECS plus video modeling had similar effects on independent initiations. Two other participants acquired PECS more quickly during the combined PECS plus video modeling, and one participant had a slightly quicker acquisition during PECS plus video modeling. The participants’ teachers rated the video modeling plus PECS intervention favorably and expressed their intention to use it in the future.

The researchers concluded that video modeling as a priming tool can help children with developmental delays more quickly acquire PECS as a mode of communication. A strength of the study was that the researchers counterbalanced requesting of both food and object items so that results were not skewed by a participant’s stronger preference for one over the other. A weakness of this study was that no generalization or maintenance measures were gathered.
Collateral Behavior Studies

Single subject studies have also been conducted to examine collateral effects of PECS training. Investigations included collateral reductions in problem behavior, increases in speech, increases in play, and untrained requests.

**Problem behavior.** Frea, Arnold, and Vittimberga (2001) examined the effects of PECS training and choices on the severe aggression of a 4 year old boy with autism in an integrated preschool setting. Sessions were conducted during play routines of the general education preschool classroom, and a multiple baseline across settings design was used. Data were collected using direct observation and event recording for both disruptive behavior and PECS requests.

During baseline conditions, four picture icons were available on a communication board within view of the participant. Baseline data were gathered in manipulative and home centers during preschool play time. No instructions were given and the participant was allowed to freely move and play with friends. If the participant aggressed toward another peer, the experimenter blocked the attempt and provided attention only to the peer. The “teaching session” consisted of experimenter delivery of PECS phases 1 through 3 according to procedures described by Frost and Bondy (1994). The teaching session was one hour per day for two consecutive days. The PECS intervention condition was identical to the baseline condition with the only exception that the experimenter used a verbal prompt “What do you want?” to evoke a PECS request. The intervention condition was first introduced to the home living center and then the manipulatives center.
Data were graphed and analyzed using visual inspection. Averages of aggression during baseline were also compared to averages during intervention. Results indicated high and variable rates of aggression during baseline and an immediate decrease after intervention was introduced. In addition, after six days, aggression was no longer occurring. The number of PECS requests showed the opposite relation. Zero PECS requests occurred during baseline and immediate increases were observed after the intervention was introduced. The researchers concluded that PECS training was successful at reducing intense aggression. They also mentioned that because of the PECS training and its effects, the participant was allowed to remain in the typical classroom. Before the study, there was considerable discussion about his removal. A strength of this study was that PECS training was introduced immediately into the natural environment only after 2 hours of pull-out training. This provides social validity to the findings that training can be transferred to the classroom quickly. A weakness was that the study only evaluated one participant with severe aggression. Their findings would have been strengthened with additional replications with more participants.

Another study that was designed to evaluate collateral effects of PECS on problem behavior was Conklin and Mayer (2011). The purpose of their study was to evaluate the effects of PECS training on both independent initiations and untargeted problem behavior on adults with severe intellectual disability, Down syndrome, and Cerebral Palsy. Participants were two females and one male (ages 38, 51, and 23). Sessions were conducted in a day-room at their community program and also a room at a community church.
A changing criterion design combined with multiple baseline across participants was used. Dependent measures were collected using direct observation. Independent initiations were measured using event recording, and problem behavior was measured using 10-second partial interval recording followed by 5 seconds for recording. Baseline procedures consisted of preferred edible items and their corresponding icons within view of the participant. No prompting was used and baseline was collected for three sessions. Treatment conditions consisted of the protocol from Frosty and Bondy, (2002). Phases 1 through 6 were taught during treatment conditions.

Data for independent initiations were graphed and analyzed using visual inspection. Data for problem behavior were also graphed and analyzed using visual inspection. Additionally, individual session values and averages were evaluated. Results indicated that independent initiations increased compared to baseline for all of the participants during PECS training. However, not all participants ended on Phase VI when the intervention was withdrawn. Untargeted problem behavior reduced over the course of the study for all participants. The researchers concluded that the environment created by PECS (e.g., achievable tasks, high rate of reinforcement) contributed to the reductions in problem behavior. A strength of the study was the researchers followed-up with participants six months after the intervention was withdrawn. A weakness of the study was that interobserver agreement data on problem behavior was not available for one of the participants. The researchers mentioned that the reliability of the data was uncertain.

**Speech.** In addition to collateral changes in problem behavior, there have also been studies that involved the evaluation of collateral changes in speech. The rationale for this type of investigation is that behaviors learned during PECS could possibly be
pivotal response behaviors (Jurgens, Anderson, & Moore, 2009). This means that learning certain behaviors (e.g., child self-initiations of interaction) may lead to the child being exposed to other conditions which occasion the learning of new behaviors that were not directly taught (Koegel, Koegel, Harrower, & Carter, 1999).

Charlop-Christy et al., (2002) sought not only to evaluate the efficacy of PECS, but also collateral changes in behaviors that were not directly targeted. They wanted to know if PECS training would produce untargeted changes in the following behaviors: speech, social-communicative behaviors, and problem behavior. Three boys with autism participated in the study (ages 3, 5, and 12). Sessions were conducted in different rooms, but all were equipped with a one-way observation mirror. A multiple-baseline across participants was used.

During PECS training, trials to criterion and minutes of duration until mastery were collected using direct observation. In addition, direct observation was used to measure spontaneous speech and length of utterance. Spontaneous speech was measured using event recording and converted to a percentage score. Length of utterance was measured using duration recording and converted to a mean length of utterance (MLU) score for each spontaneous speech response. Data were collected in free play and academic settings. Social-communicative responses (e.g., pointing, initiating interaction) and problem behavior were measured using event or interval recording, depending on the participant.

PECS training procedures were conducted according to the PECS manual (Frost & Bondy, 1994). During play and academic activities, the experimenter provided five opportunities for spontaneous speech and five opportunities for imitative speech.
Opportunities for spontaneous speech included holding up a preferred item (e.g., ball) and waiting for the child to comment on it (e.g., saying “ball”). Opportunities for imitative speech included the experimenter holding up a desired object (e.g., ball) and saying something about it (e.g., “red”). If the participant successfully imitated the experimenter, access to the item was provided.

Results for PECS training were analyzed by examination of averages and ranges of trials to criterion and duration to meet criterion. These were examined for each phase and across all six phases. Spontaneous speech was analyzed using visual analysis of the data’s line graph, as well as comparing baseline to treatment average. Problem behaviors and social-communicative behaviors were also analyzed using visual analysis of the data’s line graph and comparing baseline to treatment averages. Problem behavior was also analyzed using percentage reduction scores for each behavior in each setting.

Results indicated that all three participants acquired PECS and demonstrated significant increases in spontaneous speech compared to baseline. Mean length of utterance modestly increased for each participant. Social communicative behaviors also increased substantially for each participant compared to baseline. Reductions of 70% or more were observed with 10 of 12 problem behaviors, and four behaviors were no longer occurring.

The researchers concluded that all three participants quickly acquired the use of PECS, and that it had considerable positive effects on other behaviors such as spontaneous speech, social-communicative skills, and even reduction of problem behavior. A strength of this study was that it involved the occurrence of spontaneous
speech and the length of the occurrence. A limitation of this study was that generalization measures were not gathered for PECS communicative responses.

Kravitz, Kamps, Kemmerer, and Potucek (2002) evaluated the effects of PECS on spontaneous communication skills and social interaction for a 6 year old girl with autism. Sessions were conducted during leisure and snack activities at home, and during writing and free play activities at the participant’s school. A multiple baseline across settings was used.

Data were collected using direct observation and event recording to measure spontaneous vocal language (e.g., requests, comments, expansions). Observers also recorded when, with whom, and where the spontaneous language took place. During the first baseline condition, preferred items were made available without request to the participant. Baseline data were gathered in all settings during the aforementioned activities. Baseline two was the same as baseline one, except the communication book was present. The participant was not prompted to use it. During treatment, PECS phases I-III were conducted according to the procedures of Frost and Bondy, (1994). All treatment sessions were comprised of teaching periods and play periods immediately following. The participant was required to use a PECS icon to request preferred items in both teaching and play periods. After PECS training, a social skills training plus PECS condition was conducted with the participant’s classroom peers. The same protocol was used as during the PECS treatment phase.

Data were graphed and analyzed using visual inspection. In addition, ranges of data were compared across conditions. T-tests were used to compare differences in initiations and verbalizations from baseline to intervention. Results indicated that the
participant successfully acquired phases 1-3 of PECS. T-tests indicated there was a significant increase in the number of initiations and verbalizations. The researchers concluded that PECS had a positive effect on spontaneous language and initiations. A strength of the study was that the researchers looked at both the home and school setting during the study. A weakness, however, was that treatment integrity data were not collected, and the social skills plus PECS condition may have confounded some of the conclusions of the study. In addition, there were no maintenance probes to examine the long-term effects of the intervention.

Ganz and Simpson (2004) wanted to examine the role of PECS with potential to improve the number of words spoken, increasing the complexity and length of phrases, and decreasing non-word vocalizations. Participants were two boys and one girl. One participant had Autism Spectrum Disorder and the others had developmental delays (ages 3, 5, and 7). Sessions were conducted in each participant’s elementary school classroom. The study was designed using a changing criterion design.

Data were collected using direct observation. Participants’ correct requests were measured as either independent (score of 1) or prompted (score of 0). Number of intelligible words uttered per session was measured using event recording. Non-word vocalizations were measured using coding for presence or non-presence (1= yes, 0 = no). Speech samples were also taken from the first and last session of each phase to document anecdotal evidence of possible increases in grammar complexity.

No baseline conditions were instated in this study. PECS phases I through IV were taught to the participants according to the procedures of Frost and Bondy (1994). Data were converted to percentages of independent PECS exchanges, average number of
words spoken per trial, and percentages of trials in which non-word vocalizations occurred. These data were also graphed and analyzed using visual inspection. Results indicated that all participants met mastery criteria of the targeted PECS phases. In addition, all participants showed increases in the average number of words spoken per trial compared to when they began in phase I. Participants also increased in their complexity of spoken words. All participants began the study with zero or one word spoken per trial. After receiving training in phase IV, all participants were speaking in 3-4 word utterances. The researchers concluded that PECS participants easily acquired PECS, and that phases III and IV occasioned an increase in vocal language. They mentioned, however, that increases in intelligible speech didn’t seem to have a relationship with non-word speech (i.e., intelligible speech did not decrease for participants or remained stable throughout the study). A strength of this study is that data were collected on both intelligible and non-word speech. A weakness of this study is that no treatment integrity data were available. This provides less evidence for a functional relationship between the treatment and the observed behavior change.

Tincani, Crozier, and Alazetta (2006) also wanted to investigate outcomes of PECS training on frequency of requests and untrained speech. In study 1, participants were two male children with autism (ages 10 and 11). Sessions were conducted in either the participant’s self-contained classroom or a separate room at the participant’s school. A delayed multiple baseline across participants design was used.

Data were collected using direct observation and event recording for prompted and independent PECS mands. Frequency of vocal words and vocal approximations of words were also recorded. Later vocal words and vocal approximations were converted to
a percentage score. The number of occurrences was divided by total response opportunities per session to yield the percentage. Baseline sessions consisted of the participant gaining access to an item for 10 to 20 seconds. Afterward, the item was removed from the participant’s reach. Contingent upon vocalizing the name of the item or giving the PECS icon to the experimenter, the participant was given access to the item. If the participant did nothing, the next item on the preferred items list was presented. During treatment, one participant was taught phases I and II of PECS; while the other participant was taught phases I through IV. One participant learned fewer phases because his acquisition occurred at a slower rate, and there were time constraints in the study. Procedures were conducted according to Frost and Bondy (2002). A delay of reinforcement (3-5 seconds) was also added between the participant’s PECS request and delivery of the item in order to encourage speech. If the participant used a vocal word or approximation before the 3-5 second delay, he was granted immediate access to the item. If the participant said nothing he still gained access to the preferred item; its delivery was just delayed by 3-5 seconds. Generalization probes were conducted with the teacher (a novel communication partner).

Data were graphed and analyzed using visual inspection. Averages and ranges from baseline and treatment conditions were also compared. Results indicated that both participants increased their use of PECS during treatment compared to baseline and maintained approximately the same level of accuracy during generalization probes. One participant did not produce any speech across the course of the study. The other participant began baseline with an average of 66% of response opportunities containing a vocal approximation. These approximations declined over phases I-III, then increased to
87.6% average of opportunities during phase IV. A similar average of vocal approximations was also observed during generalization probes. The author concluded that PECS training increased participants’ level of independent manding. A strength of the study was the generalization probes conducted with the participants’ teachers. This is a good measure of whether the effects of the intervention could maintain once the study was withdrawn. A weakness of the study was the lack of treatment integrity data.

In study two, the researchers evaluated whether phase IV procedures in PECS were functionally related to increases in speech. This was conducted with a single male participant who was 9 years old and had a diagnosis of autism. Sessions were conducted in a self-contained classroom. The study used an ABAB design.

Data were collected using direct observation and event recording for vocal approximations. They were later converted to a percentage score of approximations per number of opportunities. In phase A, the participant was taught using traditional phase IV procedures of PECS (Frost & Bondy, 2002). In phase B, the same procedures were used as in phase A except a delay of 3-5 seconds was inserted between the exchange of the PECS icon and the delivery of the preferred item. If the participant vocalized before the 3-5 seconds had elapsed, he gained immediate access to the item.

Data were graphed and analyzed using visual inspection. Averages of vocal approximations between A and B phases were also compared. Results indicated that a greater percentage of vocal approximations occurred during B phases (83.3% and 80.5%) compared to A phases (3% and 2%). The researchers concluded that vocal speech was affected by the time delay procedure, and that the results suggest directly programming to reinforce vocalizations may be the best way to increase speech during AAC.
interventions. A strength of this study was the replication of effects within the same participant. This provided greater support for a functional relationship between the time delay and increase in speech. A weakness of this study was that it was conducted with only one participant, so conclusions may have been different if more participants were observed.

Jurgens, Anderson, and Moore (2009) conducted a study to examine collateral changes in speech for a single participant. The purpose of their study was to evaluate the efficacy of the PECS training protocol and also any concomitant changes in speech, play, and social initiations. The participant was a 3 year old boy with autism. All training and free play sessions were conducted in the participant’s home. Generalization probes were conducted in the participant’s classroom. A single-subject changing criterion design was used.

Data were collected using direct observation and event recording on the following measures: PECS mands, verbal mands, and verbal initiations other than mands. Mean length of utterance was also recorded on the number of morphemes that comprised the participants spoken utterance. Functional play was measured using duration recording. Items from the Caregivers Acceptance of Treatment Survey were used to assess the social validity of the intervention. Baseline conditions were not described in this study. Treatment consisted of training the participant to use PECS in phases 1 through 4 according to Frosty and Bondy (2002).

Data were graphed and analyzed using visual inspection. Averages and ranges of PECS mands, verbalizations during sessions, and verbal initiations were also compared across phases. Functional play averages and ranges were also examined across
generalization probes. Results indicated that the participant mastered all four targeted phases of PECS. During training, an increase in PECS mands was observed. However, there were low numbers of PECS mands observed in the generalization setting. Free play was variable during PECS training, but showed a steady and considerable increase in generalization settings. The number of verbal mands increased slightly throughout the study, but verbal mands were not observed in the generalization probe setting. The number of morphemes in each utterance increased as the participant progressed through the PECS phases. A notable observation was that the participant spoke 14 different words at the beginning of the study which increased to 77 words at the end of the study. The participant’s parent felt that the PECS intervention was not stressful and positively affected her child’s ability to communicate. The researchers concluded that PECS training produced positive increases in PECS mands, verbal mands, verbal initiations, and mean length of utterances. However, the role PECS plays in generalization of these behaviors to other settings is inconclusive from the generalization probe data. A strength of this study was that the researchers collected data on not only the number of words, but also the number of different words that were added to the participants’ repertoire during the study. A weakness of the study was that there was only a single participant. It is possible that participant characteristics or other factors the researchers mentioned (e.g., no communication binder present in the class sometimes) affected the generalization of PECS mands and other measures.

Travis and Geiger (2010) looked at the effects of PECS training in Phases I-IV in a pilot study based in South Africa. A mixed research design of both single subject and qualitative expansion-type methods were used. The single subject design was a multiple
baseline across two participants. Both were 9 years old and had a diagnosis of autism. The treatment consisted of bi-weekly sessions of PECS training for approximately 30 minutes. The children’s regular school staff implemented the procedure and were trained via a two-day workshop on PECS. Treatment was implemented over 9 weeks and participants acquired all six phases. Treatment was terminated once the participant demonstrated use of PECS in all six phases and in several different contexts. Maintenance of treatment effect was assessed three months after the study terminated.

Dependent measures were frequency of mands and comments using PECS. Collateral measures of verbal utterances were gathered as well. Data collection sessions consisted of 10-minute observations for both structured and unstructured opportunities to request using PECS. These were recorded in mean length of verbal utterances. Data for requests and comments were graphed in scatterplot form and interpreted using visual analysis and calculation of Percentage of Non-overlapping Data (PND). In addition, maintenance data were analyzed using Percentage of Overlapping Data (POD) calculations. As cited in Travis and Geiger, mean length of verbal utterances were analyzed using PND, POD, and the Language Assessment Remediation and Screening Procedure (LARSP; Crystal, Fletcher, & Garman, 1981). The LARSP was used to compare values before and after PECS training.

Results indicated that participants rapidly acquired the six phases of PECS with one participant showing competency with using over 130 pictures, and the second participant showing competency with 70 pictures. In addition, verbal requests were also noted. Analysis of PND indicated that during treatment for both participants, 100% of data points for mands did not overlap; this provided evidence for a clear treatment effect.
For Participant One, a PND calculation for mands during maintenance indicated a small percentage of overlap (25%) in the unstructured setting only. Analysis of maintenance for mands indicated good durability of treatment effects for both participants in the structured setting (PND = 100%). Participant One also showed 100% POD for maintenance in the unstructured setting; whereas Participant two showed 25% POD for maintenance. This indicates a lack of treatment durability for participant two in the unstructured setting.

For comments, PECS training was deemed mildly effective for Participant One (PND = 50%) and moderately effective for participant two (PND = 75%). Comments with PECS were maintained during follow-up. Both participants scored 100% POD in unstructured settings. Participant One scored 75% POD in structured settings, and Participant two showed somewhat better maintenance, scoring 100% POD in structured settings.

Mean length of verbal utterance was also analyzed using PND and POD. PECS training was found to have an effect for Participant One (PND = 100%) but not for Participant two (PND = 20%). Maintenance for treatment effects for Participant One was high (POD = 100%) except during follow-up (PND = 75%). Participant two had much lower maintenance, especially in the unstructured setting (PND = 25%). In the structured setting, maintenance was somewhat higher (PND = 50%). Overall, the researchers concluded that speech increased in both length and complexity as a result of PECS training, specifically this coincided with the introduction of Phase IV.

The researchers indicated the decrease in mands during the unstructured setting for Participant One was likely due to his teacher leaving after the study and the new
teacher having no history with teaching PECS training. Limitations of the study included a small number of participants. Treatment integrity, generalization measures, and mastery criteria were also not mentioned in the study’s methods. A strength of the study was that it was conducted in the natural school environment by teachers: thereby validating the feasibility of procedures for the school setting.

Park, Alber-Morgan, and Cannella-Malone (2011) examined the effects of mother-implemented PECS training on the independent communicative behaviors of three children with autism (ages 2-3). Mothers were ages 33, 34, and 35. Sessions were conducted in a quiet room in the participants’ homes. A changing criterion design was used.

Data were collected using direct observation and event recording for frequency of correct PECS exchanges and frequency of vocalizations. Vocalizations were defined as vocal utterances that contained at least one consonant and one vowel. Both were later converted to percentages of opportunities per session. Before the study began, mothers were trained as the communication partner for PECS during sessions that lasted between 40 and 60 minutes. Mothers received written instructions, modeling, practice, and feedback. Mothers had to meet 90% accuracy of performance before they were allowed to conduct sessions. Baseline conditions consisted of the mother holding two preferred items five feet away from the child. A communication book containing the items’ corresponding icons was also five feet away from the child. No prompting was given. If a child did exchange the picture, the mother presented the two items and said, “Take it” to check for accuracy of discrimination between the two pictures. Any exchange of an icon produced the mother’s delivery of the preferred item to the participant (whether correct or
incorrect). Any initiation (e.g., reaching) toward an item produced also the preferred item. During treatment, the mother implemented PECS training of phases 1-3B according to Frost and Bondy (2002). Generalization probes were conducted with novel communication partners in the same manner as treatment procedures, except no prompts were provided. Maintenance probes were conducted once per week for a month. A social validity questionnaire was also used to assess mother perceptions of goals, procedures, feasibility, and outcomes of the study.

Data were graphed and analyzed using visual inspection. Averages and ranges from baseline through all treatment phases were also compared. Results indicated that percentage of correct exchanges increased considerably compared to baseline across all phases of training. In addition, all participants met mastery criteria for all targeted phases of PECS (1-3B). One participant increased his number of vocalizations during phase IIIB of the study compared to no occurrences during baseline. A second participant emitted vocalizations only during a maintenance probe. The third participant did not make any vocalizations throughout the study. All participants were also able to use PECS to request with a different communication partner. The researchers concluded that mothers can be trained to successfully implement PECS in the home in a brief period of time. They also concluded that mothers can implement the PECS protocol with high fidelity and produce positive communicative outcomes for their children. A strength of this study was the competency criteria that was applied to the mother’s training of PECS, as well as the collection of treatment integrity data. Both of these components of the study provided stronger evidence for a functional relationship between PECS and the children’s outcomes. A weakness of the study was that PECS training stopped at phase IIIB due to
time constraints. It is possible with continued exposure to either phase IIIB or successive PECS phases, the experimenters may have observed additional gains in vocalizations for the children.

Play. Anderson, Moore, and Bourne (2007) also examined the indirect effects of PECS. In a smaller study, they wanted to understand whether there would be concomitant changes in behaviors that were untargeted by PECS (e.g., play and t.v. watching). The participant was a 3-year old boy with autistic disorder and sessions were conducted in several rooms of his home. The study used an A-B-C-D design. Condition A was a baseline observation, Condition B was a readiness assessment phase, Condition C was a compliance training condition, and Condition D consisted of training in phases 1 through 4 of PECS protocol. The only difference in the protocol was that the participant was encouraged to vocalize the mand as he exchanged the icon because he exhibited excessive echolalia.

Data were collected using direct observation and event recording for four dependent variables: language (any understandable words or phrases), mands, and initiations of interaction other than mands. New words were also noted using cumulative frequency recording across all sessions. Data were also collected using direct observation and duration recording for both toy play and television watching. Data for language, mands, and initiations were evaluated using visual analysis of their corresponding line graphs, as well as comparisons of averages of the means and ranges of baseline compared to subsequent phases. Results indicated increases in the frequency of manding in the PECS training condition compared to baseline, and the number of new words increased substantially once PECS training was introduced. During baseline he was only observed
to engage in one string of echolalic speech. Increases in play and decreases in t.v. watching were also observed during compliance training and PECS training conditions. From these results, the researchers concluded that PECS is easily acquired by children with developmental disabilities, and that other untargeted behavior changes occur during PECS training.

Both a strength and limitation of the study is that it was conducted in the natural home environment. The setting can be considered a strength of the study because the environment was representative of the typical place in which young children spend most of their time. However, there are other unknown variables in the home that could have occasioned some of the behavior change. For example, if the mother made an additional effort to teach her child to play with toys during the week, this may have confounded the decreased amount of t.v. watching and increased amount of toy play.

**Untrained mands.** Rehfeldt and Root (2005) also examined collateral effects of PECS. The purpose of the study was to evaluate whether untrained mands would emerge if adult participants had been taught to (a) request items using pictures, (b) match pictures to their spoken names, and (c) match printed text to the spoken name. Participants were three adults with severe intellectual disability (ages 20, 24, and 37). All participants had little to no communicative responses. Sessions were conducted in a room in the participant’s day treatment center. A multiple probe across participants design was used.

Data were collected using direct observation and event recording on the number of correct responses of derived mands, derived relations probes, and during PECS training. Data were then converted to a percentage score of correct responses per number of opportunities per session. Before the study began, baseline probes were conducted to
examine whether participants could say the name of a picture, read the printed words used during the study, match the pictures to the printed words, or match the printed words to the pictures. Participants were praised for effort, but they did not receive preferred items contingent upon correct responses. During the PECS training phase, participants were taught to request preferred items by exchanging an icon of the item’s corresponding picture. They were taught PECS phases I-III according to the Frost and Bondy (1994) procedures. After mastery of PECS phases I-III, participants were taught conditional discriminations. They were taught to select pictures of the preferred items when given its spoken name, and to select the printed word when given its spoken name. Correct responses resulted in verbal praise. Participants were also allowed to request preferred items by using PECS on some trials during conditional discrimination training. After participants met mastery criterion for the conditional discrimination training, post-test probes were administered in the same manner as baseline probes.

Data were summarized on line and bar graphs. Visual analysis of line graph data and pre-post probe scores were used to interpret results. Results showed that after intervention, participants were able to mand for items using picture icons, and all met mastery criterion for the conditional discriminations. Two of the participants requested items using the printed word with 89% accuracy. The third participant requested items using the printed word with 67% accuracy. This was a derived relation that wasn’t explicitly taught. One participant demonstrated tacting (i.e., saying the spoken name in the presence of the picture) and sight-word reading (i.e., saying the spoken name of the printed word) without explicit training. The researchers concluded that a history of reinforcement for certain conditional discriminations may occasion the emergence of new
requests that were not formally taught. A strength of this study was that it was able to test relational frame theory in the context of teaching a functional skill (teaching a PECS requests). Some studies testing these relations taught participants to match or label arbitrary stimuli that had no real-world meaning (e.g., Lowe, Horne, Harris, & Randle, 2002).

A weakness of this study was that treatment integrity data were not available and conclusions about derived relations were drawn from a single probe comprised of nine trials. It is possible that a single probe may not be a representative sample of participant performance.

Later in 2007, Rosales and Rehfeldt examined whether a history of conditional discrimination training would evoke untaught mands using printed word cards to ask for items needed to complete a task. Two adults with severe mental retardation participated in the study: a 34 year old female and 56 year old male. Sessions were conducted in a classroom or a kitchen of the participants’ day treatment center. A multiple probe across participants design was used.

Data were collected using direct observation and event recording for correct mands and correct responses during the derived relations probes. Both were later converted to a percentage score. Prior to the study, the participants were taught a chained task: either making Kool-Aid® or playing a CD in its player. During baseline probes, both participants underwent evaluations to see if they were able to exchange a printed word card for items. No other description was provided. Next, participants were pretested to determine whether they could correctly name pictures, read printed words, match pictures to printed words, and match printed words to pictures. After pretesting,
Participant One was taught to mand for items using picture icons according to the procedures of Frost and Bondy (1994). PECS phases I-III were taught. After mand training for Participant One, conditional discriminations among words, spoken words, and pictures were also taught until mastery criterion was met. Specifically, participants were taught to match spoken words to their pictures, and match spoken names to their printed text. After Participant One met mastery criterion, both participants were probed again for derived stimulus relations. Once Participant One had completed discrimination training, participant two began PECS mand training. Participants were also taught to mand using picture icons to ask for items that were missing during the task chain (e.g., a missing spoon during the Kool-Aid task). After training, participants were presented the task chains again, but this time only printed word cards were available. Maintenance probes were also conducted one month after termination of the study.

Data were graphed and analyzed using visual inspection. Ranges of data were also compared with pre-test and post-test probes. Results indicated that both participants were able to ask for items using the printed word cards without being directly taught to do so. Vocal mands for items also emerged during the study without explicit training. Maintenance probes, however, indicated that neither participant maintained this skill. One participant performed with 46% accuracy and the other at 56% accuracy.

The researchers concluded that a history of conditional discrimination training may increase the likelihood that derived mands will emerge. A strength of this study was that it taught participants to problem-solve by using a communicative response when they needed an item in a real-life context (e.g., making Kool-Aid®). In addition, by participating in this study participants gained several new ways to mand for items—they
learned to mand by picture, spoken word, or printed word. A weakness of the study was that procedural integrity data were not collected, and the data collection involved a probe-method. Because they are such small samples, the probes may not be representative samples of the entire performance of the participants.

Marckel, Neef, and Ferreri (2006) evaluated emergence of untrained mands in their study, but also sought to increase the problem-solving ability of children with autism. Problem solving was taught by training participants to use descriptor icons when an actual picture icon of an item was unavailable. They sought to examine the efficacy of their procedures to teach this improvisation with the descriptor icons, and also examine whether the children were able to use this skill to request untrained items. Two boys with autism (ages 4 and 5) participated in the study. Sessions were conducted in the participants’ homes and a multiple baseline design across descriptors of an item (shape, color, function). A changing criterion design was also used to examine the effects of increasing the number of descriptor icons required to request a preferred item.

Data were collected using direct observation on the frequency of correct requests using the descriptor icons. These data were later converted to a percentage score. Baseline consisted of the preferred item being placed out of the participant’s reach. If the participant did not respond, he was prompted to look in his communication book. If he still didn’t respond, the experimenter said “Nice try” and gave him access to the preferred item. During intervention, the participant was given access to the preferred item contingent upon correct exchange of the descriptor icon. Variations of error correction procedures were used, but procedures were modeled after the PECS procedure manual.
After mastery criteria was met for each descriptor class (e.g., shape), a generalization probe was conducted with novel items in the same manner as baseline.

Results were graphed and analyzed using visual inspection. Overall, both children acquired the use of requesting by using the descriptor icons. In addition, with each change in criterion for the number of descriptors used during a request, children met the criterion each time it was changed. The researchers concluded that more creative behaviors such as “problem-solving” can be taught with PECS as the modality of communication and behavioral intervention as the teaching method. A strength of this study was that it used PECS in a new way to promote more complex forms of language (e.g., describing an object when one doesn’t know the name of it). This expanded the more traditional approach toward language with PECS, and gave ideas as to what additional skills children could learn once they master all the phases of PECS. A weakness of this study was that no averages or range values were reported per condition and that maintenance data were not gathered to assess durability of the treatment effects.

Chaabane, Alber-Morgan, and DeBar (2009) extended the research of Marckel et al. (2006) by examining the effects of PECS training as implemented by mothers on children’s ability to request items using descriptor cards. They also examined whether the use of descriptor cards would generalize to participants’ mands of untrained preferred items. Participants of the study included two children with autism (ages 5-6) and their mothers. Sessions were conducted in the participants’ homes. A multiple baseline across descriptors (colors, shapes, and functions) was used to examine the effects of the intervention. Data were collected using direct observation on the following dependent variables: correct mands, errors, and non-responses. Both were measured using event
recording and then converted to a percentage score per session. Parents were also given a social validity questionnaire to assess feasibility of the procedures. They were also asked to record any mands using the descriptor cards to request any untrained items or if participants requested using the descriptor cards in untrained settings.

Before the experiment began, parents were trained on how to implement the procedures. The experimenters used written instructions, modeling, practice, and feedback. The experiment began when mothers met mastery criterion. Baseline procedures consisted of the mother granting the participant access to an item contingent upon a correct exchange of the item’s corresponding PECS icon. Immediately after, the mother conducted a probe in which the descriptor cards were placed in front of the participant. Access to the item was provided contingent upon the participant exchanging the correct descriptor icon. During intervention, descriptor icons were present in addition to a preferred item and neutral item (e.g., paperclip). If the participant reached for the item, the mother physically prompted the child to exchange the appropriate descriptor icon. Contingent upon correct exchange of the descriptor icon, the participant was given access to the preferred item.

Data were summarized in a line graph and visually inspected. In addition, percentages of correct requests, errors, and non-responses were also visually inspected and reported. Results indicated that both children learned to request items using descriptor icons and also used the descriptor cards to request novel (untrained) preferred items. The researchers concluded that children can learn to mand for items using icons of different stimulus characteristics (e.g., color, shape) instead of just icons that directly represent the object. They also concluded that parents can effectively teach their children
to mand for descriptor icons. A strength of this study was the three replications of the effects of the PECS intervention to teach the children to request with the descriptor cards. Another strength was the high levels of treatment fidelity exhibited by the mothers. This gives greater evidence for a functional relationship. A weakness of this study was that the researchers used only a single trainer (the mother) for the intervention and did not assess the generalization of the descriptor icon requests across people. For clinical practice, it would be helpful information to know whether the participants were able to make the request with different people because typically people do not only make requests to only one person.

**PECS Comparison Studies**

In addition to efficacy and collateral research, PECS has also been compared to other types of language training interventions. PECS has often been studied in comparison to manual sign and voice output communication aids (VOCAs). Comparison studies with manual sign are discussed first.

**Manual sign.** Adkins and Axelrod (2001) conducted a study that sought to evaluate a comparison of PECS mands versus sign language (aka manual sign) mands. They wanted to know if there was any difference between the two mand topographies in terms of acquisition rate, spontaneity of use, and generalization of using trained mands in novel contexts. Their participant was a 7-year old boy with diagnoses of Pervasive Developmental Disorder and Attention Deficit Hyperactivity Disorder. Sessions were conducted in the child’s classroom. An alternating treatments design was used to answer the research question. Procedures consisted of PECS training sessions (implemented...
according to Frost and Bondy, 1994), a training session of using sign language, and generalization sessions.

Mands were taught by delivering the preferred item to the participant contingent upon him signing the name of the item or exchanging the correct PECS icon of the item. Both training sessions ended after the participant emitted five consecutive requests independently (without any prompts). In addition, both interventions were taught using the same prompting procedure and using naturalistic teaching opportunities.

To compare each mand topography, the number of trials to mastery criterion was recorded. In addition, number of trials to mastery criterion was recorded when the same word was taught using each mand topography. The percentage of trials that required a physical prompt was recorded, as well as number of correct responses. The most (preferred) mand topography was evaluated by recording frequency of each request topography emitted during generalization sessions. The number of “words” meeting generalization criteria was also recorded. Finally, spontaneous requests were also tallied using frequency recording during the participant’s day.

Data for mastery criterion for each mand topography were visually analyzed in bar graph form, and averages of each session were also used to compare the two topographies. This was done across sessions that evaluated sign or PECS requests for different preferred items, as well as when teaching both a sign and PECS request for the same preferred item. Number of spontaneous requests using either topography was visually analyzed in line graph form. Each topography’s total number of spontaneous requests was compared on a weekly basis. The same method of analysis was used to compare the number of words that met generalization criteria for each topography.
Results indicated that PECS topography met mastery criteria more quickly and occurred more often as a spontaneous request throughout the day. During all three weeks of data collection, more PECS request words met generalization criteria compared to sign request words. The researchers concluded that more research is needed to compare the two topographies, but that PECS topography appeared to be more quickly acquired, easily used in spontaneous situations, and generalized more rapidly. A strength of this study was that the researchers used multiple measures to evaluate the “superiority” of one topography versus another instead of a single measure such as only using trials to criterion. A weakness of this study, however, is that it included only one participant. It is possible that participants with different characteristics (e.g., stronger fine motor skills) may have produced different results than this study’s participant.

Chambers and Rehfeldt (2003) compared PECS to manual sign. The study was designed to determine whether PECS or sign would be more effective in teaching mands to adults with severe or profound mental retardation. Participants included two males (ages 19 and 26) and two females (ages 40 and 36). Sessions were conducted in a quiet room at the participants’ training center. The research question was evaluated using an alternating treatments design.

Data were gathered using direct observation on the following measures: percentage of correct trials per block, frequency of mands for items not in view of the participant, and trials to mastery for each phase. During the study, participants were taught four mands in each modality: PECS and sign. Baseline for the PECS condition included the presence of the communication icons, the preferred items, and the non-preferred items. Participants were given 5 seconds to request the item. After 5 seconds,
the trial was terminated. The same items were present for the sign baseline, except no communication book. The participant was allotted 5 seconds to sign a request for a preferred item before a trial was terminated. During intervention, participants were taught skills in PECS phases I-III. Procedures were conducted according to the PECS manual (Frost & Bondy, 1994). Manual sign training was conducted in a manner similar to PECS training, with the exception that the requesting topography was a simplified manual American Sign. Four opportunities were provided during each block of trials for the participant to mand for items that were out of view. This was performed by removing all the preferred items from the participant’s view, but leaving the four icons that represented the four preferred items.

Percentage of correct mands were graphed and analyzed using visual inspection. Trials to criterion were visually inspected and organized in table format. Number of mands for items out of view were organized into bar-graph form and visually analyzed. Results indicated that for 3 out of 4 participants, mands were more quickly acquired to mastery with PECS. Two out of four participants failed to acquire mands using manual sign. All four participants emitted more mands for items out of view using the PECS modality. The researchers concluded that adults with severe disabilities can learn how to mand using PECS, and some of them can learn sign. When choosing a response modality, the researchers suggested considering teaching manual sign to those with an advanced motor imitative repertoire.

A strength of this study was that the population of interest was adults with profound disabilities. Much focus of PECS research is on younger populations, and information as to its utility for older populations is valuable. A weakness of this study is
that maintenance measures were not gathered. Because two of the four adults acquired both response modalities, it would have been useful information to know whether one modality maintained better than another—or if either maintained at all.

Tincani (2004) conducted a study to evaluate both collateral changes in speech and comparative effects of PECS versus sign language. Specifically, Tincani investigated the acquisition of using either sign or PECS by children with autism. He also examined the children’s acquisition of vocal responses. Participants were one boy and one girl with autism, ages 5 and 6. Sessions were conducted in the children’s self-contained classroom. The study involved the use of an alternating treatments design.

Data were collected using direct observation and event recording for correct sign language mands, correct PECS mands, correct motor imitation, and vocal words. Teachers and parents were also given a social validity questionnaire that included questions about feasibility, effectiveness, and future use for either sign or PECS with their child.

Baseline sessions consisted of the participant gaining access to an item for 10 to 20 seconds. Afterward, the item was removed from the participant’s reach. Contingent upon signing the name of the item, vocalizing the name of the item, or giving the PECS icon to the experimenter, the participant was given access to the item. If the participant did nothing, the next item on the preferred items list was presented. Sign language training was adapted from Sundberg and Partington’s (1998) *Teaching Language to Children with Autism or Other Developmental Disabilities*. The participant began with 10-20 seconds access to an item, and then it was removed. The experimenter then modeled the sign for the item and simultaneously said the name of the item. No vocal
prompts (e.g., “What do you want?”) were used. A second experimenter physically prompted the participant from behind to help the participant if he/she did not respond. Independent signing or prompted signing produced access to the preferred item. Progressive time delay was used to increase the time delay between the presentation of the item and the experimenter delivery of the model prompt of the vocal name and physical sign of the item. PECS training consisted of the same presentation format for preferred items. Teaching procedures were adapted from Frost and Bondy (2002). Phases 1 through 3 of PECS were trained in this condition. Generalization probes were also conducted with a novel communication partner and presented in the same manner as sign language or PECS training sessions.

Data were graphed and analyzed using visual inspection. Averages and ranges were also compared for PECS and Sign baseline and treatment conditions. Results indicated that each participant performed better with a different modality. The female participant of the study emitted more independent mands with PECS compared to sign language. The male participant of the study emitted more independent mands using sign language as opposed to using PECS. Furthermore, the male participant emitted more word vocalizations on average during sign language sessions than during PECS sessions. The female participant exhibited a decline in the number of word vocalizations during PECS sessions and showed a concomitant increase in the number of PECS mands. Her number of vocalizations in the sign language condition, however, remained at high rates and constant throughout the study. In response to this, a reinforcement delay was inserted during later sessions. This modification significantly increased the number of vocalizations again during PECS sessions. Both participants showed some generalization
of requesting to novel persons. Social validity questionnaires indicated the male participant’s caregiver expressed a preference for sign language. The female participant’s caregiver favored PECS. The researcher speculated that sign language may have served as a self-prompt for vocalizations, which may have explained the increased number of vocalizations during sign language training sessions. A strength of this study was that it trained sign language and PECS mands as similarly as possible: thereby better isolating the effects of each communication modality. A weakness of this study was that it was conducted in a setting that involved frequent staff changes; the researcher mentions this as a possible threat to the study’s internal validity.

A later study that was designed to compare PECS to sign language was Ziomek and Rehfeldt (2008); however, their participants were of an older population. Two females and one male participated in the study, with ages ranging from 42 to 52 years of age. Participants had various diagnoses, with all having some type of intellectual disability diagnosis. Intellectual disability ranged from mild to profound.

The purpose of the study was to investigate both acquisition rates and generalization of mands using both PECS and manual sign. Participants were taught to mand items in direct sight and also mand for items necessary to complete a chained task. Mands were taught by exchanging icons with PECS teaching procedures and also using manual sign language. A single-subject alternating treatments design was used to compare PECS to manual sign training.

Training of mands for in-sight preferred items was delivered in the participant’s regular developmental training center in a separate classroom. Training of mands for items needed to complete a task were taught in the facility’s kitchen. Sessions were
conducted at least three times a week. Participants were taught to mand for five different items in the PECS condition and five different items in the manual sign condition. In the PECS condition, participants were taught to mand for items up through Phase III according to procedures described in Frost and Bondy (2002). After participants mastered phase III in PECS, generalization probes were conducted. Sign training procedures were as similar as possible to the PECS procedures; however, participants were not able to move past “Phase I” of manual sign training, so other “Phases” of manual sign training were neither taught nor recorded.

An additional probe that was conducted during this study involved testing for emergence of other verbal operant functions (labeling and intraverbals). During labeling probes, experimenters held up a preferred item and said, “what’s this?” Whether the participant used PECS or manual sign and correct/incorrect labeling of the item was recorded. During intraverbal probes, participants were asked a question with the intended answer being the name of the preferred item. For example, and experimenter would say, “What do you like to play?” and the correct answer was “puzzle” (puzzle was the participant’s preferred item).

Dependent measures included number of correct mands using sign or PECS icons for each respective training condition (PECS or manual sign). The number of correct item labels or correct intraverbals during probes was also recorded before and after PECS training. Amount of time to acquire either PECS or manual sign in both number of trials and total duration across sessions were noted.

Data for correct mands (using sign or PECS) were plotted in scatterplot line graph form, and evaluated using visual analysis. Data for correct labels or intraverbals were
plotted in bar-graph form. Values were visually compared for pre-post probes and numerical values also were reported and compared directly. Time to acquire PECS vs. manual sign was evaluated by comparing numerical values of both number of trials and total duration.

Results indicated that two out of three participants acquired PECS more quickly and showed higher percentages of generalization compared to manual sign. One of the participants did not master PECS or sign, as she was diagnosed during the study with early onset dementia and exhibited increased incidence of aggression. Both participants who completed PECS training showed emergence of different verbal operants. One participant exhibited a higher percentage of correct labels compared to the pre-PECS probe. The participant exhibited emergence of a higher percentage of correct intraverbals.

The researchers surmised that PECS was more successful than sign for the two participants because with manual sign training, model prompts were used. Both participants had limited imitative ability, and the researchers felt this contributed to acquisition rates. They also noted that a limitation of the study was that it was difficult to directly compare the teaching procedures for PECS vs. manual sign because different types of prompts and prompt fading procedures were used. Treatment integrity data were also not gathered, making it difficult as well to determine whether differences in performance for PECS vs. sign were a result of treatment integrity, differing teaching procedures, or both.

A strength of the study was that different types of mands under control of different types of motivating operations were examined. Examining mands of items within sight and mands for items needed to complete a task provided richer information
about acquisition of PECS under differing antecedent control. Evaluation of emergence for untrained labeling and intraverbal responses also provided additional information for other possible collateral effects of PECS training.

**Voice output.** Bock, Stoner, Beck, Hanley, and Prochnow (2005) compared the relative effectiveness of PECS to a voice output communication device (VOCA). Participants consisted of six boys with a diagnosis of Developmental Delay, all four years of age. Sessions were conducted in various places of the child’s preschool. The researchers used an alternating treatments design and direct observation to record the frequency of correct PECS or VOCA mands during each session. Frequency of correct mands was converted to a percentage score for each session. The baseline condition consisted of placing 3-4 preferred items, the PECS icons, and the VOCA device within reach of the child.

During PECS or VOCA phases, protocol to teach the skills corresponded with the protocol to teach requests in the PECS manual for phases 1, 2, and 3. Procedures were lightly modified for the VOCA condition but mirrored the PECS teaching protocol. Initially requests were taught in a “pull out” room; however, there were a few training sessions conducted in the child’s general classroom. Generalization probes were conducted in the participant’s regular classroom and consisted of concurrent availability of both the PECS and VOCA device while preferred items were still within the participant’s reach.

Data were then summarized in a line graph and visually inspected. Generalization data were averaged and placed on a table for visual inspection. Results were mixed. For three children, PECS mands were acquired at a faster rate than VOCA mands. Data from
generalization probes indicated that three participants were found to prefer PECS, two participants preferred VOCA, and one’s data did not indicate any preference. The researchers concluded that a possible reason for the faster acquisition of PECS compared to VOCA was that the device was heavier than a paper icon, and several of the participants had difficulties acquiring the motor responses of picking up the device. A strength of the study was that the protocol for teaching PECS and VOCA was the same. However, a weakness of the study was that they didn’t match PECS and VOCA mands on the amount of response effort needed to make the request. Increased effort for one request may have potentially influenced their conclusions that a PECS mand is more easily acquired than VOCA.

Son, Sigafoos, O’Reilly, & Lancioni (2006) compared both acquisition and preference for voice output communication aids and PECS. Two girls and one boy participated in the study. Ages ranged from 3-5 years old and all participants had a diagnosis of autism or related developmental disorder. An alternating treatments design was used. Dependent measures included percentage of correct mands and number of times the child used PECS icons or the VOCA to make requests during the preference assessment.

Treatment sessions were conducted in the kitchen of each child’s home. Each child was taught to mand for two different snacks (one snack requested with PECS and the other snack requested with VOCA. For each condition, a least to most prompting procedure was used if the child did not respond within 10s of preferred item presentation. The first prompt used was verbal (e.g., “What do you want?”), the second level of prompt was pointing to the device (PECS icon or VOCA device), the third level of prompt was
physically guiding the child’s hand to perform the correct response. After training was complete, a preference assessment for assistive devices was conducted, with concurrent availability of both PECS icons and the VOCA device to mand for a preferred item. Number of opportunities to mand for an item in each preference assessment varied for each participant, ranging from 33 opportunities to 88.

Data were visually analyzed using a scatterplot graph and comparison of percentages during the preference assessment. Results indicated that all participants acquired both PECS and VOCA at approximately the same rate. One participant showed clear preference for the VOCA, and the other two participants preferred PECS.

Limitations of the study included lack of treatment integrity, generalization, and maintenance data. In addition, the number of items participants learned to request (i.e., two) was low. A strength of the study was the strong similarity of teaching procedures between the PECS and VOCA conditions which allowed greater comparability between the two conditions.

Beck, Stoner, Bock, & Parton, (2008) extended and replicated Bock et al. (2005) to compare the relative efficacy of PECS versus VOCA for four preschool-aged children. Participants were twin boys with an autism diagnosis, a boy with Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS), and a girl with a diagnosis of speech and language impairment. Sessions were conducted at the children’s preschool, and an alternating treatments design was used.

Data were collected using direct observation on frequency of correct requests with either PECS or the VOCA and also several language measures. These included total number of utterances per session, the percentage of those utterances that were
understandable by others, the percentage of understandable responses that were not imitated, and the total number of different words uttered per session.

Procedures included baseline observations before treatment. Baseline conditions consisted of a ten-minute observation in which the child had PECS icons and a VOCA device within reach. During treatment, sessions consisted of a 10-trial or 15-minute session (whichever came first) to use either PECS or VOCA to request preferred items. Sessions were counterbalanced so that if a participant used PECS one day to request, the following day the VOCA session was conducted. Both PECS and VOCA were taught in similar manner with procedures modeled after phases I, II, and III of the PECS procedure manual. Generalization probes were comprised of the participant taken to an environment in which he/she had not been trained and having concurrent access to both PECS and VOCA to request an item.

Data on the dependent variables were graphed and analyzed using visual inspection. In addition, type of error using the VOCA was recorded in a table to analyze. Language measures were averaged at 2 and 4 weeks and visually compared for PECS and VOCA. Results indicated that PECS was more quickly acquired for all participants compared to VOCA, and that language measures in each condition were mixed for participants. One had decreases in speech during both conditions, one had more intelligible utterances during VOCA but didn’t learn any new words, and two others had a greater number of utterances during the PECS condition. The researchers concluded that PECS was acquired rapidly, and that their results were consistent with previous research in that there were some unexpected observations that were unique to each participant.
A strength of this study was that data were collected on total number of utterances and whether they were non-imitated and intelligible. This provided more rich information as to the actual concomitant language effects that each device may evoke. A weakness of this study, however, is that the study ended with participants in many different phases of PECS/VOCA. It was terminated based on time (i.e., four weeks) instead of continuing to see whether differential results would regress toward an average performance across all the participants. Overall, data needed to be gathered until each participant met mastery criteria for all of the phases. This would have allowed greater comparability of results across participants.

**Literature Review Summary**

The National Professional Development Center for Autism Spectrum Disorders (2010) has identified the Picture Exchange Communication System as an evidence-based practice. Tien’s (2008) review has also identified PECS as an evidence-based practice for people with ASD because of the overall quality of the single-subject literature. Preston and Carter (2009) suggested additional group designs to address external validity limitations that are generated by the nature of single-subject designs. Review comparisons between PECS and VOCA indicated no significant difference between acquisition rates and that adoption of one communication modality over another may be due to other factors associated with parent preferences or financial circumstances (Lancioni et al., 2007). Hart and Banda (2010) found that PECS was moderately effective for 19 out of 29 participants across their review of 13 single-subject studies. When compared to sign language, PECS training appeared to be more effective in quicker
acquisition of requests. When compared to VOCA, PECS training was somewhat equivalent in acquisition rate of requests.

Flippin et al.’s (2010) review indicated an overall improvement in communication after receiving PECS training; however, little effect was found on speech when all participant data were aggregated across their reviewed group and single subject studies. Tincani and Devis (2011) highlighted that the purpose of PECS is not to increase speech, rather functional communication through icon exchange. Their review revealed that male and female participants appeared to learn PECS at an equal rate. Ganz et al. (2012) found that PECS and speech generating devices were both effective at increasing communication, but other picture-based systems were less effective. However, participants in other picture-based communication studies were also older. This may have had an effect on their acquisition rates due to several factors associated with older populations.

Group studies have yielded important information regarding acquisition rates and treatment effects of PECS with larger numbers of participants. Schwartz, Garfinkle, and Baer (1998) found that on average, it took participants 14 months to master all six phases of PECS. Magiati and Howlin (2003) found that both children who were more and less verbally advanced at the beginning of the study gained ability to mand using icons during PECS training. However, due to study limitations such as measurement methods and lack of a control group, firm conclusions could not be drawn regarding a functional relationship between PECS and communication increases. Yoder and Stone (2006) also lacked a control group, but this was due to the comparative nature of their study evaluating benefits of PECS versus Responsive Education and Prelinguistic Milieu
Teaching (RPMT). Results indicated that for more advanced children (those who had joint attention), RPMT produced a higher number of mands than PECS. For children who did not have joint attention, PECS was associated with a higher number of mands. Later in 2010, Yoder and Lieberman found that PECS training was associated with better generalization of icon exchange than RPMT training.

Carre and Felce’s (2007) group study revealed that just 15 hours of PECS training produced a significant increase in number of spontaneous successful communication initiations made by young children with autism (N = 24) compared to a control group of children with autism (N = 17). Howlin, et al., (2007) found that PECS training had an effect on rate of PECS use, but this effect dissipated during a 10 month follow-up measure. In addition, PECS had no significant effect on speech, but showed a significant effect on Autism Diagnostic Observation Schedule (ADOS) subtest scores in social interaction. McConkey et al. (2010) evaluated PECS and TEACCH in a group study as a treatment package. Results indicated significant increases for participants on all subscales of the Psychoeducational Profile Revised (PEP-R) and the effect was replicated with two different geographical locations with two different therapists.

Overall, limitations of group studies on PECS include either lack of a control group or lack of treatment integrity data. This may be due to the type of research question associated with each study, as well as difficulties with tracking fidelity of implementation with a large number of participants.

Single subject studies designed to investigate generalization of PECS effects have revealed successful results for adults with intellectual disability (Stoner et al., 2006) and
children with developmental disabilities, including autism (Carré, Grice, Blampied, & Walker, 2009; Dogoe, Banda, & Lock, 2010; Ganz, Sigafoos, Simpson, & Cook, 2008).

PECS studies indicate that icon exchanges generalize to novel settings in which the participant had no prior experience during their training. Stoner et al. (2006) found that three out of five adult participants with intellectual disability acquired PECS up to phase IV and were able to use PECS in a novel setting (a restaurant) after a summer break. Health issues prevented the other two participants from completing training. Dogoe, Banda, and Lock (2010) found generalization of icon exchange to untrained settings in the school and home, as well as to new preferred items and use of new icons.

Ganz, Sigafoos, Simpson, and Cook (2008) found that their participant was able to generalize problem solving involving communication of PECS. Specifically, the 12-year old participant with autism demonstrated generalization of icon exchange across novel communication partners and also under varying distances among the preferred item, communicative partner, and communication binder.

PECS has specialized treatment procedures as outlined by Frost and Bondy (1994, 2002). However, some studies have evaluated various modifications to icons, PECS procedures, and adding other interventions to PECS as a treatment package. Angermeier et al., (2008) evaluated the effects of PECS icons bearing high or low resemblance to the actual items. Their results indicated no difference in acquisition of PECS associated with either high or low resemblance. Almeida, et al., (2007) investigated several changes to icons, sentence strip, and teaching procedures to PECS for a participant with cerebral palsy. Some modifications included asking the participant, “is this what you want?” during phase I.
PECS procedures have also been modified for individuals with visual impairment. Lund and Troha (2008) found success with tactile icons modified for three participants who both had autism and were also blind. Verbal cues and a least to most prompting hierarchy were used during PECS phases I-III. All participants learned at various rates: Only one of three participants completed all three phases of PECS. Ali, MacFarland, and Umbreit (2011) also used tactile icons consisting of whole or partial objects mounted on boards. After modified training, the four participants were able to accurately mand for preferred items using the modified icons. During maintenance, all participants also performed phase III of PECS with high accuracy (range 93% to 100%).

A final study that involved the use of less dramatic changes to icons, yet still produced successful results was Cummings, Carr, and LeBlanc (2012). The background of “I see” icons was changed to blue, in order to facilitate discrimination between “I want” and “I see” icons. “I want” icon background color remained white. Sentence strips for each condition were also made in the same color. Colors were faded across successive trials and the authors concluded the PECS procedures were both efficient and effective.

Some researchers have explored collateral changes in other behaviors besides manding by exchange of an icon. These include reductions in problem behavior (Frea, et al., 2001; Conklin & Mayer, 2011) and increases in speech (Charlop-Christy et al., 2002; Ganz & Simpson, 2004; Schwartz, Garfinkle, & Bauer, 1998; Jurgens, Anderson, & Moore, 2009, Kravitz, et al., 2002; Park, et al., 2011; Tincani, et al., 2006; Travis & Geiger, 2010).

Other untrained changes include increases in play (Anderson, Moore, & Bourne, 2007) and untaught mands (Chaabane, et al., 2009; Marckel, Neef, & Ferreri, 2006;
Rehfeldt & Root, 2005; Rosales & Rehfeldt, 2007). Rehfeldt and Root (2005) demonstrated that conditional discrimination training and PECS training produced untaught manding with printed word cards for all three of their participants with varying accuracy. One participant also said the name of an item and sight word reading without explicit training during the study. Rosales and Rehfeldt (2007) replicated the same effect, with both of the study’s participants demonstrating ability to mand for items using printed word cards without direct training. However, maintenance measures indicated less durability of treatment effect for these participants. Marckel, et al., (2006) found that young children with autism could learn to ask for novel items by using descriptor characteristics and Chaabane et al., (2009) found that mothers were effective implementers of the same training procedures used by Marckel et al. (2006).

Finally, PECS has been evaluated in relation to other augmentative or alternative communication modalities. The most popular comparisons in the literature have been sign language or VOCA. Some studies have indicated that PECS can be more easily acquired than sign language (Adkins & Axelrod, 2001). This observation has also been found for older populations. Chambers and Rehfeldt, (2003) found that three out of four participants more quickly acquired mands using PECS than for sign. In addition, all four participants used PECS more often to mand for items out of view than sign. Ziomek & Rehfeldt, (2008) observed that PECS was also more readily acquired for two out of three participants. However, Tincani (2004) found that one participant used sign language more frequently learning both PECS and sign.

Comparison studies have also evaluated PECS versus voice output communication aids. Results are mixed and all studies were with preschool-aged children.
who had some type of developmental delay. Bock, Stoner, Beck, Hanley, and Prochnow (2005) found that three out of five participants more quickly acquired mands using PECS. Bock et al. (2005) found that all three participants acquired mands at the same rate for each modality. Beck et al. (2008) replicated and extended Bock et al. (2005) and found that PECS was more quickly acquired than VOCA for four participants. Preference assessments for each communicative device appeared to be idiosyncratic based upon the mixed results from several of the studies’ device preference assessments.

Overall, ample literature exists regarding the evaluation of PECS and its implementation with paper icons. Many informative questions have been answered about efficacy, generalization, collateral changes in other behaviors, and comparison studies with other types of AAC. With the overall reduction in costs for portable technology in recent years, tablet technology is growing in popularity through both professional and recreational realms. Use of such technology may help children with autism who use AAC not to stand out from peers (Sennott & Bowker, 2009): thereby increasing more seamless inclusion into the general education setting and community. Despite the potential benefits, little is known about many of the applications. This study will provide additional information about the efficacy and social validity of the implementation of PECS training through a digital response medium.
CHAPTER 3

METHODOLOGY

Autism is a neurodevelopmental disorder that is characterized by delays in development of social communication skills, social interaction skills, and excesses in repetitive behavior or restricted interests (American Psychiatric Association, 2013).

Previous researchers (Baker & Cantwell, 1982) suggest that children with fewer communication skills are more likely to engage in challenging behavior. Specifically, children with autism may use challenging behavior as a means to request or reject (Chiang, 2008). One way to alleviate problem behavior is through functional communication training. In 1994, Bondy and Frost developed the Picture Exchange Communication System (PECS). PECS is a functional communication system, with research support (Charlop-Christy et al., 2002; Ganz & Simpson, 2004; Kravits et al., 2002). However, according to criteria of the National Autism Center (2009), PECS is still considered an emerging practice for individuals with autism.

A recent expansion of tablet technology has increased the need for quality studies that evaluate the effectiveness of tablet use to facilitate communication. Currently, there are a limited number of studies that specifically evaluate any communication applications for portable tablet computers. Given the likelihood of increased use of tablet computers and the increased availability of communication applications (apps) for them, the purpose of this study was to examine the effects of one such application. The application that was evaluated was the PECS phase III application for the iPad™. The efficacy of this application was evaluated through several measures of participant behavior. These measures included independent mands, spontaneous words, and spontaneous
approximations of words. To date, these applications have been untested (A. S., Bondy, personal communication, April 16, 2012) and a recent review of the literature on PECS interventions indicated there were no studies on tablet applications for PECS. Furthermore, additional studies on PECS are needed in order to clarify its role as an evidence-based practice.

Thus, the purpose of this study was to examine the effects of PECS phase III application training on independent mands in young children with autism. To address this purpose and based upon previous literature on PECS efficacy, the following research questions were answered.

1. Does training with a PECS phase III iPad™ application increase the frequency of independent mands among young children with autism spectrum disorder?

2. Does training with a PECS phase III iPad™ application result in similar levels of independent mand performance among young children with autism spectrum disorder within an alternate setting?

3. Will the effects of PECS phase III iPad™ application training maintain after the intervention is withdrawn?

4. Will participants indicate a preference for requests using the iPad™ over requests using PECS paper icons?

5. After viewing a brief video clip or live demonstration of their child using the PECS phase III iPad™ application, will parents perceive it as feasible to use with their children at home or in the community?
Participants

Participant Demographic Data

A total of five children with a diagnosis of Autism Spectrum Disorder participated in this study. There was also one pilot participant. The five participants’ ages ranged from two years seven months to four years old. There were four males and one female. The participants came from various ethnic backgrounds. A parent intake form (see Appendix A) was used to collect these demographic data in addition to information about medications, services the participant was receiving, and medical problems (i.e., hearing, vision, seizures). Participant ethnic background was gathered verbally from each parent. Parents were told that this was voluntary information and did not have to provide it. However, all parents provided ethnic background information. See Table 1 for individual demographic data related to each participant.

Participant Selection

The criteria for participation in this study were a diagnosis of autism and an age of 2.5 years or older. Secondary disorders or diagnoses did not preclude a participant from participating, providing they met all other inclusion criteria.

Additional criteria for inclusion in the study included (a) less than five words of functional speech (Angermeier et al., 2008, Yoder & Stone, 2006), (b) confirmation of passing a hearing and vision test as indicated by parent report (Yoder & Stone, 2006), (c) no prior history of requesting using PECS (Ali et al., 2010), and (d) parent consent (see Appendix B).
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</tr>
</tbody>
</table>

*Note. P = Participant, ABA = Applied Behavior Analysis, OT = Occupational Therapy*

Participant two had received prompting to point to a picture of an item he wanted during his break as part of his therapeutic behavior plan. However, PECS procedures were not used to teach choice-making and it was not reported that he spontaneously requested items using pointing and the picture choice board. Thus, he was included in the study.

Potential participants were excluded from the study if (a) during the pre-experimental tablet probe they threw the tablet or used the tablet to hit objects, themselves, or other people; (b) severe sensory or motor deficits or impairments were identified per results from hearing tests and/or parent self-reports (Howlin et al., 2007; Yoder & Stone, 2006). No participants exhibited these behaviors during the iPad™ interaction probe and all were retained for the entire study. These exclusionary criteria
helped to isolate the effects of the intervention by eliminating potential confounding characteristics of participants.

A sample of five was chosen to account for possible attrition rates and to provide sufficient replications in the study design. Attrition did not occur, however, only three out of five participants finished all phases of the study in the prescribed timeline. Participants who completed all phases were, Participant One, Participant Three, and Participant Four. Participants who did not complete all phases were Participant Two and Participant Five. Both Participant Two and Participant Five were in PECS Phase IIIA iPad™ training when the study ended. Although all of the participants were able to continue with treatment throughout the study, allowances had to be made for illnesses or family vacations.

In addition to the five study participants, one additional child (i.e., pilot participant) received the same instructional procedures on an individual basis. This pilot participant received the procedures prior to the other five. This informed the researcher of needed procedural changes for the five additional participants. Demographic information about this pilot participant is provided in Appendix C.

**Settings**

Each individual participant had his or her sessions for pre-experimental, experimental, and post-experimental procedures in the same room. Participant One, Participant Two, and Participant Four had sessions conducted in clinic. Participant Three and Participant Five had sessions conducted in-home because their parents were unable to transport them to the clinic. For participants who received PECS training in clinic, the same clinic room was used for all procedures except during generalization probes.
The clinic room for the Participant One and Participant Four was approximately 9 ft x 12 ft. The clinic room contained a small square table, two chairs, and a toy closet. A different clinic room was used for generalization probes. This room was approximately 10 ft x 14 ft. It contained a small round table, two chairs, and a toy closet. This room also had a single canvas printed with pictures of different sport balls.

Participant Two received training in his regular ABA therapy room, which was approximately 10 ft x 12 ft. It contained a small table, two chairs, and a plastic toy closet. The only exception that occurred in the clinic setting was that Participant Two was moved to a new clinic room by his behavioral consultant for programming reasons for his last three sessions. This room was approximately 12 ft x 14 ft. It contained one large table and one small table. Sessions were conducted using the small table. No generalization probes were conducted for Participant Two as he never met mastery criteria for Phase IIIA.

As mentioned previously two participants had sessions conducted in their respective homes: Participant Three and Participant Five. Participant Three received PECS training in his designated indoor play area. This area was approximately 13 ft x 14 ft. The floor was carpeted and had a small half wall 3.5 feet high. There was a baby gate at the entrance of the play area. A T.V. was mounted on the wall of this area but never turned on during the session. All toys in the play area that belonged to Participant Three were removed before sessions began.

Generalization probes for Participant Three were conducted in the living room that was separated from the play area by the baby gate and short wall. The living room was 7 ft by 7 ft, carpeted, and contained a sofa and love seat. A toy box was in the living
room and covered with a blanket to hide the toys. A television was also in the living room but never turned on. Although the play area and living room were connected, they were considered separate areas by the parents, and Participant Three was not allowed in the living room unless supervised.

Participant Five received PECS training in his living room and no generalization probes were conducted because he did not meet mastery criteria for Phase IIIA. The living room was 9ft x 14ft. The room’s floor was hardwood and contained a sofa, loveseat, and television. The television was never turned on during sessions. The living room was separated from the kitchen by three short stairs and a baby gate.

**Sessions**

Each PECS pre-training condition or treatment condition session was comprised of ten opportunities to request a preferred item. Occasionally, 9 or 11 trials were presented by the experimenter. This occurred very infrequently and was included in the percentage score calculation. Sometimes several sessions were conducted per day, depending on the participant. If a participant stopped manipulating or indicating interest in all six of the preferred items, the session ended and was finished on the next corresponding session day. For example, Participant Two and Participant Five sometimes only requested toys for four to six trials, and the remaining trials of the session were conducted on the next scheduled training day.

**Materials**

A video camera, tripod, various toys, and/or edible items were used during sessions. Common household items (i.e., coffee filter, a shoe, a paper clip) were also used in the PECS Phase IIIA iPad™ condition. For Participant One, Participant Two, and
Participant Three, rooms were equipped with a table and two chairs. For Participant Three and Participant Five, a small laundry basket was used as a portable table to hold toys and the iPad™ or communication binder. PECS laminated-paper icons were used to teach PECS pre-training (phases I and II). Pictures were selected from the Pics for PECS© software program, drawn by the experimenter in Microsoft™ “Paint”, or obtained from google images. All text was located above the image on the icon. Care was taken to ensure that pictures were of equivalent complexity and all icons had a white background. A white binder with four strips of Velcro on the front was used to hold the paper PECS icons. Icons were 2.3 x 2.3” on either iPad or paper. One iPad™ was used during all baseline and iPad™ training phases. Clipboards, pens, data sheets, Microsoft Excel™ software, Dell™ laptop computer, and IBM SPSS™ 18 software were used to record and analyze various aspects of the data. Video footage and data were stored on a Seagate™ portable hard drive. The PECS manual by Bondy and Frost (2002) was also used for reference during the implementation of the PECS pre-training and treatment sessions.

**Design**

A single subject, concurrent multiple baseline design (MBL) (Cooper, Heron, & Heward, 2007) across five participants was used to examine the effects of the PECS phase III application training on young children with ASD. Participant baselines were staggered according to timing of attaining mastery criterion during PECS pre-training. In addition, previous researchers have evaluated PECS with the MBL design, and therefore it is logical to keep the same design in place when evaluating an electronic version of
PECS (e.g., Angermeir et al., 2008; Ali et al., 2007; Charlop-Christy et al. 2002; Dogoe et al., 2010; Lund & Troha, 2008; Ostryn & Wolfe, 2011; Tincani et al., 2006).

This design has a distinct advantage for evaluating interventions that are potentially irreversible (Gast, 2010). In addition, it controls for both historical events and participant maturation (Carr, 2005). The design evaluates experimental control through distinct features. First, the effects of the intervention are isolated when a participant receiving the intervention shows a clear, immediate change in behavior; while the other participants’ behavior in baseline remains the same (Gast, 2010). Second, the effects of the intervention are replicated across each successive participant (Carr, 2005).

The previously mentioned features of the MBL permit attribution of the observed behavior change to the independent variable (internal validity). Such an assumption can be made provided that with each introduction of the intervention, all other baselines remain independent. In addition, the observed behavior change must be relatively immediate with a visible change in level. Regarding external validity, replication across participants in this study can support the generalization of findings to other children with autism who are of similar age and with similar characteristics. However, additional replications in different settings and with different populations will help increase external validity of findings.

**Instrumentation**

Direct observation forms were used to collect data relevant to the current study. The recording methods are described in the subsequent section for each portion of the study. Interobserver reliability data for experimental sessions were gathered using direct
observation to assess believability of the data (Johnston & Pennypacker, 2009). Treatment integrity was also assessed using direct observation.

**Pre-Experimental Measures**

Before the PECS pre-training began, preference for both toys were identified through three sessions of a multiple stimulus without replacement (MSWO) preference assessment (DeLeon & Iwata, 1996). For Participant Two, an additional single session MSWO preference assessment was conducted with edible items after he stopped manipulating toys. Edible items were only used because Participant Two did not manipulate any of the toys and also threw them when prompted to sample.

Some items used for the preference assessments were identified via a modified Reinforcer Assessment for Individuals with Severe Disabilities (RAISD) form (Fisher, Piazza, Bowman, & Amari, 1996). See Appendix D for the modified RAISD form. Other items were identified during the informal preference probe.

During the MSWO preference assessment, observers scored item preference by recording the order in which items were chosen. A choice was defined as any participant contact with an item using his or her hand and manipulating the object for five seconds or longer. Items identified as moderately preferred were those ranked by the MSWO as 4th through 6th. Highly preferred items were ranked 7th through 10th (see Appendix E for the MSWO preference assessment data sheet). Ranking of an item was determined by adding each ranking per session, dividing by three, and rounding to the nearest whole number. Non-preferred items for PECS training sessions were identified during a five-minute informal non-preferred item probe. The non-preferred item probe consisted of presenting
the participant with presumably uninteresting items (i.e., a house sponge, a shoe, a pen) and recording whether the participant interacted with any of the items.

**PECS Pre-Training Measures**

During pre-experimental training of PECS phases I and II, data were collected on frequency of correct, independent mands using PECS low-tech icons. Low-tech icons are defined as icons that are made of laminated paper. Frost and Bondy’s (2002) criteria for a correct, independent mand were used. These mands are defined as those in which the participant reaches, picks up the correct icon, and releases it into the communicative partner’s hand in the absence of any prompts or verbal instructions. If any prompt was delivered by the communicative partner or the experimenter (e.g., physical, model, gesture, visual) or instruction was given, the mand was not scored as independent for that opportunity. An open hand or extending the arm with an open hand toward the participant was classified as a gestural prompt (Tincani, et al., 2006). Appendices F and G display data sheets used during PECS pre-training (phases I and II). Correct, independent mands were measured using cumulative frequency per session.

**Experimental Measures**

During the study, data were collected on independent, discriminated mands (e.g., Beck et al., 2008). Independent mands were measured during the baseline conditions, experimental conditions, maintenance probes, and generalization probes using cumulative frequency per session (i.e., event recording) (Cooper, et al., 2007). See Appendix H for data sheet. Cumulative frequency of mands was recorded by making a “+” sign for each instance in which the participant emitted an independent, discriminated mand. These
mands are defined as requests in which the participant touches the iPad™ and selects the correct icon on the iPad™ in the absence of any prompts or verbal instructions.

If any prompt (i.e., physical, model, gesture, visual, verbal) was delivered by the communicative partner or the experimenter, the mand was not scored as independent for that opportunity. This was indicated by a “-” sign on the data sheet. If a participant selected an icon of a preferred or non-preferred item during baseline or phase IIIA but did not manipulate it for at least 5 seconds after receiving it, the trial was scored as incorrect. If the participant selected an icon of a non-preferred icon and manipulated the item for at least five seconds after receiving it, the mand was scored as correct. In addition, self-corrections were scored as a correct mand if performed only once. For example, when a participant touched an incorrect icon and then immediately self-corrects within 1 second to touch the correct corresponding icon, these were scored as correct. Ganz et al. (2008) also scored self-corrections as correct responses; however, in this study a “one self-correction rule” was implemented to avoid having a participant learn to simply select and switch among multiple icons if the preferred item was not delivered. This avoided reinforcement behavioral chains of selecting the wrong icon and then moving to a different icon or the only other icon on the screen. The magnitude of the second response (i.e., pressing the icon multiple times) toward the correct icon was classified as a behavioral indicator that the second response was the true “choice” of the participant.

After the session, cumulative frequency of independent, discriminated mands were converted to a percentage score by dividing the number of independent, discriminated mands by total opportunities per session. This method of recording was modeled after previous studies (e.g., Ali et al., 2010; Beck et al., 2008; Bock et al. 2005;
Carré et al., 2009; Cihak et al., 2012). A total of ten opportunities were presented per session to allow comparability across data points. An opportunity is defined as the presentation of a preferred item within the participant’s visual field, but out of the participant’s reach (Tincani et al., 2006). See Appendices G and H for the data sheets.

**Post-Experimental Measures**

The mand preference assessment was conducted at the conclusion of the study. During the mand preference assessment, data were gathered to assess the relative preference of the participant between the iPad™ and the low-tech, PECS paper icons (as modeled by Falcomata et al., 2010). Preference for a device was measured by recording cumulative frequency of independent mands using either the iPad™ or the low-tech PECS paper icons. After the session ended, frequency was converted to a percentage score by dividing by the number of total opportunities per session (10) and multiplying by 100. See Appendix I for the mand preference assessment data sheet.

**Overview of Research Procedures**

There were three phases in this research. These phases were (a) study preparation, (b) study implementation, and (c) data analysis. The study preparation phase consisted of obtaining research permission, obtaining informed consent from participants, and training research assistants.

The study implementation phase consisted of pre-experimental, experimental, and post-experimental assessments. Pre-experimental assessments consisted of an iPad™ interaction probe, parent completion of the modified RAISD form, an informal preference probe, an informal non-preferred item probe, a multiple stimulus without replacement (MSWO) preference assessment, and PECS pre-training (Phases I and II).
After PECS pre-training was complete, then experimental conditions began. Six generalization probes were conducted throughout the experiment (2 per treatment condition). Post-experimental procedures consist of maintenance probes, a mand preference assessment, and parent questionnaire. Post-experimental procedures were conducted between one and three weeks after the study ended. See Appendix J for a chronological outline of the study’s procedures.

The data analysis phase consisted of organizing and analyzing all collected data. The analysis was conducted to answer each research question.

**Phase One: Study Preparation Procedures**

**Obtain Research Permissions**

Permission to implement the study was obtained from the University of Nevada, Las Vegas Interim Review Board (IRB). All study procedures were approved by April 9, 2013. In addition, permission to use clinic rooms from a local Applied Behavior Analysis therapy provider was also obtained from its two owners/operators.

**Obtain Informed Consent**

Meetings with the parents were scheduled in order to obtain informed consent. Parents were told of the options to withdraw from the study at any time, and they were told that withdrawal would not affect their relationship with any of the experimenters or University of Nevada, Las Vegas. Meetings were approximately 20 minutes, and the experimenter answered any questions the parent had about the study or its procedures.

**Train Research Assistants**

Research assistants who implemented PECS pre-training procedures were already trained in implementation of PECS. For one research assistant with no prior experience,
instruction in how to record data was provided in three, 15-minute sessions before
beginning the study. During this time, the assistant was taught how to mark the behavior
observation on the data sheet according to which behavior she was told to mark. Prior to
beginning the study, the research assistant reached 100% correct recording of data.
During the study, this research assistant recorded data based upon the primary
experimenter’s directions on what to record. For example, the experimenter would tell
her during the session that a trial was correct or incorrect to ensure accuracy and the
research assistant would mark a plus or minus on the data sheet, depending on the
primary experimenter’s directions. The research assistant with no prior experience was
taught again in three additional 15-minute sessions how to serve as a communicative
partner for the child participant. Modeling and role playing was used to teach the research
assistant and review of the communicative partner’s role was discussed prior to any
session in which the research assistant served as the communicative partner.

**Phase Two: Study Implementation Procedures**

**Pre-Experimental Assessments and PECS Pre-Training**

Pre-experimental procedures consisted of (a) an iPad™ interaction probe, (b)
parent completion of the modified RAISD form, (c) an informal preferred items probe,
(d) an informal non-preferred items probe, (e) an MSWO preference assessment, and (f)
PECS pre-training phases I and II. During all pre-experimental procedures except PECS
pre-training phases I and II, data were collected in-vivo and one experimenter was
present. During PECS pre-training phases I and II, data were collected by watching video
footage of the session. Two experimenters were present to conduct PECS pre-training
sessions. Subsequently, more detailed descriptions of each pre-experimental procedure are provided.

**iPad™ interaction probe.** The iPad™ interaction probe was ten minutes in duration for each participant. The purpose of the iPad™ interaction probe was to assess the participant’s interaction skills with the iPad™. During the probe, the experimenter and the participant entered the room and the participant was presented with the iPad™ after either sitting on the floor, couch, or in a chair at the table. The experimenter modeled how to use the “Touchtrainer”, probe application. With “Touchtrainer”, the user must touch the picture to activate motion and sound. Varying levels of sizes of the picture are presented with each successful touch. After modeling appropriate interaction with the iPad™, the experimenter presented the iPad™ to the participant. The participant then had ten minutes to interact with the iPad™.

During the probe, the experimenter recorded any throwing, forcefully tapping, and hitting self or another person with the iPad™ using cumulative frequency per session. Predetermined criteria for study exclusion consisted of two or more occurrences of the aforementioned behaviors during the session. Other interactive behaviors (e.g., orienting eyes and head toward the screen, moving the finger up and down and left to right while maintaining contact with the screen) were informally noted. Results of the probe indicated that all participants were able to look at the screen, touch the icon, and interact with the iPad™ appropriately (i.e., no throwing, forcefully tapping, hitting with the iPad™).

**Modified RAISD form.** Parent completion of the modified RAISD form took approximately 15 minutes. During the initial intake meeting, parents were asked to
complete the modified RAISD form. The experimenter explained to parents that this form would help the researchers understand what foods or toys their children enjoy, and that these items may be used to teach requesting with PECS. Parents were also asked if they did not want their children to have certain foods or toys during this study. For example, if a participant was on a gluten/casein free diet, it was planned to not provide wheat or dairy snacks to the child.

**Informal preferred items probe.** The informal preferred items probe was five minutes in duration. The informal preferred items probe served to identify potential items to include during the MSWO preference assessment. During the session, the child entered the room with the experimenter. There were five toys arranged in a semi-circle on the floor. These were toys that had *not* been identified by parents as potentially preferred. The experimenter walked the participant around the circle and allowed him/her to sample the items. The participant was then allowed to interact with the items in any way he/she wanted. During the session, if the participant manipulated or looked at an item (e.g., watching bubbles being blown) for two seconds or longer, the experimenter wrote the item’s name on a list of “potentially preferred” items. The participant had free access to all five items during the entire session.

**Informal non-preferred items probe.** The informal non-preferred items probe was five minutes in duration. The probe was used to evaluate potential non-preferred items to use during iPad™ phase IIIA. During the session, ten items were simultaneously presented to the participant by arranging them in a semi-circle on the floor. The experimenter presented items to the participant if he/she did not appear to notice them (i.e., continually manipulated a single item, or began to walk away from the array). This
was done to ensure that the participant briefly contacted every item and that lack of interaction was due to low interest in the item; not unawareness of the item. For Participant One, Participant Four, and Participant Five, more than one non-preferred probe was conducted because the participant interacted with four or more items for 2 seconds or more. If the participant did not manipulate, look at, or interact with an item for more than two seconds, the experimenter noted the item as non-preferred. Six items from the non-preferred item probe were used during the iPad phase IIIA condition.

Non-preferred items for Participant One consisted of a coffee filter, paper clip, small note paper, plastic sandwich bag, container, and shoe. Non-preferred items for Participant Two included a coffee filter, plastic sandwich bag, paper towel, paper clip, sock, and shoe. Non-preferred items for Participant Three consisted of a sock, sponge, clip, container, plastic sandwich bag, and paper clip. Non-preferred items for Participant Four consisted of a sock, string, container, sponge, scoop and clip. Finally, non-preferred items for Participant Five consisted of a sponge, sock, clip, coffee filter, battery, and receipt. The clip was later removed from distracters for Participant Five because during an early session of iPad™ phase IIIA training, he continually attempted to grab the clip and cried for ten minutes immediately after it was removed from his grasp by the experimenter.

**MSWO preference assessment.** Three MSWO preference assessment sessions were conducted for toys on three separate days, and were approximately 15-20 minutes per session. For Participant Two, a single session of an MSWO preference assessment was also conducted later in the study. This was because mand frequency for toys greatly reduced for several consecutive sessions on different days.
The multiple-stimulus without replacement (MSWO) preference assessment was conducted to identify preferred items for PECS training. The MSWO preference assessment served to identify the relative rankings of preference among items. It also served to identify several items to rotate throughout the study and prevent satiation effects (Egel, 1981; Roane, Vollmer, Ringdahl and Marcus, 1998). Six items, identified through the MSWO as highly and moderately preferred, were used during PECS training. Items ranked 1\textsuperscript{st} through 3\textsuperscript{rd} were classified as highly preferred, and items ranked 4\textsuperscript{th} through 6\textsuperscript{th} were classified as moderately preferred. Item ranking across the three sessions was established by averaging each item’s average ranking score and ranking each item from highest to lowest average score. For example, if a slinky toy’s average score was 1.5 and bubble’s average score was 2.3, then slinky was ranked as more preferred than bubbles.

The three sessions of the MSWO were conducted according to procedures of Roane et al., (1998). Leisure items were arranged in a semi-circle or whole circle on the floor (depending on how much the participant moved during the session). The participant was free to manipulate the item(s) of his/her choice. The participant began on the outside of the circle or semi-circle. Prior to a session, the experimenter led the participant around the circle to ensure contact with each stimulus. After each item was sampled, the participant was moved approximately 0.6 m (about 2 feet) from the assessment area. The therapist then withdrew from the assessment area, and the assessment began.

The experimenter then pointed to the array and delivered one of the following instructions, “Go play” or “Pick a toy,” or “Choose”. Instructions varied according to the abilities of participant. The experimenter was located beside the stimulus array and
presented social attention (e.g., “That’s a fun toy!”) or helped operate the toy once the participant picked it up or attempted to manipulate it for 5 seconds or longer but showed difficulty (for example, the participant could not independently turn on a toy, or couldn’t blow the bubbles.) Upon selection, participants had at least 30 seconds to engage with the item while the experimenter rearranged the remaining items to a new location in the semi-circle. Items were rearranged so that they were across the circle from their previous location. The purpose of rearranging items was to help control for location bias. After the 30 seconds elapsed, the item was removed from the participant and not replaced in the array. This process continued until only one item remained.

During the assessment, observers scored item selection by recording the order in which items were chosen. A choice was defined as any participant contact with an item using his or her hand, and manipulating the object for five seconds or longer.

The preferred items for Participant One consisted of Squinkies™, wind-up toys, princess dolls, a musical elephant mirror, ball ramp, and gumball toy. For Participant Two, highly and moderately preferred items consisted of a gumball toy, bubbles, tops, ring stacking toy, a vibrating ball, and water play. From his second preference assessment with edible items, highly and moderately preferred items were gummy candy, Cheetos™, mini-marshmallows, bread, apples, and black gumdrops. The preference assessment for Participant Three indicated that bubbles, a hippo figurine, magazine, ball pit, stacking rings, and blocks were all highly or moderately preferred.

Preferred items for Participant Four were a musical elephant mirror, ballramp, dinosaur & turtle figurines, Dora the Explorer™ phone, computer toy, and blocks.
Preferred items for Participant Five were puzzles, bubbles, long strips of paper, gumball toy, stacking rings, and tickle play with an adult.

**PECS pre-training.** Before baseline data were collected, pre-training for PECS phases I and II were conducted. Because participants had no experience with PECS, this served to allow comparability across participants’ performance. It also served to control for history effects (i.e., one participant may perform better with the iPad™ because he/she had more prior experience using PECS.) PECS training for Phases I and II was conducted according to the PECS training protocol manual (Bondy & Frost, 2002). The same prompting and error correction procedures were used as in the PECS manual.

During PECS pre-training, the communicative partner for each participant varied. Silent prompting was always delivered by the primary experimenter from behind the participant. For Participant One, a single experimenter and her mother served as the communicative partners. For Participant Two, his typical behavioral therapists served as his communication partners. There were three different therapists during PECS pre-training who served as his communicative partners. A single experimenter and the father served as pre-training communicative partners for Participant Three. For Participant Four, three different experimenters and his mother served as the communicative partners. Finally, For Participant Five, a single experimenter and his mother were communicative partners.

**PECS pre-training phase I.** PECS pre-training phase I sessions were conducted 3-5 days per week. Ten opportunities to request items were presented during all sessions (Ali, et al., 2007; Cihak, et al., 2012). Sessions terminated after 10 opportunities to request an item were presented.
Pre-training sessions began with the experimenters entering the room with the participant. The primary experimenter instructed the participant to sit at a table if he/she was capable of sitting for five minutes. If participants were not able to sit at a table, they were free to move about the room and the PECS icon was located on the portable table that the experimenters moved about the room as needed.

For participants who were able to sit, he/she was prompted back to the chair by the experimenters using a least-to-most prompting hierarchy (Wilder, Atwell, & Wine, 2006). This meant that if the participant first did not respond to the initial instruction “Please Sit down”, the experimenter first repeated the instruction in a neutral tone of voice, “(Participant’s Name), please sit down.” If the participant complied, brief praise was delivered. If the participant did not comply, the experimenter re-presented the instruction while tapping or pointing to the chair. Compliance resulted in brief praise from the experimenter. If the participant again did not comply, the experimenter lightly guided the participant to the chair while simultaneously re-presenting the instruction. Any problem behavior that did not pose a safety risk to the participant or experimenter during the session was ignored. If problem behavior (e.g., hitting, kicking, screaming, pulling on the doorknob, crying with tears, etc.) occurred for five minutes or more, the session was terminated. Sessions were terminated three times for Participant Five and twice for Participant One because of crying for five minutes or more. During all instances the mother of Participant Five reported he had just woken from a nap or missed his nap. For Participant One, her mother reported that she had started summer school and had to awaken much earlier than usual or that she was unusually tired that day.
Four highly or moderately preferred items as previously identified by the MSWO were made available for request during sessions. The primary experimenter allowed the participant to sample a single item as needed. The secondary experimenter stood behind the participant. If the participant either interacted with the item for longer than five seconds or ate an edible item, the experimenter assumed that a motivating operation (MO) was present for the item (Michael, 1993/2004). In this case, the assumption was that if the participant interacted with the item, the necessary conditions were present that would occasion a request for the item. The experimenter then placed the icon of the corresponding picture on the table in front of the participant. No other icons were present. If the participant did not manipulate the item, the experimenter presented other preferred items until the participant interacted with the item. Occasionally, participants walked to where the toys were stored and looked inside for a new toy. During these times, they were allowed to look among the four toys and select an item to sample.

After the participant sampled the item, the experimenter removed it and said “My turn.” The trial began when the experimenter presented the preferred item within the participant’s visual field but out of the participant’s reach. During this time, the experimenter said nothing. If the participant reached toward the item, the secondary experimenter physically prompted the participant to pick up the paper icon, reach toward the primary experimenter, and release the icon into the primary experimenter’s hand. The secondary experimenter said nothing during the session.

Initially, the primary experimenter used an open hand as a gestural prompt as indicated by the PECS manual (Frost & Bondy, 2004). Contingent upon the participant correctly manding for two consecutive trials, prompts were faded according to a
hierarchy of steps. Each step graduated to a less intrusive prompt. Fading of the open hand consisted of the following steps: (a) experimenter extended her open hand toward the participant with elbow locked straight, (b) experimenter’s hand was open but fingers were curled toward palm and elbow at 90 degrees touching her side (c) experimenter’s hand was fully closed until icon touches hand—then the hand opened to receive icon—elbow was still at 90 degrees touching side.

Once the icon was released into the primary experimenter’s hand, the corresponding preferred item was delivered within 1 second and simultaneously the name of the item was said. All mands were reinforced via the delivery of the preferred item on a fixed-ratio of one to one. If the participant pushed the item away, set it down and didn’t interact with it, the trial was ended and scored as incorrect (Dogoe, Banda, & Lock, 2010). Responses that were more independent than the previous response produced 30 seconds with an item. All other responses (prompted or equal amount of independence to the previous response) produced 20 seconds with an item.

Physical prompts for pick up, reach, and release were faded over successive trials as the participant began to independently or partially independently perform each step. This was a most-to-least prompting procedure and criteria for fading the level of prompt was two consecutive correct responses. The pick-up, reach, and release of the icon were taught using a backward chain (Bondy & Frost, 2002). That is, prompting for the release of the icon was faded first, then the reach, and finally the pick-up.

The hierarchy of prompts consisted of a full physical prompt (hand over hand guidance), partial physical (initially guiding the participant to begin the response but then letting go during the end of the response), light touch (e.g., touching the hand or elbow to
evoke a response but no clear guidance), and finally, no prompt or touch whatsoever. Again, to graduate from each prompt level, the participant had to correctly mand for two consecutive trials.

If at any time during the training of the picture exchange the participant engaged in unwanted behavior with the icon (e.g., mouthing the icon for more than 3 seconds, waving the icon in front of his/her eyes) a back-stepping procedure was implemented (Bondy & Frost, 2002). Specifically, the secondary experimenter removed the icon and placed it back on the table. If the child dropped the icon and did not pick it up independently, the secondary experimenter said nothing, retrieved the icon, and it was returned to the original position. If the child dropped the icon, the trial was ended and a new trial was presented. This trial was not recorded as it was considered part of the error correction. Criteria for mastery of PECS phase I was 8 out of 10 correct, independent mands across three consecutive sessions.

**PECS pre-training phase II.** PECS pre-training phase II sessions were conducted 3-5 days per week. Two experimenters were present during sessions. Ten opportunities to request items were presented (Ali et al., 2010; Cihak, et al., 2012). Sessions terminated after 10 opportunities to request an item were presented. Several sessions were conducted per day, depending on the participant.

During phase II, procedures were the same as phase I. The only differences were that (a) the picture was now on the front of the binder, (b) the distance between the primary experimenter and the participant was systematically increased, and (c) the distance between the binder and the participant was systematically increased.
Shaping was used to reinforce successive approximations of travelling to different targets. Several targets were shaped according to the protocol described by Frost and Bondy (2002). Three targets or travelling skills were taught to the participant during phase II. These were (a) traveling to the communicative partner (with participant starting with the communication binder in front of him/her); (b) traveling to the communicative partner with the binder in the same direction as the communicative partner, and (c) traveling to the communicative partner with the binder located in the opposite direction of the communicative partner. The participant travels in a triangle, first to the binder and then to the communicative partner in the opposite direction.

Initially, the participant was taught to remove the icon from the top of the binder, as this was not learned during PECS pre-training Phase I. Physical prompts were faded according to the same hierarchy and criteria (i.e., two consecutive correct mands) in PECS pre-training Phase I. After the participant independently removed the icon to mand for an item for two consecutive trials, shaping of traveling began.

Shaping for traveling consisted of an experimenter keeping her hand closer to the body to occasion a longer reach from the participant during the exchange. This was far enough away so that the participant had to stand up from the chair or current location in order to exchange the icon. After two consecutive correct trials of getting up from the chair or standing up from the floor to exchange the icon, the experimenter increased the distance away from the participant in increments of 1 foot.

Shaping ended when the participant was able to independently cross the room to exchange the icon with the experimenter for two consecutive trials. The same criteria were used to for shaping distance related to traveling to the communicative partner with
the binder in the same direction and traveling to the communicative partner with the binder in the opposite direction. The communicative partner did not provide any prompting to the participant to occasion the response (e.g., “Come here!” or “Look what I have!!”). Moreover, the communicative partner did not make eye contact with the student as the distance was increased (Frost & Bondy, 2002). Eye contact was not used once the participant was able to independently initiate walking at least half-away across the room to exchange the icon. This prevented the participant’s requesting behavior from coming under control of the communicative partner’s look. If needed, a secondary experimenter used the same prompting hierarchy as used in Phase I to help the student walk over to the communicative partner and make the icon exchange. During this phase, error correction procedures were the same and the schedule of reinforcement was the same.

If the participant dropped the icon when walking toward the communicative partner or when attempting to place the icon into the partner’s hand, and he/she picked it up independently, the trial was continued as usual. During the study, all participants independently picked up the icon within 1-2 seconds after dropping it (every time it was dropped). Because participants independently picked up the icon and began again initiating the exchange, it was unnecessary to back-step and replace the icon into its original position at the start of the trial (as recommended by Bondy & Frost, 2002).

After the participant was able to independently walk toward and exchange the icon with the primary experimenter in 8 out of 10 trials, across three consecutive sessions, the distance of the binder was systematically increased and the participant was then shaped to travel to the communicative partner with the binder in the same direction and travel to the communicative partner with the binder in the opposite direction. The
distance of the binder was shaped either in the same direction or opposite direction of the participant’s starting point. This was taught using the same shaping and prompting procedures as were used to shape the first travelling target (i.e., traveling to the communicative partner). Exit criterion for traveling to the communicative partner with the binder in the same direction was correctly manding for two consecutive trials. Exit criterion for the final shaping target, traveling to the communicative partner with the binder in the opposite direction, was 80% correct for three consecutive sessions. This criterion was used as this final shaping target was considered an indicator of overall mastery of travelling skills taught in PECS Phase II. For the five participants, it was deemed that two consecutive trials correct were necessary to graduate to the next step in PECS phase II pre-training, in order to avoid satiation of the limited number of toys.

**PECS pre-training results.** Participant One acquired phases I and III in 120 trials, Participant Two acquired both phases in 270 trials, Participant Three in 250 trials, Participant Four in 250 trials, and Participant Five in 670 trials, respectively. The pre-training sessions helped ensure comparable knowledge prior to initiating the experimental conditions. See Appendix K for Pilot Participant pre-training results in addition to other method information.

**Experimental Conditions**

Experimental procedures consisted of baseline, PECS Phase IIIA iPad™ training, PECS Phase IIIB iPad™ training, PECS Phase IIIB iPad™ multiple icons and tabbing training, and generalization probes. Measures were collected using the same methods across all conditions. The measures were conducted during the same time of day throughout the study to allow data comparability across sessions. All experimental
sessions (baseline, iPad™ phase IIIA training, iPad™ phase IIIB training, PECS Phase IIIB iPad™ multiple icons and tabbing training, and generalization probes) were videotaped to be scored later.

**Baseline IIIA.** Baseline sessions were conducted 3-5 days per week. Ten opportunities to request items were presented during all baseline sessions (Ali et al., 2007; Cihak et al., 2012). Several sessions were conducted per day, depending on the participant’s duration of interest in playing with the toys.

The purpose of the baseline condition was to evaluate untreated levels of independent, discriminated mands, spontaneous vocalizations or spontaneous approximations of words, and problem behavior in the absence of the intervention. This provided a contrast for the treatment conditions. Essentially, the baseline functioned as a predictor of the target behaviors if left untreated (Wacker, et al., 1990). Baseline conditions were conducted before any treatment conditions were instated. Baseline sessions consisted of ten trials or opportunities to request a preferred item. If the participant engaged in problem behavior (e.g., hitting, kicking, throwing objects, crying), those behaviors were physically blocked and/or minimal eye contact or verbal statements were made from the experimenters. If problem behavior persisted for more than five minutes, the session was terminated. No prompting or error correction procedures were used. Baseline data were gathered until visual analysis indicated that data showed a steady state, and/or a trend that was not in the predicted direction of responding in the presence of the treatment. Trend was evaluated by inserting a median line through the baseline data using Microsoft Excel™ functions.
Baseline procedures consisted of both experimenters entering the room with the participant to begin the session. Four preferred items were available for the participant to request. Four non-preferred items were also used. These were the items identified as non-preferred from the informal non-preferred items probe. Examples of non-preferred items included a coffee filter, a dry sponge, a shoe, a paper clip, rubber band, etc.

After the participant sat at the table, sat on the floor, or stood for 2 seconds or longer, the communicative partner placed the iPad™ with the PECS phase III application in front of the participant (either on the table, on the floor, or on a portable table). The iPad™ had two icons available for the participant to select: one preferred item and one non-preferred item. During a ten-trial session, the icons on the iPad™ were re-arranged to ensure the presentation of icons for an equal number of times on the left and right sides. Four preferred items and four non-preferred items were available to request during the session.

A trial began when the experimenter presented the preferred item and non-preferred item across from the participant so that he/she could see the items, but they were out of reach. The communicative partner waited 5 seconds for a response from the participant. Contingent upon the participant selecting the correct icon on the iPad™ the experimenter delivered the corresponding item to the participant and simultaneously said the name of the item. The participant then had 20 seconds to play with the item. While the participant was playing with the item, the iPad™ was removed from the participant’s reach or turned over so he/she could not make a selection on the screen. If a different preferred item or non-preferred item was going to be presented during the next trial, an experimenter placed the appropriate different icons on top of the binder or selected them
on the iPad™ before placing them in front of the participant. After 20 seconds elapsed, the experimenter removed the item and said, “My turn.” The iPad™ was then placed back in front of the participant.

If the participant selected both icons on the iPad™ at the same time, the experimenter removed both the preferred and non-preferred items, turned over the iPad™ so the participant could not make a selection, and the trial was terminated. Any attempts to reach toward or grab the preferred item were blocked by the first experimenter.

**PECS phase IIIa iPad™.** The PECS Phase IIIA iPad™ training conditions were conducted 3-5 days per week. Ten opportunities to request toys or edibles were presented during all training sessions (Ali et al., 2007; Cihak et al., 2012). Sessions terminated after 10 opportunities to request an item had been presented. Several sessions were conducted per day, depending on the participant.

During phase III iPad™ training, two experimenters were present. An additional experimenter was present in order to prompt the communication initiation from behind if needed. This was because the iPad™ was a new communication device that the child was not accustomed to using and some participants (Participants Three and Five) had difficulty selecting icons using their finger. The purpose of the iPad™ phase IIIA application phase was to evaluate independent mands, in the presence of the PECS phase III intervention, with the iPad™ application functioning as the assistive communicative device. During this phase, discrimination between two pictures was taught. One picture was of a preferred item, and one picture was of a non-preferred item. The session began when both experimenters entered the room with the child.
After the participant sat at the table, sat on the floor, or stood still for 2 seconds, the communicative partner presented the iPad™ with the PECS phase III application on the table in front of the participant. The application was turned on and had one preferred and one non-preferred icon that was visible to the participant and experimenters. If necessary, a secondary experimenter stood behind the participant and was ready to prompt if necessary. Four preferred items were present in the room, but they were only accessed by the experimenters. Sometimes a participant would look in a bin or bag that typically held the toys. If this happened, he/she was allowed to select a toy and sample it for 5 seconds. The participant was free to move about the room, interact with the experimenters, and access the preferred items contingent upon a correct mand using the iPad™ application. The experimenter had four non-preferred items identified from the informal non-preferred items probe. Examples of non-preferred items included a coffee filter, a dry sponge, a shoe, and a paper clip.

The trial began when the communicative partner presented both a preferred and non-preferred item within the participant’s visual field but out of his/her reach. If the participant initiated the request (e.g., reaching toward the item, looked at it for 2 seconds or more, cried or whined within 2 seconds of the item being removed or presented), either the primary or secondary experimenter prompted him/her to select the correct icon. There were two icons that were available on the iPad™ screen. When the participant selected an icon, the PECS phase III iPad™ said the “name” of the icon/item and grew slightly in size. Contingent upon participant selection of the correct icon, the communicative partner delivered the preferred item within 1 second. Simultaneously, she said the name of the item. If the participant pushed the item away, set it on the table and didn’t interact with
the item or eat it, the trial was ended and scored as incorrect (Dogoe et al., 2010). If the participant manded for a non-preferred item and interacted with it for less than five seconds, the trial was scored as incorrect. Contingent upon selecting a non-preferred item that the participant did not play with, error correction was implemented. The “model, prompt, switch, repeat” error procedure was conducted according to Frost and Bondy (2002). Only two error correction procedures were conducted consecutively. After the second error correction, a full physical prompt was provided on the next consecutive trial.

For Participants Two, Three, and Five, errorless learning strategies were used in the form of a full physical prompt that was faded according to criteria in PECS pre-training Phases I and II. These procedures were used because Participant Two and Participant Five were observed to either walk away from the experimenter immediately after error correction and did not make additional attempts to request using the iPad™. Participant Five stopped responding and sat in his chair. It was hypothesized that error correction was functioning as a punisher, or it reduced responding because of increased effort or delayed reinforcement. Increased response effort or delay of reinforcement can decrease the likelihood of a response occurring (Horner & Day, 1991). This is because during error correction, access to the preferred item is delayed because the participant watches the experimenter model the response, is prompted to perform the correct response, wait for a few seconds, and is then provided another opportunity to request the item. If the participant erred again, then error correction was implemented a second time, further increasing the response time and delaying access to the preferred item.

Regardless of the mechanism, it was decided that access to the preferred item needed to be faster and with minimal effort for Participant Two, Participant Three, and
Participant Five. Therefore, participants were either fully prompted and the prompt was faded; or if error correction was used, it was used a single time and then the participant received a full physical prompt during the next trial.

Ten trials were presented per session. The session ended after all ten trials were presented. As previously stated, the session was terminated if the participant engaged in problem behavior for longer than five minutes. After the participant selected the correct icon on the iPad™ in 8 out of 10 trials, across three consecutive sessions, the PECS Phase IIIB iPad™ condition was instated.

**PECS Phase IIIB iPad™.** This condition was conducted 3-5 days per week. Ten opportunities to request items were presented during all sessions (Ali et al., 2007; Cihak et al., 2012). Sessions terminated after 10 opportunities to request an item were presented. Often several sessions were conducted per day, depending on the participant. During phase IIIB training with the iPad™, two experimenters were present for each session. Two experimenters were present due to Interim Review Board requirements as well as to provide prompting from behind if necessary for certain participants.

The purpose of this condition was to evaluate independent, discriminated mands, spontaneous vocalizations during PECS phase III intervention with the iPad™ as the assistive communication device. During this phase, discrimination between two icons of preferred items was taught. Both icons were pictures of preferred items. General procedures, prompting procedures, error correction, and presentation of trials were the same as in the PECS Phase IIIA iPad™ phase. The only difference was that the communicative partner presented two preferred items to the participant on a tray, and conducted correspondence checks for 40% of trials according to Frost and Bondy, (2002).
The purpose of correspondence checks was to assess accuracy of participant’s mands. Correspondence checks were conducted by presenting two preferred items on a tray, showing them to the participant, but keeping them out of reach. When the participant pressed an icon on the iPad™, the experimenter simultaneously presented both preferred items on the tray and said, "Go ahead, take it" while smiling. If the participant reached for a different item than the icon he/she selected, the experimenter physically blocked access to the item, and the “model, prompt, switch, repeat” error correction was implemented.

This consisted of the experimenter touching the correct icon, fully prompting the participant to touch the correct picture, and praising the participant when he/she touched the correct picture. The experimenter then turned over the iPad™ for two seconds and the next trial was presented by holding up the two preferred items out of reach of the participant. A second correspondence check was conducted when a participant exhibited an error during a correspondence check (Frost and Bondy, 2002).

Participant One and Participant Four, were provided another opportunity to mand independently and error correction was implemented a second time if needed. Participant Three received one error correction and then was fully prompted on the next trial to touch the correct icon. Again, this was in order to reduce response effort.

**PECS Phase IIIB iPad™ multiple icons and tabbing.** During this phase, procedures were similar to the iPad™ phase IIIB condition, with the exception that additional icons were added to the visual array on the iPad™ and tabbing among the electronic “binder pages” was taught. Scanning and selecting the correct icon among three or more icons was taught first. Tabbing was taught after the participant met mastery criteria for correctly manding with five icons in an array.
When teaching mand discrimination among multiple icons, an icon was added to the array if a participant correctly manded for an item for two consecutive trials. Participants began with three icons in the array, then progressed to four, and finally ended with five. Correspondence checks were conducted for a minimum of 40% of trials during a 10-trial session. After each mand, icons were re-arranged in the field to prevent the participant from developing location bias. The criteria to graduate to learn tabbing was three consecutive sessions of 80% correct.

During session 23, the primary experimenter observed that Participant Three was continually attempting to turn his head. It appeared that he was looking at the images “upside down”. Between session 23 and 24, the primary experimenter presented the five-icon array on the iPad™ to Participant Three with the images “upside-down”. When images were presented “upside-down,” Participant Three correctly manded for an item for three consecutive trials. Based on these observations, the primary experimenter hypothesized that the selection response had come under control of the reverse image.

As a result, during session 24 Participant Three received light physical guidance from behind by the primary experimenter. This guidance was given to align his head and body correctly in order help him scan the icon images while right-side up. Criteria was that during 90% of a session’s trials, Participant Three did independently positioned his head straight and his eyes were aligned to view the icons right-side up. This physical guidance was continued until session 50.

The procedures for tabbing were similar to those with multiple icons. The purpose of this procedure was to teach the participant to “tab” through the blank binder pages on the application in order to produce the correct page containing the array of five icons. All
other “binder pages” on the application were blank except one containing five icons of preferred items. During this phase, initially the experimenter presented the iPad™ with all five icons within the participant’s view and immediately before setting it on the table, the experimenter touched a different tab on the iPad™ to show a “blank” binder page. These procedures were adapted for the PECS iPad™ application but based upon teaching procedures by Frost and Bondy, (2002) to teach participants how to look through the binder.

**Generalization probes.** Generalization probe sessions consisted of ten trials and were conducted two times per treatment condition (Dogoe et al., 2010). These probes were only conducted until after the participant met mastery criteria. The purpose of waiting until mastery criteria was met was to create better comparability across participants’ data. There were six generalization probes in total (two after PECS Phase IIIA iPad™ condition, and two after the PECS Phase IIIB iPad™ condition, and two after PECS Phase IIIB iPad™ multiple icons and tabbing condition). Generalization probes were conducted in a different setting at the participant’s regular training site. There were two experimenters present during generalization probes or an experimenter and a parent. Only experimenters served as the communicative partners during generalization probes. Data for generalization probes were scored in vivo, but video footage was consulted if an experimenter needed to review a specific trial. Finally, all dependent measures collected in generalization probes were collected using the same methods during baseline and treatment conditions.

During generalization probe sessions, trials were presented in the same manner as the each of their corresponding treatment conditions (PECS Phase IIIA iPad™, PECS
Phase IIIB iPad™, or PECS Phase IIIB iPad™ with multiple icons and tabbing), with the exception that no prompts or error correction procedures were used. A correct mand using the iPad™ produced delivery of the corresponding item by the experimenter within 1 second of the request. The experimenter also simultaneously said the name of the item as it was delivered to the participant. This was implemented on a reinforcement schedule of fixed ratio one-to-one. If after manding for an item the participant pushed the item away, set it on the table, and/or didn’t interact with it, the trial was ended and scored as incorrect (Dogoe et al., 2010). For some participants toward the end of the study, after receiving the item he/she would walk away for a few seconds and come back to play with the item and then manipulated it for a period of approximately 20 seconds. During these instances, the mand was scored as correct. Generalization probes were conducted during the same time of day to allow comparability across probes. Times were individualized to fit participant schedules.

**Post-Experimental Assessments**

Post-experimental assessments consisted of maintenance probes, a mand preference assessment, and parent questionnaire. For maintenance probes and the mand preference assessment, two experimenters were present or the experimenter and a parent were present. All post-experimental sessions were scored in-vivo, but videotaped to be scored later by a secondary observer.

**Maintenance Probes.** The purpose of the maintenance probes was to assess durability of treatment effects. Maintenance probes were scheduled to be conducted one week after the treatment ended. However because of participant availability, fatigue, or illness, some maintenance probes were also conducted in the second and third weeks.
Three maintenance probes were conducted for each participant. Each probe was comprised of ten opportunities to request preferred items. The maintenance probes were conducted in the same manner as PECS Phase IIIB iPad™ multiple icons and tabbing condition. That is, five preferred items were presented simultaneously on a tray (out of reach) and their corresponding five icons were presented on the iPad in front of the participant. However, icons were out of sight under a different tab than was presented in front of the participant. Therefore, the participant had to “tab” through or select different “tabs” in order to produce the icons on the screen. No prompting or error correction was implemented during maintenance probes. Any attempts to grab items without manding for them were blocked by the experimenter. At least four correspondence checks were conducted per session, but if the participant reached for the wrong item, it was not blocked and the mand was scored as incorrect.

**Mand preference assessment.** The mand preference assessment was conducted in three sessions on three separate days. Each session contained 10 opportunities to mand for preferred items. The mand preference assessment was conducted to assess the participant’s relative preference between the iPad™ and low-tech PECS paper icons as a communicative device. This was used as a measure of social validity of each communicative device. Wolf (1978) suggests using direct observation measures of social validity in addition to consumer validity questionnaires.

The mand preference assessment was conducted under PECS Phase IIIB iPad™ conditions, with the exception that two communicative devices were available. These were the laminated paper PECS icons and the iPad™. Conditions of Phase IIIB with two icons were instated in order to control for response effort. That is, during the study
participants were not directly trained to select and exchange a paper icon among five icons and lift the binder tabs to find the icons. This was to avoid artificial inflation of preference for iPad due to other factors (i.e., response effort). Conducting the mand preference assessment under PECS Phase IIIB condition with only two icons in the array helped to better isolate preference of the participant because response effort was as comparable as possible across the two devices.

To further expand, during the mand preference assessment, the same procedures were used as the PECS Phase IIIB iPad™ condition, with the exception that both the PECS paper icons and iPad™ PECS phase III application were available concurrently for the participant to mand for an item. Both the paper icon binder and the iPad™ were presented simultaneously on a tray in front of the participant. This was to avoid evoking a response based upon which device was set on the table first. Two paper icons were attached via Velcro to the top of a binder, and two icons were available on top of a “binder page” on the iPad™ screen. No prompts or error correction procedures were used during this assessment. The participants were presented with 10 trials per session.

A trial began by the communicative partner presenting two preferred items out of the participant’s reach. If participants tried to grab an item prior to manding for it, the experimenter blocked the attempt. The participant had the opportunity to mand for an item using either the low-tech PECS paper icons or iPad™. The reinforcement schedule was a concurrent fixed ratio of one-to-one for each device (FR1/FR 1) (Falcomata, Ringdahl, Christensen, & Boelter, 2010). That is, a mand using either paper icons or the iPad™ produced the requested item every time.
Contingent upon a mand with either paper icons or the iPad™, participants were allowed a minimum of 20 seconds with an item contingent upon a request. While the participant manipulated the item, the experimenter switched the location of both the binder and the iPad™ so that each device would appear on the right or left an equal number of times during the session. In addition, icons of preferred items were also switched in position from left to right on both devices so that they would also appear an equal number of times on the left or right during the session. This served to isolate preference for the device from any possible location biases of the participants and to allow comparability of the assessments across participants.

**Interobserver Agreement (IOA)**

A secondary observer who was trained in behavioral observation gathered data on a minimum of 33% of all conditions by watching the participant’s performance live during the session or watching the video footage of the session. Sessions in which IOA were scored live were selected based upon availability of a secondary experimenter. Sessions that were scored via video footage were chosen by drawing enough session sheets from a binder without looking to complete 33% of the total sessions. For example, if a condition had nine sessions and none of the sessions were scored live, three session numbers from that condition were drawn from the binder. Once drawn, session papers were not replaced. If the video footage was not available for a particular session, the secondary observer independently chose another video file.

Interobserver agreement data were gathered on the experimental conditions (Baseline, PECS Phase IIIA iPad™, PECS Phase IIIB iPad™, PECS Phase IIIB iPad™ multiple icons and tabbing, Generalization probes, and Maintenance probes). A point-by-
point agreement method was conducted according to Cooper, Heron, and Heward (2007). The number of agreements were divided by the number of agreements plus disagreements and then multiplied by 100 to yield a percentage score (Tincani et al., 2006). Percentage scores from individual sessions were averaged to yield an overall IOA percentage score for each participant.

A point-by-point agreement method of IOA was chosen over a total agreement method because in total agreement, observers may record the same total but not actually agree on when the behavior actually occurred (Yoder & Symons, 2010). The point-by-point agreement method addressed this limitation and provided an index of whether the record of behavior truly represented the actual events. A high percentage of IOA using this method of calculation can help increase the believability of the data (Johnston & Pennypacker, 2009).

**Treatment Integrity**

A secondary observer who was trained in behavioral observation also gathered treatment integrity data on 33% of PECS Phase IIIA iPad™, PECS Phase IIIB iPad™ and PECS Phase IIIB iPad™ multiple icons and tabbing conditions by independently watching video footage.

Two separate checklists were used to evaluate implementation of the PECS Phase IIIA iPad™ condition, PECS Phase IIIB iPad™ condition, and PECS Phase IIIB iPad™ multiple icons and tabbing condition. See Appendix L for the treatment integrity checklist used to evaluate implementation of PECS Phase IIIA iPad™ training. See Appendix M for the treatment integrity checklist used to evaluate the PECS Phase IIIB iPad™ condition, and PECS Phase IIIB iPad™ multiple icons and tabbing condition.
These treatment integrity checklists were created specifically for this study and based upon the PECS implementation guidelines (Frost & Bondy, 2002).

For each trial, the checklist was used to evaluate each experimenter’s implementation of the PECS protocol. The sum of correctly performed steps were tallied and converted to a percentage score by dividing by the number of steps (13) and multiplying by 100. The percentages for each trial during a session were then averaged to yield a total percentage of implementation per session. An overall average was then calculated per participant by summing each participant’s percentages of implementation per session, and dividing by the total number of sessions.

Sessions in which treatment integrity was scored were chosen by placing all of the session numbers in binder. The secondary observer then drew 33% of the total number of data sheets in a condition (without looking). For example, if a treatment condition had nine sessions, the secondary observer drew three papers from the binder. Once drawn, session papers were not replaced.

**Social Validity**

Several procedures were used to assess social validity among participants, parents, and the participants’ preschool teachers. For participants, a mand preference assessment was conducted at the end of the study to evaluate the social validity of using the iPad™. Relative preference for the two communicative devices was evaluated by presenting the iPad™ and low-tech PECS paper icons in a concurrent choice format (Falcomata et al., 2010).

For parents, a brief questionnaire was used to assess the feasibility of potentially using the PECS iPad™ application in the home. They completed the questionnaire after
viewing either a video clip or a live performance of their child using both the low-tech paper icons and the iPad™. Viewing their child using both assistive devices helped parents understand what each intervention could entail if they were asked to speculate about their comfort level with using one or both PECS approaches at home. The parent questionnaire combined items from Ostryn & Wolfe, 2011; Park et al., 2007; Tincani, 2004). See Appendix N for the parent questionnaire.

**Phase Three: Data Analysis**

Upon completion of the experimental condition, the acquired data were organized and analyzed to answer the five research questions in this study. The first three research questions to be answered were (a) Does training with a PECS phase III iPad™ application increase the frequency of independent mands among young children with autism spectrum disorder? (b) Does training with a PECS phase III iPad™ application result in similar levels of independent mand performance among young children with autism spectrum disorder within an alternate setting? and finally (c) Will the effects of PECS phase III iPad™ application training maintain after the intervention is withdrawn?

To answer these three questions, experimental data were entered into Microsoft Excel and graphed as a simple line graph (Gast, 2010). For each participant, baseline data paths were compared to treatment data paths on characteristics of level change, trend, and variability (Gast, 2010). In addition, effect sizes were calculated for each participant and across all participants (Parker et al., 2009). This served to identify the percentage of change in data that can be attributed to treatment on both the individual and group level. Improvement Rate Difference was used to calculate effect size. As cited in Ganz et al., (2012) Improvement Rate Difference (IRD) is the mathematical difference between the
percentage of high scores between baseline and treatment (Buckley & Newchok 2005; Thompson et al. 1998). An improvement rate is the number of improved data points divided by the total number of data points in that phase (Parker et al., 2009).

Improved data points are identified through visual analysis of the data paths between baseline and treatment conditions. Data points that are not improved in baseline are data points that do not contain values that are equal to or higher than any treatment data points. In like fashion, data points that are not improved in treatment are those that are equal to or have lower values than a single baseline data point or more. (Parker et al., 2009).

As previously mentioned, Improvement Rate Difference was calculated by subtracting the percentage of improved baseline data points from the number of improved treatment data points. For example, if 72% of treatment data points are improved, and 13% of baseline data points are improved, then the improvement rate index was \(0.72 - 0.13 = 0.59\). A 95% confidence interval for the IRD value was calculated using free software called WINPEPI, retrieved from http://www.epi-perspectives.com/content/1/1/6 as suggested by Parker et al., (2009). See Abramson (2004) for a description of its functions. Specifically, WINPEPI calculated a Wilson score interval using Newcombe’s method with continuity correction. A 95% confidence interval was chosen as Parker et al., (2009) suggested that for research publication purposes, a 95% confidence interval was more appropriate than an 85% or 90% confidence interval (which was suggested for clinical decision-making).

Finally, for research question one, a summary table for each participant was created containing averages, standard deviations, and ranges for all baseline and PECS
iPad™ treatment conditions in the study. Tables were used to describe and compared participant performance in baseline and treatment conditions.

To answer research question three, ranges of data across all maintenance probes and percentage of overlapping data (POD) was also calculated. POD can be used as a measure of durability of treatment effects (Travis and Geiger, 2010). Percentage of overlapping data was calculated by identifying the number of data points in maintenance that equaled or surpassed the values of the last three data points of the previous treatment phase (Travis & Geiger, 2010). POD values were then examined within and across participants.

The final research questions four and five were inquiries of social validity for the proposed iPad™ intervention. These questions were (a) Will participants indicate a preference for mands using the iPad™ over mands using PECS paper icons? and (b) After viewing a brief video clip or live demonstration of their child using the PECS phase III iPad™ application, will parents perceive them as feasible to use with their children at home or in the community?

To answer the fourth research question, the frequency of mands made with each device during the mand preference assessment sessions were tallied and converted to a percentage score. That is, across all three sessions, the total number of mands made with each device were divided by the total number of trials (30 total). The percentages for each device (iPadTM or paper PECS) were then compared. The device associated with the higher percentage of mands was identified as the “preferred” mand topography. Data were analyzed by converting raw data into a bar graph and visually inspecting both bar graph and percentage data.
To answer research question five, data from parent questionnaires were evaluated by entering all answers into an excel spreadsheet. For items in which parents circled a word in a forced-choice format, frequency was used analyze the distribution of responses across all parents. Additionally, average scores, standard deviations, and ranges were calculated for all individual items in the questionnaire which had a Likert-type response format. There were also open-ended questions. For analyses of these responses, notable descriptive data are reported verbatim in the manuscript (e.g., “during this study my child learned not only how to communicate, but he/she also learned to seek out people to get help for things he/she wants”).
CHAPTER 4
RESULTS
The purpose of this study was to examine the effects of PECS phase III application training on independent mands in young children with autism. Measures of independent, discriminated mands, and social validity of the intervention as indicated by both observations of participants’ behavior and parent perceptions were recorded during the study. In total, five research questions were answered. Data collection method, data analysis, and results corresponding to each research question are described in this chapter. Finally, the chapter concludes with a summary of key findings.

Research Question 1
Does training with a PECS phase III iPad application increase the frequency of independent mands among young children with autism spectrum disorder?

Data were collected using direct observation and cumulative frequency per session. Data were then converted to a percentage score by dividing the number of correct mands per session by the number of opportunities to mand per session (i.e., 10). For each participant, mands were organized into line graphs. Using the line graphs, baseline data paths were visually compared to treatment data paths on characteristics of level change, trend, and variability (Gast, 2010). Trend was analyzed by drawing a line through the first and last data points for each condition of the study. Level change between baseline and the first treatment condition (PECS Phase IIIA iPad) was visually analyzed. Variability was analyzed by examining value ranges for each condition.

In addition, effect sizes were calculated for each participant and across all participants (Parker, Vannest, & Brown, 2009). Improvement Rate Difference was used to calculate effect size. As cited in Ganz et al., (2012) Improvement Rate Difference (IRD) is the
mathematical difference between the percentage of high scores between baseline and treatment (Buckley and Newchok 2005; Thompson et al. 1998). An improvement rate is the number of improved data points divided by the total number of data points in that phase (Parker Vannest, & Brown, 2009).

Improved data points were identified through visual analysis of the data paths between baseline and treatment conditions. Data points that were improved in baseline were data points that contained values that were equal to or higher than any treatment data points. A treatment data point was considered improved if its value was greater than any of the baseline data point values (Parker Vannest, & Brown, 2009). A 95% confidence interval for the IRD value was calculated using free software called WINPEPI, retrieved from http://www.epi-perspectives.com/content/1/1/6 as suggested by Parker et al., (2009). Specifically, WINPEPI calculated a Wilson score interval using Newcombe’s method without continuity correction.

It was predicted that when treatment was instated, the number of independent mands using the iPad™ would increase. The number of sessions (and total trials) a participant required to meet mastery criteria is also reported. The data of the pilot participant are discussed in Appendix O.

**Participant One.** The data for Participant One showed a large level change between baseline ($M = 4\%, SD = .05$) and the initiation of the PECS Phase IIIA iPad™ condition ($M = 80\%, SD = .22$). Baseline data showed a small upward trend and the PECS Phase IIIA iPad™ condition showed a very slight downward trend. Participant One met mastery criteria for the PECS Phase IIIA iPad™ condition in three sessions (30 trials). The PECS Phase IIIB iPad™ condition and the PECS phase IIIB iPad™ multiple
icon and tabbing condition both showed upward trends. Participant One met mastery criteria for The PECS Phase IIIB iPad™ condition in four sessions (40 trials) and the PECS phase IIIB iPad™ multiple icon and tabbing condition in nine sessions (90 trials). Data for Participant One exhibited the most variability in the PECS Phase IIIB iPad™ and PECS Phase IIIB iPad™ multiple icons and tabbing conditions (ranges were 50-100% and 60-100% respectively). See Table 2 below for a summary of means, standard deviations, and ranges for each condition.

Table 2  
*Performance Summary for Participant One*

<table>
<thead>
<tr>
<th></th>
<th>Baseline IIA</th>
<th>PECS Phase IIIA iPad™</th>
<th>PECS Phase IIIB iPad™</th>
<th>PECS Phase IIIB iPad™ Multiple Icons and Tabbing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4%</td>
<td>93%</td>
<td>80%</td>
<td>87%</td>
</tr>
<tr>
<td>(SD)</td>
<td>(.05)</td>
<td>(.06)</td>
<td>(.22)</td>
<td>(.14)</td>
</tr>
<tr>
<td>Range</td>
<td>0-10%</td>
<td>90-100%</td>
<td>50-100%</td>
<td>60-100%</td>
</tr>
</tbody>
</table>

*Note. (SD) = standard deviation.*

After visual inspection, Improvement Rate Difference (IRD) was calculated by visually identifying the number of improved data points between baseline and treatment conditions. Data were then entered into WINPEPI for analysis. None of the baseline data points were improved for Participant One. For her treatment conditions, 100% of the data points were improved. Results of the IRD calculation yielded an Improvement Rate Difference of 1.0, indicating a very large treatment effect (Parker et al., 2009). The confidence interval for her IRD was .41 to 1.00. See Table 7 for IRD calculations and confidence intervals for all participants, including Participant One. See Figure 1 for a visual depiction of the performance of Participant One across all conditions of the study.
Participant Two. Data are incomplete for Participant Two. The study ended (due to time constraints) before he was able to meet mastery criteria for any treatment condition. When the study ended, Participant Two was still in the PECS Phase IIIA iPad™ condition. Baseline data for Participant Two were stable and exhibited 0% correct for five consecutive sessions. There was no variability during baseline. Upon introduction of treatment, mands rose to 60% in the first session. This indicated a moderate and immediate level change between baseline and treatment. A trend line was drawn through the first and last data points during treatment and indicated a slight downward trend. When a trend line was drawn through the last ten data points of the condition, an upward trend was observed. Overall, independent mands throughout PECS Phase IIIA iPad™ condition were highly variable (range 0-90%) for Participant Two. At the end of the study, Participant Two had been exposed to a total of 57 sessions, or 570 trials. See Table
3 for means, standard deviations, and ranges for Participant Two mands during baseline and the PECS Phase IIIA iPad™ condition.

Table 3
Performance Summary for Participant Two

<table>
<thead>
<tr>
<th></th>
<th>Baseline IIIA</th>
<th>PECS Phase IIIA iPad™</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD)</td>
<td>0% (0)</td>
<td>40% (.22)</td>
</tr>
<tr>
<td>Range</td>
<td>0-0</td>
<td>0-90%</td>
</tr>
</tbody>
</table>

Note. (SD) = standard deviation

After visual inspection, Improvement Rate Difference (IRD) was calculated by visually identifying the number of improved data points between baseline and treatment conditions. Data were then entered into WINPEPI for analysis. For Participant Two, all baseline data points were improved because they equalled the value of a single baseline data point. For treatment, 98% of data points were improved. Results of the IRD calculation yielded an Improvement Rate Difference of .02, indicating no treatment effect (Parker et al., 2009). Due to visual analysis of 98% of all the treatment data points not overlapping baseline and consideration of the effects of the single data point in treatment that contained a value of zero, a post-hoc analysis was conducted with a second IRD calculated. During the second IRD calculation, the single data point in treatment was removed and single data point was removed from baseline (see Parker et al., 2009 for discussion of removal for small numbers of overlapping data points). The results of the second IRD calculation yielded an IRD of 1 with a 95% confidence interval of .48 to 1.00. See Table 7 for IRD calculations and confidence intervals for all participants,
including Participant Two. See Figure 2 for a visual depiction of the performance of Participant Two across all conditions of the study.

**Figure 2.** Independent Mands Across all Conditions for Participant Two.

**Participant Three.** The data of Participant Three showed a small, immediate level change between baseline and the first session of treatment and the PECS Phase IIIA iPad™ condition. Baseline data showed a small downward trend ($M = 1\%, SD = .04$) and the PECS Phase IIIA iPad™ condition showed a steep upward trend ($M = 60\%, SD = .40$). Participant Three met mastery criteria for the PECS Phase IIIA iPad™ condition in seven sessions or 70 trials. The PECS Phase IIIB iPad™ condition and the PECS phase IIIB iPad™ multiple icon and tabbing condition both showed upward trends for Participant Three. He mastered the PECS Phase IIIB iPad™ condition in three sessions or 30 trials, and met mastery criteria for the PECS Phase IIIB iPad™ multiple icons and
tabbing condition in 70 sessions or 700 trials. During the PECS Phase IIIB iPad™ multiple icons and tabbing condition, the mands of Participant Three were highly variable, ranging from 0-100%. Extensive prompting was required during this phase for him to look at the icon images while “right-side up”. See Table 4 for a summary of means, standard deviations, and ranges for each condition.

After visual inspection, Improvement Rate Difference (IRD) was calculated by visually identifying the number of improved data points between baseline and treatment conditions. Data were then entered into WINPEPI for analysis.

Table 4

<table>
<thead>
<tr>
<th>Performance Summary for Participant Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline IIA</td>
</tr>
<tr>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Range</td>
</tr>
</tbody>
</table>

Note. (SD) = standard deviation.

During baseline, all data points were improved because they equaled the value of a single data point in treatment or more. For treatment, 62.5% of data points were improved. Results of the IRD calculation yielded an Improvement Rate Difference of - .38, with a 95% confidence interval of -.49 to .08; indicating no treatment effect (Parker et al., 2009). See Table 7 for IRD calculations and confidence intervals for all participants, including Participant Three. See Figure 3 for a visual depiction of performance across all conditions of the study for Participant Three.
Participant Four. Participant Four’s data showed little to no level change between baseline ($M = 81\%, SD = .26$) and the initiation of the PECS Phase IIIA iPad™ condition ($M = 85\%, SD = .13$). Baseline data showed a steep upward trend. Although Participant Four met mastery criteria during baseline, baseline was continued for the minimum number of data points necessary for the multiple baseline design. The PECS Phase IIIA iPad™ condition also showed a steep upward trend, with a slight drop in percentage of mands during the first treatment session of the PECS Phase IIIA iPad™ condition.

Participant Four met mastery criteria for the PECS Phase IIIA iPad™ condition in four sessions (40 trials). Both baseline and PECS Phase IIIA iPad™ condition exhibits some variability of correct mands ranging from 50% and 60% to highs of
100%. The PECS Phase IIIB iPad™ condition showed clear stability with three consecutive sessions at 90%. The PECS phase IIIB iPad™ multiple icon and tabbing condition showed an upward trend with some variability (range 60% to 100%).

Participant Four met mastery criteria for The PECS Phase IIIB iPad™ condition in three sessions (30 trials) and the PECS phase IIIB iPad™ multiple icon and tabbing condition in seven sessions (70 trials). See Table 5 for a summary of means, standard deviations, and ranges for each condition.

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Performance Summary for Participant Four</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline IIIA</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>81% (.26)</td>
</tr>
<tr>
<td>Range</td>
<td>30-100%</td>
</tr>
</tbody>
</table>

*Note.* (SD) = standard deviation.

After visual inspection, Improvement Rate Difference (IRD) was calculated by visually identifying the number of improved data points between baseline and treatment conditions. Data were then entered into WINPEPI for analysis. For Participant Four’s baseline, 75% of data points were improved. During treatment, 0% of data points were improved. Results of the IRD calculation yielded an Improvement Rate Difference of -.75, with a 95% confidence interval of -.96 to -.27; indicating no treatment effect (Parker et al., 2009). See Table 7 for IRD calculations and confidence intervals for all participants, including Participant Four. See Figure 4 for a visual depiction of performance across all conditions of the study for Participant Four.
Participant Five. Data for Participant Five showed no immediate level change between baseline ($M = .01\%, SD = .03$) and the initiation of the PECS Phase IIIA iPad™ condition ($M = 24\%, SD = .22$). Baseline data indicated no trend. During the baseline condition, mands remained relatively steady at zero levels throughout the condition, with the exception of the second session (10%). The PECS Phase IIIA iPad™ condition showed an overall upward trend with initial zero percentages of independent mands for the first four sessions of treatment. A delayed treatment effect was observed after six sessions of treatment (marked as session 15 as depicted in Figure 5). Participant Five did not meet mastery criteria for the PECS Phase IIIA iPad™ condition by the time the study ended. During the study, treatment was instated for 33 sessions (330 trials). Considerable variability of correct mands was observed for the PECS Phase IIIA iPad™ condition,
ranging from 0% to 80%. See Table 6 below for a comparison of means, standard deviations, and ranges for each condition.

Table 6  
Independent Mands Across All Conditions for Participant Five

<table>
<thead>
<tr>
<th></th>
<th>Baseline IIIA</th>
<th>PECS Phase IIIA iPad™</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD)</td>
<td>.01% (.03)</td>
<td>24% (.22)</td>
</tr>
<tr>
<td>Range</td>
<td>0-10%</td>
<td>0-80%</td>
</tr>
</tbody>
</table>

*Note. (SD) = standard deviation.*

After visual inspection, Improvement Rate Difference (IRD) was calculated by visually identifying the number of improved data points between baseline and treatment conditions. After identification, improved data points were then entered into WINPEPI for analysis. For baseline, 100% of data points were improved. During treatment, 63.6% of data points were improved. Results of the IRD calculation yielded an Improvement Rate Difference of -.36, with a 95% confidence interval of -.55 to -.04; indicating no treatment effect (Parker et al., 2009). See Table 7 for IRD calculations and confidence intervals for all participants, including Participant Five. See Figure 5 for a visual depiction of performance across two conditions of the study for Participant Five.

**Research Question 1 Summary**

Three out of five participants (i.e., Participant 1, Participant 3, and Participant 4) met mastery criteria for all treatment conditions within the time constraints of the study. In other words, three out of five participants demonstrated independent mands in several successive steps of difficulty and with a high level of accuracy.
Participant Four showed high levels of correct mands during the baseline condition; therefore the effect of the treatment as a source of behavior change is questionable. In contrast, Participant One, Participant Two, Participant Three, and Participant Five demonstrated baseline performances that indicated they did not produce high levels of independent mands prior to initiation of treatment, providing better comparisons for treatment conditions. Participant Two and Participant Five ended the study while still receiving training in PECS Phase IIIA iPad™ condition. The treatment did not advance to producing independent mands during all targeted phases within the timeframe of this study, but these participants showed progress over time.

Only one IRD effect size (for Participant One) indicated a large treatment effect. When the second IRD calculation is considered for Participant Two, this increases the
number of participants to only two. Overall, participants exhibited a great deal of overlap between baseline and treatment data points, and this is reflected in the negative IRD values for Participant Three, Participant Four, and Participant Five. See Table 7 on the following page for IRD value comparisons and confidence intervals for all participants. Finally, Figure 6 displays the multiple baseline depiction of the five participants included in this design (see Appendix P).

**Research Question 2**

Does training with a PECS phase III iPad™ application result in similar levels of independent mand performance among young children with autism spectrum disorder within an alternate setting?

<table>
<thead>
<tr>
<th>Table 7</th>
<th><em>IRD Proportions and Confidence Intervals per Participant</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Participant One</td>
</tr>
<tr>
<td>Baseline IR</td>
<td>0%</td>
</tr>
<tr>
<td>Treatment IR</td>
<td>100%</td>
</tr>
<tr>
<td>IRD</td>
<td>1.00</td>
</tr>
<tr>
<td>95% CI</td>
<td>.41 to 1.00</td>
</tr>
</tbody>
</table>

Notes. Confidence intervals were calculated using Wilson Score (Newcombe’s Method) with continuity corrected. Participant Two has two IRD calculations: initial and Post-Hoc with single data point removal in his two conditions. IR = Improvement Rate; IRD = Improvement Rate difference; CI = confidence interval.
Data were collected using direct observation and cumulative frequency per session. Data were then converted to a percentage score by dividing the number of correct (a.k.a. independent) mands per session by the number of opportunities to mand per session (i.e., 10).

For each participant, mands were organized into line graphs (see Figures 1-5). Data were analyzed by visually inspecting individual values for each probe. Analysis was conducted within and across participants. A range across participants was also recorded. It was predicted that participants would exhibit mands in a novel setting after meeting mastery criteria for each phase.

Results of generalization will be discussed for all participants with the exception of Participant Two and Participant Five, who did not meet mastery criteria during the PECS Phase IIIA iPad™ condition. Results from the Pilot Participant are found in Appendix Q.

**Participant One.** Participant One exhibited consistent generalization of independent mands across all six probes in the study, with the exception of the first generalization probe session during the PECS Phase IIIB iPad™ condition (60%). Two generalization probes were conducted after the PECS Phase IIIA iPad™ condition, the PECS Phase IIIB iPad™ condition, and the PECS Phase IIIB iPad™ multiple icons and tabbing condition. Results indicated relatively high accuracy of mands exhibited in a novel setting. After the PECS Phase IIIA iPad™ condition, Participant One independently manded for preferred items during 100% of opportunities in both generalization probes. During generalization probes for the PECS Phase IIIB iPad™ condition, Participant One independently manded for items during 60% and 90% of
opportunities. Finally, both generalization probes for the PECS Phase IIIB iPad™ multiple icons and tabbing condition indicated that Participant One correctly manded for 80% and 90% of opportunities.

**Participant Three.** Participant Three also exhibited generalization of correct, independent mands across all probes. Two generalization probes were conducted after the PECS Phase IIIA iPad™ condition, the PECS Phase IIIB iPad™ condition, and the PECS Phase IIIB iPad™ multiple icons and tabbing condition. Results indicated that Participant Three was able to independently mand in a novel setting. Participant Three correctly manded for preferred items during 70% and 100% of opportunities during the PECS Phase IIIA iPad™ condition. He also independently manded for 70% of opportunities on generalization probes for the PECS Phase IIIB iPad™ condition. Finally, both generalization probes for the PECS Phase IIIB iPad™ multiple icons and tabbing condition had higher accuracy, showing independent mands for 90% and 80% of opportunities.

**Participant Four.** Participant Four’s generalization probes indicated that he was able to independently and correctly mand in a novel setting across the entire study. Two generalization probes were conducted after the PECS Phase IIIA iPad™ condition, the PECS Phase IIIB iPad™ condition, and the PECS Phase IIIB iPad™ multiple icons and tabbing condition. Results indicated that Participant Four independently manded for preferred items during 90% and 70% of opportunities during the PECS Phase IIIA iPad™ condition. Accuracy of mands during generalization probes for the PECS Phase IIIB iPad™ condition were 80% and 70%, respectively. Finally, generalization probes for both the PECS Phase IIIB iPad™ multiple icons and tabbing condition had the highest
accuracy, with Participant Four accurately manding during 100% of opportunities in each of the two probes.

**Research Question 2 Summary**

In conclusion, participants who completed the study showed a moderate to high accuracy of correct mands in a novel setting (60% to 100%). Although the PECS manual suggests training in multiple settings, this study conducted training in one setting and then tested generalization in a novel setting. The novel setting had never been paired with reinforcement for mands for the four participants, yet all four were able to independently mand at moderate to high levels of accuracy. None of the participants exhibited a lack of generalization to a novel setting and were able to perform with similar levels of accuracy to training conditions (with the exception of a single session for Participant One).

**Research Question 3**

Will the effects of PECS phase III iPad™ application training maintain after the intervention is withdrawn?

Data were collected using direct observation and cumulative frequency per session. Data were then converted to a percentage score by dividing the number of correct mands per session by the number of opportunities to mand per session (i.e., 10). For each participant who completed all PECS phases, three maintenance probes were conducted and correct mands were plotted onto a line graph (see Figures 1-5). Data were analyzed by visually inspecting individual values for each probe, calculating ranges and comparing maintenance scores to the participant’s range of scores in last treatment phase. In addition, Percentage of Overlapping Data (POD) was also calculated. As cited in Travis and Geiger, (2010) POD can be used as a measure of durability of the treatment’s
effects (Schlosser, 2003). Percentage of overlapping data is calculated by identifying the number of data points in maintenance that equal or surpass the values of the last three data points of the previous treatment phase (Travis & Geiger, 2010). Analysis was conducted within and across participants. It was predicted that participants would maintain similar levels of mands even after the intervention was withdrawn. Maintenance scores are not available for Participant Two and Participant Five because they did not complete all conditions of the study. Maintenance results for the Pilot Participant are found in Appendix Q.

**Participant One.** Participant One’s maintenance probes also ranged from 80% to 100% of correct mands per number of opportunities per session. Her maintenance sample showed a higher range of correct mands than her overall performance of the PECS Phase IIIB iPad™ multiple icons and tabbing condition (range 60% to 100%). Her Percentage of Overlapping Data was 66.7%, or two out of three data points.

**Participant Three.** Participant Three correctly manded for 100% of opportunities for all three maintenance probes (range 100% to 100%). This was a consistently higher percentage of correct mands compared to the PECS Phase IIIB iPad™ multiple icons and tabbing condition (range 0% to 100%). The percentage of overlapping data was 100%.

**Participant Four.** Participant Four also showed maintenance of treatment effect (range 70% to 100%). This sample appeared comparable to his performance in the PECS Phase IIIB iPad™ multiple icons and tabbing condition (range 60% to 100%). The percentage of overlapping data was 66.7%.
**Research Question 3 Summary**

Overall, all participants who completed all conditions of the study showed clinically acceptable maintenance levels of mands in the absence of treatment for 1-3 weeks after treatment ended. The range across Participant One, Participant Three, and Participant Four demonstrated maintenance scores from 70% to 100% of correct mands per session. This indicated that even after treatment was withdrawn for one to several weeks, the participants tabbed through the binder and correctly manded for preferred items among five icons in the absence of any prompting or error correction. In sum, results indicated good durability of treatment effects.

**Research Question 4**

Will participants indicate a preference for mands using the iPad™ over mands using PECS paper icons?

To answer research question four, frequency of mands made with each device were tallied and converted to a percentage score during the mand preference assessment sessions (i.e., across all three sessions, the total number of mands made with each device was divided by the total number of trials (i.e., 30 total)). The percentages for each device (iPad™ or paper PECS) were then compared. The device associated with the higher percentage of mands was identified as the “preferred” mand topography. The participants’ raw data were converted into a bar graph and visually inspected in addition to the percentage data comparisons. No prediction was made with regard to participant preference for one topography over another. See Appendix R for the results of the pilot participant’s mand preference assessment.
**Participant one.** Out of thirty trials, (across three separate sessions), Participant One used paper icons to mand for preferred item during 10% of opportunities. For the remaining 90% of opportunities, she manded for preferred items using the iPad™. Therefore, her preferred mand topography was deemed to be the iPad™. See Figure 7 to see the results of her bar graph in comparison to other participants.

**Participant two.** Out of thirty trials, (across three separate sessions), Participant Two used paper icons to mand for preferred item during 30% of opportunities. For the remaining 70% of opportunities, he manded for preferred items using the iPad™. Based on these data, his preferred mand topography was deemed to be the iPad™. See Figure 7 to see the results of his bar graph in comparison to other participants.

**Participant three.** Out of thirty trials, (across three separate sessions), Participant Three used paper icons to mand for preferred item during 0% of opportunities. For the remaining 100% of opportunities, he manded for preferred items using the iPad™. Therefore, his preferred mand topography was identified as the iPad™. See Figure 7 to see the results of his bar graph in comparison to other participants.

**Participant four.** Out of thirty trials, (across three separate sessions), Participant Four used paper icons to mand for preferred item during 7% of opportunities. For the remaining 93% of opportunities, he manded for preferred items using the iPad™. Based on these data, Participant Four’s preferred mand topography was the iPad™. See Figure 7 to see the results of his bar graph in comparison to other participants.

**Participant five.** Out of thirty trials, (across three separate sessions), Participant Five used paper icons to mand for preferred item during 0% of opportunities. He manded for preferred items using the iPad™ for 100% of all opportunities. Results indicated his
preferred mand topography to be the iPad™. See Figure 7 to see the results of his bar graph in comparison to other participants.

**Research Question 4 Summary**

Surprisingly, all participants in this study showed clear preferences for the iPad™ versus paper icons to use when manding for preferred items. Please see Figure 7 for a visual summary of all bar graphs for the six participants.

*Figure 7. Mand Preference Assessment Results for all Participants*
Research Question 5

After viewing a brief video clip or live demonstration of their child using the PECS phase III iPad™ application, will parents perceive the system as feasible to use with their children at home or in the community?

Data from parent questionnaires were evaluated by entering all answers into an excel spreadsheet. For items in which parents circled a word in a forced-choice format, frequency was used to analyze the distribution of responses across all parents. Additionally, average scores, standard deviations, and ranges were calculated for all individual items in the questionnaire which had a Likert-type response format. There were also open-ended questions. For analysis of these responses, notable descriptive data were reported verbatim in the manuscript (e.g., “during this study my child learned not only how to communicate, but he/she also learned to seek out people to get help for things he/she wants”).

Question 1: Would paper icons or the iPad™ be easier for you to use with your child in during your daily routine? Frequency analysis for parent responses to this question indicated a majority of parents felt that the iPad™ would be easier to use on a daily basis (see Table 8 on the following page).

Question 2: Generally, how did participation affect your child? One out of the five parents left this question blank. Of the remaining four parents, all of them reported positive effects (e.g., “Great, saw huge differences,” “It really helped ___’s communication,” “learnt to associate with picture icons,” and “improved pointing”).

Question 3: Did you see any positive difference at home? Among the five parents, four of them reported a difference at home. Two parents reported collateral
positive effects with pointing. One said, “I noticed her pointing improved”. The other parent also reported increased pointing and answered that her son was, “Requesting more, pointing, speaking.” Another parent reported that her child “now uses gestures/moves my hand to open certain items.” The last parent reported that her child was “communicating more.” Finally, one parent reported not seeing a difference at home.

Table 8
Distribution of Parent Responses to Question 1

<table>
<thead>
<tr>
<th>Response Option</th>
<th>Number of Parents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>0</td>
</tr>
<tr>
<td>iPad TM</td>
<td>4</td>
</tr>
<tr>
<td>Both</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
</tr>
</tbody>
</table>

**Question 4: When going out in the community, would you rather have your child use paper icons or iPad TM to tell you what he/she wants?** All five parents answered this question. Frequency analysis indicated all parents felt that they would like their child to use the iPad TM when out in the community.

**Question 5: If given training how comfortable are you with using the iPad TM application with your son/daughter?** All five parents answered this question in Likert-type format. A response of “1” indicated very uncomfortable, a “2” indicated somewhat uncomfortable, a “3” was neutral, a “4” indicated comfortable, and a “5” indicated a parent was very comfortable. Across all parents, responses indicated that they comfortable with using the iPad TM application if given proper training ($M = 4.4, SD = .89$). Responses ranged from neutral (3) to very comfortable (5).
**Question 6: My child learned picture exchange by participating in this study.**

Of the five parents, 4 of them either wrote “yes” or “agree” to the statement that their child had learned PECS by participating in the study. One parent wrote that her son learned it “a little” because he was not using PECS at home.

**Question 7: My child made meaningful progress through participation in this study.** One parent left this question blank. Responses were of a Likert-type format with “1” indicating strongly disagree, and “5” representing strongly agree. A score of “3” indicated neutral. Results indicated that on average, parents felt their child made meaningful progress as a result of their participation in the study ($M = 4.40, SD = .89$). The range of responses was from “neutral” to “strongly agree”.

**Question 8: I feel that the iPad™ and the application are (circle one) expensive - reasonably priced - inexpensive.** All five parents answered this question and generally felt that the price of an ipad™ would be affordable (see Table 9).

<table>
<thead>
<tr>
<th>Response Option</th>
<th>Number of Parents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expensive</td>
<td>0</td>
</tr>
<tr>
<td>Reasonably Priced</td>
<td>3</td>
</tr>
<tr>
<td>Inexpensive</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
</tr>
</tbody>
</table>

**Question 9: I would like my child to continue using the PECS paper icon intervention after this study.** All five parents answered this question. Across all parents, the average score was neutral ($M = 3.00, SD = 1.22$). However, there were a variety of parent responses to this question (range 1-4). Because of the wide range of response scores, frequency analysis was then used to further analyze the distribution of responses.
One parent indicated “strongly disagree” and two parents indicated a neutral response. The remaining two parents agreed that they would like their child to continue with paper icons.

**Question 10: I would like my child to continue using the PECS iPad™ application intervention after this study.** All five parents answered this question and responses were in a Likert-type format. Across all parents, responses favored continuation of the PECS iPad™ application intervention ($M = 4.40, SD = .55$). The range of scores was 4-5: indicating that all of the parents either agreed or strongly agreed that they wished to continue the intervention with the PECS iPad™ application.

**Question 11: I am likely to tell other parents to try using PECS with their kids.** All five parents answered this question and responses were in a Likert-type format. Results indicated that parents were very likely to tell other parents to try using PECS ($M = 4.80, SD = .45$). The range of responses was from agree (4) to strongly agree (5). A majority of parents (four out of five) indicated strongly agree.

**Question 12: After watching the video footage, I feel that the (circle one) iPad paper icons appeared to be a more natural interaction.** All five parents answered this question and responses were analyzed using a frequency table. Results indicated that a majority of parents felt that the iPad™ was a more natural way to communicate (see Table 10). One parent did not circle an option and wrote that “both were effective”.

<table>
<thead>
<tr>
<th>Table 10</th>
<th>Distribution of Parent Responses to Question 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response Option</td>
<td>Number of Parents</td>
</tr>
<tr>
<td>iPad™</td>
<td>3</td>
</tr>
<tr>
<td>Paper Icons</td>
<td>1</td>
</tr>
<tr>
<td>Both</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5</strong></td>
</tr>
</tbody>
</table>
**Research Question 5 Summary**

Overall, parents’ responses indicated that the iPad™ would be feasible for them to use with their child in either the home or community setting. All parents reported that the iPad™ and the PECS Phase III application were either reasonably priced or inexpensive. A majority of parents (four out of five) felt that the iPad™ would be easier to use in their daily routine. On average, parents were confident that with training they would be able to use the iPad™ to support their child’s communication. Parents indicated a much higher preference for continuing the PECS phase III iPad™ application ($M = 4.40$, $SD = .55$) compared to PECS paper icons ($M = 3.00$, $SD = 1.22$). Finally, a majority of parents (three out of five) felt that using an iPad™ was more natural than using paper icons. Taken together, information from this sample indicates that parents may feel comfortable with supporting their child’s communication with an iPad™ and may also feel more comfortable using it while out in the community.

**Interobserver Agreement**

Interobserver agreement on correct mands was gathered for a minimum of 20% of sessions. Camera difficulties, additional availability with in-vivo scoring, and differences in the number of conditions completed within the timeframe of this study resulted in inconsistencies in the percentages of sessions observed and the conditions observed. Specifically, 44% of baseline, treatment, generalization, and maintenance probes were gathered for Participant One. For Participant Two who did not complete all conditions, interobserver agreement on correct mands was gathered for 33% of baseline and treatment sessions. For Participant Three interobserver agreement on correct mands was gathered for 33% of baseline, treatment, generalization, and maintenance probes.
Interobserver agreement on correct mands for Participant Four was gathered for 100% of Phase IIIB iPad treatment probes, 29% of Phase IIIB multiple icons and tabbing treatment probes, 50% of generalization, and 33% of maintenance probes. Finally, IOA data for Participant Five are representative of 33% of the PECS Phase IIIA iPad™ treatment probes. Interobserver agreement for either iPad™ or paper icon selection was gathered on 33% of mand preference assessment sessions for all participants.

Results of Interobserver agreement yielded 92% agreement between observers (range 83% to 95%). Interobserver agreement results for each participant are shown in Table 11. Results for the Pilot Participant are found in Appendix S.

Treatment Integrity

Treatment integrity data were gathered for 33% of sessions for Participant One, Participant Two, Participant Three, and Participant Five. Due to lack of available video footage for Participant Four, no treatment integrity data are available for him. Results indicated that treatment was implemented with fidelity an average of 90% of opportunities. Treatment integrity for individual participants is shown in Table 11 on the following page. Results for the Pilot Participant are found in Appendix S.

Summary of Findings

Given the high percentage of correct mands for Participant Four during baseline, a functional relationship cannot be established. However, baselines for Participant One, Participant Two, Participant Three, and Participant Five all remained at low, stable levels and did not show a level change in number of independent mands until the initiation of treatment. Based upon the logic of the multiple baseline design, each of the participants’ graphs in this study showed behavior change only after treatment began.
Therefore, there was evidence of several replications of a functional relationship across these 3-4 participants. A range of 3-4 participants is mentioned because the performance of Participant One will be specifically discussed in more detail during Chapter 5.

Table 11

<table>
<thead>
<tr>
<th>Participant</th>
<th>Experimental IOA</th>
<th>Mand Preference Assessment IOA</th>
<th>Treatment Integrity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant One</td>
<td>95%</td>
<td>100%</td>
<td>99%</td>
</tr>
<tr>
<td>Participant Two</td>
<td>85%</td>
<td>100%</td>
<td>86%</td>
</tr>
<tr>
<td>Participant Three</td>
<td>98%</td>
<td>100%</td>
<td>81%</td>
</tr>
<tr>
<td>Participant Four</td>
<td>95%</td>
<td>100%</td>
<td>Not available</td>
</tr>
<tr>
<td>Participant Five</td>
<td>90%</td>
<td>100%</td>
<td>93%</td>
</tr>
</tbody>
</table>

*Note. IOA = Interobserver Agreement*

However, Improvement Rate Difference (IRD) calculations did not indicate favorable treatment effects for three of the five participants. The IRD value for Participant One and the second IRD calculation for Participant Two showed a strong effect (1.00). All other participants’ calculations yielded a negative value, which is counterintuitive when compared to the overall progress of participants. This point will be discussed further in Chapter 5.

Across the three participants who completed all the conditions in the study, generalization of mands were observed in a novel setting at moderate to high levels of accuracy (range 60% to 100%). Generalization was not programmed to occur as a direct product of the treatment. That is, participants completed PECS training in the same room each day and received no opportunities to mand in novel settings other than during the generalization probes. Maintenance of mands was also relatively high among
participants who completed the study. All participants showed clinically acceptable ranges of maintenance (range 70-100%).

Results of the mand preference assessment indicated that all participants showed a preference for the iPad™. Participant Three and Participant Five used the iPad™ exclusively on all 30 trials; while Participant One, Participant Two and Participant Four infrequently used the paper icons (range of use was from 7% to 30% for these participants). Participant Two used paper icons on 30% of trials, the most of all the participants. Because all the participants showed clear preference for the iPad™, it can be concluded that for this sample of young children with autism, the iPad™ was a socially acceptable mand topography.

Finally, parent questionnaire responses also confirmed the social validity of potential use of the iPad™ by parents in either home or the community. All parents felt that the iPad™ was affordable and preferred to use it when going out in the community. Parents also reported feeling confident that they could use the iPad™ with their child (if provided training). A clear preference among parents showed preference for continuation for the iPad™ over paper icons as part of the future implementation of the PECS intervention. This mirrored the preference of participants in the mand preference assessment.
CHAPTER 5
DISCUSSION

Children with autism often exhibit communication deficits (Baker & Cantwell, 1982). Because they lack communication skills, they also have increased risks for challenging behavior such as tantrums and aggression (Dominick et al., 2007). Functional communication training has been helpful in improving the ability to communicate needs and desires and reducing a variety of problem behaviors (e.g., Davis et al., 2009; Dolezal & Kurz, 2010; Falcomata, et al., 2010; Franco et al., 2009; Hagopian, et al., 2005; Horner & Day, 1991; Olive, Lang, & Davis, 2008; Padilla Dalmau et al., 2011; Wacker et al., 1998; Wu, Mirenda, Wang, & Chen, 2011). The Picture Exchange Communication System (PECS) can be considered a type of functional communication training in some circumstances. Initial PECS training involves the exchange of a picture in order to request a preferred item. For some young children in early childhood settings, this can be an important first step toward using appropriate communication skills instead of using challenging behavior to request or reject (Chiang, 2008). The use of PECS may also lead to learning new behaviors that were not directly taught (Jurgens, Anderson, & Moore, 2009).

Previous researchers who evaluated PECS training up to Phase III (Ali et al., 2011; Angermeier et al., 2008; Barnes et al., 2011; Carré et al., 2009; Chambers & Rehfeldt, 2003; Dogoe et al., 2010; Frea et al., 2001; Kravitz et al., 2002; Lund & Troha, 2008; Park et al., 2011; Rehfeldt & Root, 2005; Rosales & Rehfelt 2007; Tincani 2004, Ziomek & Rehfelt, 2008) have evaluated PECS in its low-tech modality—namely the exchange of a tangible icon made of laminated paper. These studies coupled with others
which have evaluated later phases of PECS have provided enough support for PECS to be considered an evidence-based practice by the National Professional Development Center for Autism Spectrum Disorders (2010). The purpose of the current study was to extend previous literature on PECS to include an evaluation of the efficacy of PECS training using the PECS Phase III iPad™ application on independent mands in young children with autism.

There are several purposes for this chapter. The first purpose is to discuss findings and conclusions that correspond to each research question in the study. The second purpose is to discuss methodological limitations. Finally, the third purpose of this chapter is to consider the implications for practitioners, parents, and future research.

**Research Discussion**

The purpose of this study was to examine the effects of a PECS phase III application training on independent mands in young children with autism. Results of the study are reviewed with each research question and in context with previous PECS studies.

**Research Question 1**

Does training with a PECS phase III iPad™ application increase the frequency of independent mands among young children with autism spectrum disorder?

Three out of five completed the study by demonstrating independent mands with a high level of accuracy in several successive steps of difficulty. Previous researchers who specifically targeted PECS Phases I-III have reported successful acquisition by at least some or all of their participants (Ali et al., 2011; Angermeier et al., 2008; Barnes et al., 2011; Carré et al., 2009; Chambers & Rehfeldt, 2003; Dogoe et al., 2010; Frea et al.,
2001; Kravitz et al., 2002; Lund & Troha, 2008; Park et al., 2011; Rehfeldt & Root, 2005; Rosales & Rehfelt 2007; Tincani 2004, Ziomek & Rehfelt, 2008). Thus, the findings of this study concur with those of previous researchers in spite of using iPad technology instead of paper icons.

It was predicted that when treatment was instated, the number of independent mands using the iPad™ would increase compared to the baseline condition. Of the five participants, one (i.e., Participant Four) met mastery criteria during baseline conditions and three exhibited immediate increases in independent mands upon the introduction of treatment (Participants One, Two, Three).

Participant Four met mastery criteria during baseline condition and thus, a functional relationship cannot be determined from his data. Data from participants 1, 2, and 3 showed evidence for a functional relationship, with one possible exception pertaining to treatment required for Participant One. Participant One’s exception will be discussed first.

Although the baseline data of Participant One showed an immediate increase upon introduction of the treatment phase, for all three sessions in the PECS Phase IIIA iPad™ condition, she independently initiated a selecting response to mand for the item—with the exception of one full physical prompt during a single trial. Because of the lack of prompting or error correction (especially in the first session of the PECS Phase IIIA iPad™ condition in which she manded accurately and independently for 100% of opportunities) a functional relationship cannot be determined for her data. Specifically, a functional relationship cannot be determined from a comparison between accuracy of mands in baseline and in the PECS Phase IIIA iPad™ condition.
However, in later conditions of the study Participant One did require prompting and error correction. Based on this knowledge, comparing her baseline data to data in the other two conditions (in which difficulty of requesting increased) may be appropriate to consider evidence for a functional relationship. If the PECS Phase IIIA iPad™ condition data were removed from the IRD analysis, her IRD value would equal 1.00. It is likely that if a second baseline were conducted, she would have demonstrated low or chance levels of independent mands in the PECS Phase IIIB iPad™ condition (as evidenced by her first session of 50% during this condition.)

A plausible explanation for this result was that because preferred items were delivered contingent upon correct independent mands during baseline, Participant One contacted reinforcement for manding with the iPad™. Although her contact with reinforcement was brief (only on two trials across the last two sessions) it is possible that delivery of the preferred item contingent upon a correct mand served as a powerful reinforcer and as a result; the future probability of mands increased dramatically. Future researchers may wish to conduct separate baseline conditions before each level of difficulty or before each Phase of PECS is introduced in order to prevent difficulties in analysis resulting from findings similar to Participant One. This would be achieved by a multiple baseline across training phases similar to procedures by Cummings, Carr and LeBlanc (2012). Another design suggestion could also consist of using an AB probe design in which the most difficult PECS skill is probed first during condition “A” (PECS phase IIIB iPad™ multiple icons and tabbing) and during condition “B” after training is completed. This may have provided a clearer or less “muddled” demonstration of treatment effects in a different format, somewhat analogous to a “pre-post” scenario. For
example, this would have provided more clear results for Participant Three because his training required extensive prompting, yet he still met mastery criteria and learned all the skills targeted in the study. An AB design which probed the most difficult skill before and after his training would have yielded very clear results.

As previously mentioned, IRD values for Participant Two, Participant Three, Participant Four, and Participant Five were negative values (with the exception of the second post-hoc analysis for Participant Two). However, the level change for each of these participants was immediate upon the first introduction of treatment for all participants except for Participant Five, who exhibited a delayed treatment effect. To further evaluate the level change for Participant Five, an absolute level change calculation was conducted according to Gast (2010). Absolute Level Change for Baseline was 0% and Absolute Level Change for the treatment condition was an improvement of 40% in accuracy. This provides some evidence for a functional relationship in regards to Participant Five’s data.

An explanation of the negative IRD values lends itself to examination of the frequent overlap of the data between baseline and treatment. An explanation of overlap for Participant Four is not required, as he clearly demonstrated mastery of mands during baseline conditions. Participant Three and Participant Five required extensive prompting during treatment, which is why many sessions were at 0% correct mands. Prompting was also required for Participant Two because he did not initiate frequently to mand for preferred toys. Participant Two was observed to frequently engage in both motor and vocal stereotypy. It is hypothesized that his stereotypy competed with manipulating toys or engaging with the experimenter with the toys (e.g., blowing bubbles).
Participant Three also exhibited many sessions at 0% correct because he required extensive physical prompting to realign his visual perception of the icons to right-side up. Finally, Participant Five also required extensive prompting as he frequently attempted to touch the bottom of the iPad™ screen instead of the icons.

As previously noted, Participant Two and Participant Five did not complete the study within the time frame. Previous studies on PECS have encountered similar results. For example, Angermeier et al., (2008) had three out of four participants who did not meet mastery for Phase III by the end of their study’s time frame and Beck et al., (2008) had only two out of four participants meet mastery criterion for Phase III. This can be attributed to individual learning pace of the participants which has also been found in other PECS studies (e.g., Dogoe et al., 2010). However, it is predicted that with more training time, both participants would have acquired all Phases of this study. Participant Two ended the study with an upward trend across his last three sessions and Participant Five showed an overall upward trend across all treatment sessions.

It is possible that slow results for both Participant Two and Participant Five may have been due to availability of competing responses: specifically in the form of motor or vocal stereotypy. Both Participant Two and Participant Five allocated a considerable amount of time during sessions toward either motor or vocal stereotypy. Participant Two was also observed by the primary experimenter and reported by his mother to have low interest in toys. Yoder and Stone (2006) found that participants who exhibited lower levels of object exploration tended to have less successful outcomes with non-imitative speech when provided PECS training.
It is possible that outcomes may have been improved if the toys were not kept constant throughout the study. Satiation with the toys may have occurred due to the consistency of the six toys across training phases in the study. This may have affected allocation of responding from toys (initially observed to be preferred and effective at evoking independent mands during PECS pre-training phases) to stereotypy. However, it is also hypothesized that if Participant Two had prior training to play with objects, PECS training would have been more effective. Fifteen new toys were presented to probe for preference after initiations were observed to be lacking. All toys were rejected in the form of throwing them across the room. As a result, it was determined that the participant did not have sufficient interest in toys and later in the PECS Phase III iPad™ condition; preferred items were changed to edible items. If greater flexibility were available in the study to continually change items on a moment-to-moment basis, it is possible that PECS training may have been more successful for these participants.

To further examine the results of the participants who were successful with the training, an interesting relationship was noted. Common information described by the parents of Participant One and Participant Four was that prior to the study, these participants could independently operate their parent’s smart phone or tablet device. For example, these participants were able to turn on the device, navigate through the main menu, watch and select videos, or play with preschool-age applications.

It is possible that the initial high levels of correct mands for Participant One during the first session of treatment without any error correction and high levels of correct mands for Participant Four during the third baseline session may have been the result of exposure to the contingency during baseline. That is, after a few trials with
receiving the distractor item instead of the preferred item for incorrectly selecting the
distractor icon may have been sufficient to produce discriminated responding among the
two icons. Participant One only contacted reinforcement during one trial during the last
two sessions of baseline, but this may have been sufficient to produce the high levels of
mands during the first session of treatment.

There are other factors that have also contributed to the quick increases in
accuracy of mands during baseline for Participant Four. These factors may be one or a
combination of any of the following: (a) prior history of reinforcement for general picture
discrimination; (b) prior history of reinforcement for discriminated selecting responses on
a portable electronic device; (c) prior history of reinforcement for mands during PECS
pre-training and/or (d) stimulus generalization between paper and electronic icons. Figure
8 illustrates how these factors may have interacted to produce high levels of mands
without extensive training for Participant four.

Figure 8. Possible Roles of PECS Pre-training, Icon Similarities, and Prior History of
Reinforcement Affecting Rapid Acquisition of Mands with the iPad™.
To further expand, the ability of Participant One and Participant Four to navigate device menus indicated that these participants already had a prior history of reinforcement for icon discrimination under control of a similar function (e.g., access to games or videos on the device).

Moreover, PECS pre-training (i.e., the participant receiving the item after exchanging a picture of the item) may have contributed to the emergence of the mand using the iPad™. It is possible that because the electronic icons on the iPad™ were the same picture as those delivered in paper form, that there was sufficient stimulus similarity to evoke stimulus generalization between paper and electronic icons, to the degree that both stimuli became functionally equivalent (i.e., both functioned as a mand). Therefore, the function of pressing electronic icons became equivalent to the function of exchanging paper icons that was directly taught in PECS Phase II of pre-training. See Figure 9 for an illustration of this idea.

Stimulus generalization was also observed in several observations across several participants during the mand preference assessment. For example, Participant One, Participant Two, Participant Three, and Participant Five all pressed on the paper icons during the mand preference assessment in the same manner as when using the iPad™ to mand.

Finally, two other events that occurred with Participant Four during his mand preference assessment and one of his treatment sessions should be noted. During the mand preference assessment, Participant Four removed both paper icons from the Velcro binder and placed them directly on top of both electronic icons on the iPad™ several times. Participant Four also began attempting to “tact” pictures during one of the
sessions. Namely, he looked at the examiner, pointed to a picture, and then attempted to say the name of the picture. For example, he pointed to the “Figurines” icon on the iPad™ and said, “Fa-Fa-Fa” while looking at the experimenter.

![Diagram](image)

*Figure 9. Possible Roles of Stimulus Generalization and Other Variables for Emergence of Picture Selection on the iPad™ as Part of the Same Response Class as a Paper Icon Exchange. Taught relations are indicated by solid lines, untaught by dotted lines.*

Through these observations, Participant Four demonstrated matching paper icons to electronic icons and also demonstrated “matching” the spoken vocal approximation “fa fa fa” to the electronic figurine icon without direct training. Matching of the paper icons to the electronic icons may have been due to the similarity between the electronic and paper icons. This alone may have been sufficient for each stimulus to become part of the same stimulus class. The mother of Participant Four reported that he was “very good at matching” and therefore had a history of putting or placing similar images together. “Matching” images was likely part of his regular direct programming at school.
In regards to the emergence of the vocal approximation of “figurines” or “fa fa fa,” it is possible that through temporal pairing of the two stimuli during training (seeing the electronic icon and hearing the spoken name of item) the electronic icon and spoken name of the icon became equivalent members of the same stimulus class. See Figure 10 for an illustration.

![Figure 10. Possible Roles of Temporal Pairing of the Sight of Electronic Icon and Spoken Name of Item to Produce Equivalent Members of the Same Stimulus Class. Taught relations are indicated by solid lines, untaught by dotted red lines.](image)

Stimulus equivalence relations may have emerged between the paper and electronic icon, or the electronic icon and spoken name of the item, or possibly among all the stimuli used in PECS training (e.g., paper icon, electronic icon, item, and item name). However, in this study there were no direct tests for generation of equivalence relations as a byproduct of PECS training; and therefore no firm conclusions may be drawn as to the mechanisms behind these observations (Sidman & Tailby, 1982). Other researchers have evaluated stimulus equivalence relations after participants underwent both
conditional discrimination training and PECS training (Rehfeldt & Root, 2005; Rosales & Rehfeldt, 2007). Future researchers may wish to evaluate conditional discrimination training coupled with PECS phase III application training, and then test for equivalence relations among the paper icon, electronic icon, and spoken name of the item.

**Research Question 2**

Does training with a PECS phase III iPad™ application result in similar levels of independent mand performance among young children with autism spectrum disorder within an alternate setting?

All participants who completed all conditions of the study (i.e., Participant One, Participant Three, and Participant Five) showed moderate to high percentages of correct mands within an alternate setting during all generalization probes. Percentages of mands ranged from 60% to 100% correct across all generalization probes. These results indicated that although not directly programmed, mands were observed to occur in a new setting in which the participant had no prior history of reinforcement for mands using the iPad™. These results are consistent with previous researchers who specifically targeted PECS phases I-III and observed similar high levels of mand generalization using paper PECS in a new setting without direct training (Ali et al., 2011; Chambers & Rehfeldt, 2003; Dogoe et al., 2010; Ziomek & Rehfelt, 2008).

This researcher’s assessment of successful generalization of PECS mands to a novel setting expands previous studies on PECS, as one previous PECS literature review indicated that only 54% of studies had some type of generalization measure (Hart & Banda, 2010). This study is also the first study designed to assess the effects of
generalization for mands using the PECS Phase III application using the PECS protocol (Frost & Bondy, 2002).

The most likely explanation for the successful generalization in novel settings was that common stimuli from PECS training were still present. For example, the same experimenters, the same toys, and the same icons were all present in the new setting. It is likely that during training, mands came under control of item deprivation, the presence of the experimenters, the presence of the icons on the iPad™ screen, or any combination of these stimuli.

Participant One and Participant Four displayed the lowest generalization percentages score of 60% and 70% respectively. This percentage was due to manding for a toy and then subsequently not playing with it. On certain days Participant One and Participant Four exhibited satiation with the toys because throughout the study the six toys remained constant for all participants except Participant Two (edibles were introduced during later sessions of the PECS Phase IIIA iPad™ condition for him).

Results from generalization probes indicate that time and resources may be saved by conducting short probes to assess generalization instead of providing supplemental intensive training sessions in novel settings. Frost and Bondy (2002) state that it is important to train in a variety of settings--and clinicians are still encouraged to do so to the greatest extent possible. However, this study provides evidence that if time or resources are limited, and intensive PECS training is only available in a limited number of settings, then generalization of mands using the iPad™ may be observed for certain participants without more intensive training. It may be helpful to conduct generalization
probes as each step in PECS is acquired and additional programming decisions may be made based upon performance of the participant.

A final aspect to consider was that during this study, the communicative partner and the preferred items were kept constant during generalization probes. This may have contributed to the successful transfer of the mand. More extensive training may be required to achieve generalization of mands to new communicative partners and to new preferred items.

**Research Question 3**

Will the effects of PECS phase III iPad™ application training maintain after the intervention is withdrawn?

For all three participants who completed the study (i.e., Participant One, Participant Three, Participant Four), the effects of training with the PECS phase III iPad™ application were tested and found to maintain at high levels of accuracy between 1 and 3 weeks after treatment had ended. Some previous studies on PECS training which specifically targeted acquisition of PECS Phases I-III also observed high levels of accuracy (80% accuracy per session or above) for all of their participants during maintenance probes (Ali et al., 2011; Chambers & Rehfeldt, 2003; Park et al., 2011).

These results indicate that training with the PECS Phase III iPad™ application were durable for at least a brief period of time. However, it is interesting to note that the parents of Participant One contacted the experimenter a few months after the study and stated that they were still using the iPad™ at home with their child as a communicative device. Future researchers may want to evaluate the durability of treatment effects for this type of training after a longer period of time (e.g., 3 to 6 months).
Research Question 4

Will participants indicate a preference for mands using the iPad™ over mands using PECS paper icons?

For all five participants, a clear preference for manding with the iPad™ was observed during the mand preference assessment. This indicates that there is a greater possibility that for these participants, the use of the iPad™ would be more likely to sustain the participants’ interest over time compared to paper PECS. Explanations for preference may include fine motor abilities or prior history with portable devices, and will be discussed in context of specific participants.

Beginning with fine motor abilities, Participant Three and Participant Five had considerably less fine motor control compared to the rest of the participants. It is possible that their lack of fine motor skills contributed to their preference for the iPad™. Both Participant Three and Participant Five received modifications to icons during PECS pre-training. Specifically, their icons were mounted on foam board because they were unable to grip and pull the icon from the Velcro on the binder. This modification was eventually faded successfully, but still a notable occurrence for these two participants. During his mand preference assessment, Participant Three was frequently observed to attempt to take the icons off the binder, but then used the iPad™ after a brief period of attempting to remove the icon. Had Participant Three been more advanced with his fine motor skills, the results of his mand preference assessment may have indicated a preference for paper icons.

Finally, it is also possible that the results of the mand preference assessment for the participants were the result of prior history of reinforcement for using portable
electronic devices. Since all of the participants had parents who had “smart” phones or other portable electronic devices, participants may have already had a history of pairing the mobile technology with enjoyable activities. It would have been useful to compare the mand preference results of participants who were naïve to the recreational uses of portable electronic devices to further isolate factors associated with preference for mands made with the iPad™.

**Research Question 5**

After viewing a brief video clip or live demonstration of their child using the PECS phase III iPad™ application, will parents perceive the system as feasible to use with their children at home or in the community?

Overall, four out of five parents in the study felt that the iPad™ would be easier to use in their daily routine. Parents were also confident that they would be able to use the iPad™ to support their child’s communication (if given training). At the end of this study, four out of five parents received between 1 and 1.5 hours of informal training by the primary experimenter to show them how to use the application, and how to support their child’s use of the application according to PECS protocol (Frost & Bondy, 2002). As previously mentioned, a few months after the study ended two parents independently contacted the primary experimenter and stated that they continued to use the iPad™ and PECS Phase III application with their child. Future researchers may also wish to examine formal training with parents to support their child’s use of PECS with the PECS Phase III iPad™ application.

In addition, parents indicated a much higher preference for continuing the PECS phase III iPad™ application compared to PECS paper icons. A majority of parents (three
out of five also felt that using an iPad™ was more natural than using paper icons. Logically, many children (or adults) are commonly seen in public using or playing with portable devices every day. It may be helpful to further compare parent perceptions of those who prefer paper icons versus a portable electronic device, and the variables responsible for their different preferences.

When accounting for the results across the mand preference assessment and overall results of the parent questionnaire, the PECS Phase III application training on the iPad™ appeared to be a socially acceptable means of requesting preferred items among both child and parent participants. Although these results cannot be generalized to all young children with autism and their parents, it provides some validation for researchers to continue exploring the use of the PECS Phase III application and other means of AAC via publicly available portable electronic devices. Hocking (1991) stated that three of several reasons for abandoning an assistive device were (a) the device was challenging to use or was not reliable, (b) the person did not receive enough training, and (d) the appearance or size of the assistive technology was problematic. To avoid abandonment of devices due to lack of fit with device expectations or training, this researcher suggests including family and the person who will use the technology during the selection of an augmentative/alternative communication device. The individual preferences of children, adults, and their caregivers are important in terms of sustainability of use.

**Conclusions**

Based on results obtained in this study, the following conclusions may be drawn.
1. PECS training using the PECS Phase III application was beneficial for all the participants—even when participants did not complete all phases of the study within the time frame. Participants who did not complete the study showed improvement in accuracy of mands across the course of the study.

2. A functional relationship could not be determined for Participant Four.

3. Data from Participants One, Two, Three, and Five suggest a functional relationship through various methods of analysis.

4. All participants who finished all phases of the study (Participant One, Participant Three, and Participant Four) showed moderate to high levels of accuracy (60% to 100%) during generalization probes in a new setting without direct training.

5. All participants who finished all phases of the study (Participant One, Participant Three, and Participant Four) showed clinically acceptable levels of maintenance (70% to 100%) when tested 1-3 weeks after treatment was withdrawn.

6. All five participants indicated a clear preference for using the iPad™ to mand for preferred items.

7. Parents indicated high levels of satisfaction related to feasibility, cost, and ease of use of the iPad™ with their children in home and community settings.

8. Parents indicated a much higher preference for continuing the PECS phase III iPad™ application compared to PECS paper icons.
Limitations

Some limitations exist in this study. These include the limited sample and different ranges of skill across participants, baseline data comparisons for certain participants, brevity of PECS training, aspects of generalization measures, aspects of maintenance measures, and limitations associated with interobserver agreement and treatment integrity for Participants Four and Five.

Beginning with the sample of participants, only five participants were included in this study. Although participants were of similar age, the comparability of ability levels is unknown. It would have been helpful information to explore PsychoEducational Profile (PEP) scores in relation to a participant’s progress rate of acquiring mands using the iPad™. In one prior study, a developmental score of 16 months or lower on the PsychoEducational Profile-Revised (PEP-R) (Schopler et al. 1990) was associated with lack of success acquiring Phase III of the Picture Exchange Communication System (Pasco & Tohill, 2011).

Again, as previously mentioned, a functional relationship cannot be determined according to baseline measures of Participant One and Participant Four. A limitation of determining treatment effectiveness is also noted in the method of calculation of the Improvement Rate Difference (IRD) value. For example, it is noted that the deletion of a single data point for Participant Two made the difference between an IRD value of 0 and an IRD value of 1.00.

Because of the way the IRD value is calculated, it may be presumptuous to determine that if a participant exhibits frequent overlap between baseline and treatment, that the treatment was not effective. It simply may be an artifact of the calculation
method or a relationship between the procedures used in the study (i.e., full physical prompts) and the way the dependent variable was measured (i.e., the mand had to be free of full physical prompts in order to be correct).

For example, Participant Three required extensive prompting during treatment, and as a result many of his sessions had 0% independent, correct mands. His IRD value was of a negative value, indicating by some interpretation standards that the treatment made his performance deteriorate (Parker et al., 2009). A negative IRD value is indicative of considerable overlap between treatment and baseline; however, at the end of the study Participant Three was performing at 100% accuracy during maintenance conditions. If one visually inspected this participant’s data and examined maintenance and accuracy of mands during later sessions of treatment, then a different treatment effect may be determined than the one derived from the IRD value. It is advised that treatment effects not be completely discounted if for example, an IRD value does not indicate a positive effect according to its interpretation guidelines set forth by Parker et al., (2009).

Final limitations to be discussed were the brevity of PECS training, aspects of generalization measures, and aspects of maintenance measures. The time frame of this study’s PECS training may be considered a limitation because it did not allow for all of the Participants to finish acquisition of all sub-phases during Phase III. It is possible that additional modifications may have been made to procedures in order for Participants Two and Five to successfully acquire mands across all levels of difficulty in the study. Such modifications may be helpful information for researchers or clinicians to understand when working with similar participants who have greater levels of stereotypy or less toy exploration.
With regard to generalization measures, this study only measured one aspect of generalization (i.e., generalization of mands to a new setting). To fully understand generalization of mands, it would have been helpful to gather measures of generalization with novel communicative partners and novel items. Finally, maintenance data during this study were gathered after a relatively brief period of time after treatment termination. It is clinically important that individuals are able to maintain communication skills such as mands long after a one to three week period of time.

Finally, due to unavailability of some video footage, interobserver agreement is not fully representative across all conditions of the study for Participant Four and Participant Five. Treatment integrity data are also not available for Participant Four for the same reason. Although it was planned to gather measures for all participants in interobserver agreement and treatment integrity, logistical aspects of data collection hindered the comparability of these measures for both Participants Four and Five.

**Practical Implications**

Overall, the participants acquired mastery of the PECS Phase III application at varying rates. Those who were already able to navigate a mobile device acquired mands using the iPad™ very quickly. Clinicians or teachers may wish to consider this aspect before beginning PECS training. For participation in this study, one of the major requirements was that participants did not hurt themselves or others with the iPad™. Participant Three had difficulty with forming a pointing response and learning to touch a target. This skill deficit slowed his acquisition of successfully touching an icon when multiple icons were present, as well as touching the small “binder tabs” at the bottom of
the screen. Participant Two also showed difficulty with using a pointing/selecting response and had to be fully prompted to make a pointing response during treatment.

Because of these observations, it is recommended that before a clinician decides to use the PECS Phase III iPad™ application, a child should be able to use his or her pointer finger to touch a target of similar size to the anticipated icon size to be introduced in Phase IIIA. It is possible that if participants have difficulty touching a target accurately, this will unduly hinder their progress with communication for somewhat arbitrary reasons. For these participants it is recommended to continue using paper if the pointing response is not easily made independently and/or the participant has difficulty with one-to-one correspondence skills (i.e., looking at a target and touching a target.) This suggestion is based upon recommendations that only one skill be taught at a time (Frost & Bondy, 2002). Because some of the participants had to learn these types of skills at the same time they were learning to mand, it is hypothesized that this was one major factor responsible for slower progress among certain participants (Participant Two and Participant Three). Therefore, it is highly recommended that clinicians, teachers, or multidisciplinary teams conduct a careful screening of pre-requisite skills to manipulate a portable device with a touch screen in order to avoid unnecessary slowing of progress toward communication acquisition. Response effort is especially important if the AAC device is used to replace challenging behavior (Horner & Day, 1991).

Another aspect for clinicians to consider is the relationship between motivation and acquisition of mands using PECS. Acquisition of mands using PECS is crucial to the presence of a motivating operation for an item. Both a strength and weakness of this study was that for five out of six participants, the set of six toys remained constant across
a considerable period of time (approximately 3-4 months). This may be considered a strength for the study’s procedures because this consistency allowed better comparability across all treatment. However, this aspect is also considered a weakness and not recommended for clinical, home, or academic implementation. It is recommended in practice to make a variety of toys and activities available for request (Frost & Bondy, 2002). This will help ensure that the motivating operation is present to evoke mands and allow more opportunities for communication practice. Clinicians or teachers will need to constantly re-evaluate preferences and start PECS training with a large number of known preferred items in order to avoid satiation effects. In turn, they will also need to prepare a large variety of icons prior to beginning PECS Phase III training with the iPad™.

A final aspect to consider before deciding to use the iPad™ for PECS phase III training is the participant’s ability to transition away from an iPad™. During this study, the iPad™ was removed immediately after the participant manded in order to avoid the opportunity for him/her to “play” with it. Participant Five had several tantrums during PECS Phase IIIA iPad™ training, sometimes to the degree that the session had to temporarily be postponed for several minutes. A similar but less intensive emotional response was observed with Participant Four, as he continued to attempt to press the icon after the toy was delivered and some yelling and grabbing of the iPad™ was evoked by the experimenter removing the iPad™.

It is possible that clinicians or teachers may evoke similar emotional responses when teaching a new function for the response of touching an icon on the iPad™. Specifically, during PECS training with an iPad™ the participant will learn that touching the icons on the iPad™ is used to request an item and not to produce preferred visual or
auditory stimulation. This could be a potential difficulty associated with of PECS training with an iPad™ for certain children with disabilities. Many children today already have a history of playing with similar devices. There are many preschool iPad™ applications in which children can touch pictures or icons and then a song, animation, or sound is made. Careful consideration of this factor may help clinicians or teachers decide whether a child or adult is ready for PECS training with an iPad™.

**Recommendations for Future Research**

The following is a list of recommendations for future research and their rationale based upon the findings from this study:

1. Participant Four exhibited high levels of mands using the iPad™ during baseline and Participant One exhibited relatively high levels of accurate mands without error correction during the first session of treatment. This may be due to either learning from exposure to the contingency during baseline or generalization of responding due to stimulus symmetry between paper and iPad™ icons. Future studies may wish to compare acquisition rates of mands using the PECS Phase III iPad™ application between children who have mastered navigation of a mobile device and those who have not. It was noted during this study that the participants who had fluent ability to navigate mobile devices tended to acquire mands using the iPad™ much more quickly than those who did not have that skill.

In addition, future researchers may wish to evaluate participant characteristics and correlate their success or lack of success with mands using either paper icons or the PECS Phase III iPad™ application. It is possible that certain unknown participant characteristics may influence their success with acquiring mands using the PECS Phase
III iPad™ application. Future researchers may also want to compare acquisition rates of mands using traditional paper icons or the PECS Phase III iPad™ application. Finally, future researchers may wish to examine parent training with the PECS Phase III iPad™ application as they are an important communicative partner in the life of a young child with a developmental disability.

2. In this study, generalization of mands was observed in a novel setting for all of the participants who completed all of the treatment conditions. However, future studies should also assess generalization of mands for new items or activities and with novel communicative partners. It is also suggested to compare PECS paper icons with the PECS Phase III iPad™ application with regard to how quickly each response topography generalizes in novel settings. For example, Adkins and Axelrod (2001) compared generalization rates of mands using either paper PECS or manual sign and found that mands using paper PECS more quickly generalized to a new setting.

3. Maintenance of effects for this study were assessed and shown to be durable across 1-3 weeks after treatment had ended. Future studies should assess maintenance of PECS Phase III training using the PECS Phase III iPad™ application for longer periods (e.g., 3 months) after treatment is withdrawn.

4. Social validity measures indicated that the iPad™ was deemed socially acceptable among parents and more highly preferred as a mand response topography by all five participants. Future researchers may wish to compare results of mand preference assessments with general preference assessments and include an iPad™ as one of the available leisure items. It is possible that children who have higher preferences for playing with mobile devices may also exhibit a higher preference for using an iPad™ or
other portable electronic device as their primary AAC device. Future researchers may also wish to examine factors influencing parent preference for portable electronic devices versus low tech, paper icons for their child’s primary AAC device.
Appendix A

Parent Intake Questionnaire

1. What is the age of your child? ___________ years
2. What is your child’s birthdate? ________________
3. What is your child’s diagnosis?
   __________________________________________________________________________
   a. Who made the diagnosis (a psychologist, psychiatrist, pediatrician, neurologist, etc.)?
   __________________________________________________________________________
   b. Does your child have any other diagnoses?
   __________________________________________________________________________

4. Does your child have a history of seizure disorders? Circle one YES  NO

5. Has your child’s vision and hearing been tested? Circle one YES  NO
   a. Did he/she pass the hearing test Circle one YES  NO
   b. Did he/she pass the vision test? Circle one YES  NO

6. Is your child currently taking any medications? Circle one YES  NO
   If so, please write the name of the medications, the dosage, and how long your child has been taking the medication.
   __________________________________________________________________________
   __________________________________________________________________________
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7. Is your child overly sensitive to light, sound, touch, smells, certain tastes, etc.? If so, please describe.
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

8. Does your child have any sleeping problems? If so, please describe
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
Appendix A (Continued)

Parent Intake Questionnaire

Does your child sometimes engage in problem behavior to get things that he or she wants? If yes, please describe.
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________

9. Does your child receive any services (e.g., speech/language therapy, Applied Behavior Analysis Therapy, etc.)? If so, please give an estimate of how many hours a week and month that your child receives these services.
______________________________________________________________________________________
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______________________________________________________________________________________
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Appendix B
Parent Consent Form

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

PARENT PERMISSION FORM
Department of Educational and Clinical Studies

TITLE OF STUDY: Effects of PECS Phase 3 and 4 iPad Applications on Independent Manding and Speech in Young Children with Autism

INVESTIGATOR(S): Susan Miller, PhD; Jessica Love, MA

CONTACT PHONE NUMBER: Susan Miller, 702-895-1108

Purpose of the Study:
Your child is invited to be involved in a research study. The purpose of this study is to see if a Picture Exchange Application on the iPad is effective for increasing communication and speech for children with autism.

Participants:
You are being asked to be involved in the study because you fit these criteria:
- You have a child between the ages of 3 and 6 with diagnosis of autism
- Your child has fewer than 5 words of functional speech
- Your child has no hearing or sensory impairments
- Your child has no previous experience with picture exchange communication training
- Your child has a Psycho-Educational Profile indicating a score of 16 months or higher

Procedures:
If you volunteer to become involved in this study, you will be asked to do the following:

1) Complete and return two intake forms containing questions about your child including a brief medical history and medication your child takes.

2) Allow your child to participate in a screening session involving a psychoeducational assessment for approximately 1.5 hours and an iPad interaction probe for 10 minutes (to make sure that the child doesn’t throw or hit the iPad on objects or individuals). Allow your child to participate in two 5-minute sessions to determine items he enjoys (e.g., specific types of toys) and items he does not enjoy (e.g., sponge, coffee filter). Allow your child to participate in three 15-minute sessions to determine food and play preferences. These assessments will take place prior to the study in your child’s regular classroom setting.

Approved by the UNLV IRE. Protocol #:21212-4329M
Received: 01-30-13 Approved: 02-07-13 Expiration: 02-06-14
Appendix B (Continued)

Parent Consent form

3) Allow your child to participate in instructional sessions designed to help him/her make requests using paper icons or an iPad. This instruction will occur for a minimum of 3 days a week for 6 to 8 weeks. Your child’s teacher will assist with teaching your child this new skill. Each session will last from 10 to 30 minutes, depending on how your child learns. This instruction will take place in your child’s regular classroom setting. The last five sessions of the study will involve assessing whether your child (a) remembers how to make requests without prompts, (b) is able to make requests in different locations of the school, and (c) whether your child prefers to use paper icons or the iPad. By signing this form, you are also agreeing to allow us to videotape your child during these instructional sessions.

4) Answer a brief questionnaire about what you think about the intervention.

Benefits of Participation
There may be direct benefits for your child’s participation. Your child may learn to tell people what they want by using pictures and/or the iPad. Picture exchange has been shown to be effective for children with autism, but this study is the first to test the iPad application. Other benefits may include your child showing less problem behavior and using a little more speech. These are good side effects that may result from your child learning to communicate with pictures—but do not occur for all children.

Risks of Participation
There are risks involved in all research studies. This study may include only minimal risks. The level of anticipated risk is low. Your child may initially become frustrated because he/she will be learning a new way to communicate. Some frustration may occur during instruction if the child does not exchange the correct picture. If the child doesn’t give the correct picture, he/she will not get the favorite toy or food right away. Prompting and error correction procedures (showing your child the correct choice and giving him/her another chance to request) are used during training to prevent and/or reduce these frustrations for your child.

Cost /Compensation
There are no financial costs for you to participate in this study. The study will take 10-30 minutes per session, 3-5 days per week. The study will last 6 to 8 weeks, depending on the speed of your child’s progress. You will not be compensated for your time.

Confidentiality

All information gathered in this study will be kept as confidential as possible within the research team and your child’s teachers. No reference will be made in written or oral materials that could link your child to this study. All records will be stored in a locked facility at UNLV for 5 years after completion of the study. After the storage time the study’s data and video footage will be destroyed and/or deleted.

Contact Information
If you have any questions or concerns about the study, you may contact Jessica Love at (530) 200-2254 or Susan Miller at (702) 895-1108. For questions regarding the rights of research

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Appendix B (Continued)

Parent Consent Form

After conducting the study, any complaints or comments regarding the manner in which the study is being conducted may contact the UNLV Office of Research Integrity - Human Subjects at 702-895-2794 or toll free at 877-895-2794 or via email at IRB@unlv.edu.

Voluntary Participation
Your participation in this study is voluntary. You may refuse to participate in this study or in any part of this study. Your child will be allowed to withdraw for any reason at any time. If they exhibit certain behaviors that indicate unhappiness with the procedures (cries, screams or asks to leave, runs away). Specifically, the researcher and the child's teacher will terminate the session if any of these behaviors occur for five minutes or more. If sessions are terminated 5 times in a row it will be assumed that your child no longer wishes to participate. If your child indicates that he/she no longer wishes to be in the study either verbally or behaviorally, the withdrawal will be at no penalty to you, nor will it negatively affect your relationship with UNLV in any way. Additionally, if your child throws the tablet or uses the tablet to hit objects, themselves, or other people he/she will be withdrawn from the study.

You may withdraw at any time without prejudice to your relations with Acelero Head Start or University of Nevada, Las Vegas. You are encouraged to ask questions about this study at the beginning or any time during the research study. Refusal to participate in this study or withdrawal from the study at any time will not affect your relationship in any way with Acelero Head Start or University of Nevada, Las Vegas.

Confidentiality
All information gathered in this study will be kept completely confidential. No reference will be made in written or oral materials that could link your child to this study. All records will be stored in a locked facility at UNLV for 3 years after completion of the study. After the storage time the study's data and video footage will be destroyed and/or deleted.

Participant Consent:
I have read the above information and grant permission for my child to participate in this study. I am at least 18 years of age. A copy of this form has been given to me.

_________________________  _______________________
Signature of Parent          Date

_________________________
Participant Name (Please Print)

Audio/Video Taping

I also agree to for my child to be videotaped for the purpose of this research study.

_________________________  _______________________
Signature of Parent          Date

_________________________
Participant Name (Please Print)

Approved by the UNLV IRB. Protocol #1212-1323M
Received: 01-30-13 Approved: 02-07-13 Expiration: 02-06-14
## Appendix C

### Pilot Participant Demographic Information

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<tr>
<td><strong>Age</strong></td>
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<tr>
<td><strong>Ethnic Group</strong></td>
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<td><strong>Medications/Seizures</strong></td>
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<tr>
<td><strong>Hearing/Vision/Medical Problems</strong></td>
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</table>
Appendix D

Modified RAISD Form

The purpose of this survey is to obtain information about the toys that you believe would be useful as rewards for your child.

If you have signed the consent form, please answer the following questions regarding your child’s preferences:

1. Some children really enjoy toys like puzzles, books, blocks, figurines, musical toys, playdoh, etc. What are the specific toys your child really likes?

   - ___________________
   - ___________________
   - ___________________
   - ___________________
   - ___________________
   - ___________________
   - ___________________
   - ___________________
   - ___________________
   - ___________________

2. Please go back to the list in question number one, and place a number in each box to rank these toys from most favorite (1) to least favorite (10).

3. Are there any toys that you would prefer your child not to play with during our study?

   ____________________________________________________________________________________
   ____________________________________________________________________________________
   ____________________________________________________________________________________
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   ____________________________________________________________________________________
Appendix D (Continued)

 Modified RAISD Form

The purpose of this survey is to obtain information about the foods that you believe would be useful as rewards for your child.

If you have signed the consent form, please answer the following questions regarding your child’s preferences:

1. Some children really enjoy foods like apples, chips, pretzels, candy, cookies, bananas, etc. What are the specific foods your child really likes?
   - ___________________
   - ___________________
   - ___________________
   - ___________________
   - ___________________
   - ___________________
   - ___________________
   - ___________________
   - ___________________
   - ___________________

2. Please go back to the list in question number one, and place a number in each box to rank these foods from most favorite (1) to least favorite (10).

3. Are there any foods that you would prefer your child not to eat during our study?
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
Appendix E

MSWO Preference Assessment Data Sheet

Observer Name_____________
Participant Initials_____________
Session Number _____________

Instructions: (1) Write them name of each item in the blank. (2) When participant chooses an item,* write the number of the corresponding item with its corresponding number (order) in which it is chosen.
*(Choosing is defined as participant physically touching/manipulating the item with his/her hands for 5 or more sec.)

<table>
<thead>
<tr>
<th>Item 1</th>
<th>Item 2</th>
<th>Item 3</th>
<th>Item 4</th>
<th>Item 5</th>
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<th>Item 10</th>
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<th>Trial 5</th>
<th>Trial 6</th>
<th>Trial 7</th>
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Appendix F

*Modified Data Sheet for PECS Pre-Training – Phase I*

<table>
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<th>Staff Initials</th>
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<td></td>
<td></td>
<td>FP</td>
<td>PP</td>
<td>+</td>
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</tbody>
</table>

*Tally for correct, independent mand*

|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |

*Tally for correct, independent mand*

|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |
|                |      |          |      | FP      | PP     | +       | YES No    |

FP= Full Physical Prompt      PP = Partial Physical Prompt  +  = Independent
YES = The open hand is still visible   NO  = The open hand has been faded
Appendix G

Data Sheet for PECS Pre-Training – Phase II

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<tr>
<th>Staff</th>
<th>Date</th>
<th>Activity</th>
<th>Item</th>
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<th>Distance to Book</th>
<th>+ / -</th>
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<td>+ -</td>
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<td>+ -</td>
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<td>+ -</td>
<td>0.3 3-6 6-9 &gt;9</td>
<td>+ -</td>
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</table>

Circle the distance traveled. Distances are in feet

+ = moved the indicated distance independently
- = needed assistance from the physical prompter or required the back-up error correction procedure
Appendix H

Data Sheet for Baseline and All PECS iPad™ Training Conditions

| Student: |

<table>
<thead>
<tr>
<th>Trial Number</th>
<th>Correct request iPad + or -</th>
<th>Discrimination Level (circle item student requests on iPad)</th>
<th>Negative reaction?</th>
<th>Correspondence Check + - or n/a</th>
<th>Error Correction? + - or n/a</th>
<th>Speech?</th>
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<tr>
<td>1</td>
<td>HP+NP</td>
<td>HP+CI</td>
<td></td>
<td></td>
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<td>W or VA</td>
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<tr>
<td>2</td>
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<td></td>
<td></td>
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<td>W or VA</td>
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<td>W or VA</td>
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<td>HP+CI</td>
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<tr>
<th>Discrimination Level:</th>
<th>HP = Highly Preferred</th>
<th>NP = Non-Preferred</th>
<th>CI = Contextually Inappropriate</th>
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<tr>
<td>Speech</td>
<td>W = intelligible word</td>
<td>VA = vocal approximation</td>
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<tr>
<td>Negative Reaction?</td>
<td>Y = Yes</td>
<td>N = No</td>
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Appendix I
Mand Preference Assessment Data Sheet

<table>
<thead>
<tr>
<th>Participant Initials</th>
<th>Date</th>
<th>Experimenter Initials</th>
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**Directions**: For each trial, place a check mark next to the name of the device that the child used to request a preferred item.

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Appendix J

Chronological Outline of Study Procedures

1. Pre-experimental Assessments
   a. iPad™ interaction probe (single session, 10 minutes)
   b. informal preferred items probe (single session, 5 minutes)
   c. informal nonpreferred items probe (single session, 5 minutes)
   d. MSWO preference assessment (three sessions, 10 trials / ~ 20 min each)

2. PECS Pre-training (Phases I-II, terminates after 3 consecutive sessions of 80%)

3. Experimental Conditions
   a. Baseline condition (10 trials each, terminates after steady state and at least 3 sessions)
   b. PECS Phase IIIA iPad™ training (terminates after 3 consecutive sessions of 80%)
   c. PECS Phase IIIB iPad™ training (terminates after 3 consecutive sessions of 80%)
   d. PECS Phase IIIB iPad™ multiple icons and tabbing (terminates after 3 consecutive sessions of 80%)
   e. Generalization probes (two per treatment condition, 10 trials each)

4. Post Experimental Assessments
   a. Maintenance probes (3 sessions, 10 trials each)
   b. Mand preference assessment (two sessions, 10 trials)
   c. Parent Questionnaire (completed within 1 week after study ends)
Appendix K

Additional information for Pilot Participant Method

- **Non-Preferred Items**: The Pilot Participant’s non-preferred items consisted of clip, sponge, sock, rubberband, container, paper clip.

- **Preferred Items**: The Pilot Participant’s preferred items were play dough, light up ball & wand, bubbles, ballramp, spinning tops, and a Dora the Explorer™ phone.

- **Communicative Partner for Pre-training**: For the Pilot Participant, a single experimenter served as his communicative partner.

- **Exit Criteria during PECS Phase II Pre-training**: It is important to note that the Pilot Participant’s exit criteria was initially three consecutive sessions at 80% correct for each of the three steps in PECS Phase II pre-training. However, it was observed that the Pilot Participant began showing signs of satiation with the toys because of the high number of trials required to meet mastery criterion with each sub-step. Specifically, the Pilot Participant was observed to sigh, shuffle his feet to exchange the icons, and run into another room after a few exchanges were made. He clearly had mastered the exchange, but pre-set criteria were still followed for him. Therefore, one should interpret his results for pre-training separately and avoid comparison to other participants. It is anticipated that if his criteria were the same as for the remaining five, his number of trials to acquisition would have been considerably lower.

- **Pre-Training Results**: The Pilot Participant acquired PECS phases I and II in a total of 210 trials.

- **Baseline IIIB**: For the Pilot Participant, a second baseline was conducted. Because the Pilot Participant was the first participant to enter treatment and he met mastery criteria during Baseline IIIA, a second baseline was conducted in order to assess his ability to perform mands under PECS phase IIIB iPad™ conditions. This baseline was exactly the same as the PECS phase IIIa iPad™ condition, with the exception that no correspondence checks, prompting, or error correction procedures were used. The Pilot Participant met mastery criteria during this baseline as well; however, because no correspondence checks were used during this phase, PECS phase IIIB iPad™ treatment was instated in order to check his accuracy in the presence of two preferred items.
Appendix L

Treatment Integrity Checklist

**PECS Phase IIIA iPad™ Training**

1. Places iPad with two pictures (1 preferred and 1 non-preferred) in front of participant.
2. Presents 1 preferred and 1 non-preferred item out of participant’s reach and waits silently with no gestures or other prompts.
3. Delivers preferred item and simultaneously says “item name” within 1 second after the participant selects the preferred item icon on the iPad.
4. Allows participant at least 20 seconds with preferred item.
5. Removes item after a minimum of 20 seconds and says, “My turn”. (A 5 second initial sampling of the item is not subject to this criterion).
6. Delivers non-preferred item within 1 second after the participant selects the icon of the non-preferred item and simultaneously says “non-preferred item name”
7. Within 5s after delivering the non-preferred item, experimenter removes non-preferred item and implements “model-prompt- switch-repeat” error correction **Model:** Experimenter touches the correct icon **Prompt:** Experimenter uses gestural prompt (points to correct picture) or full physical prompt (guides participant hand using hand-over-hand guidance) to guide participant’s hand to touch the correct icon.
8. **Praise:** Experimenter says, “Good, that’s Preferred Item Name”
9. **Switch:** Experimenter turns the iPad over for at least 2 seconds.
10. **Repeat:** Experimenter re-presents the two items out of reach from the participant and waits silently with no gestures or other prompts.
11. Allows access to preferred item for at least 20 seconds after participant selects the correct icon of a preferred item.

<table>
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</tbody>
</table>
Appendix M

Treatment Integrity Checklist

PECS Phase IIIB iPad™ Training

1. Places iPad with two icons (of 2 preferred items) in front of participant.
2. Presents 2 preferred two items that correspond to the icons out of participant’s reach and waits silently with no gestures or other prompts.
3. Delivers preferred item within 1 second of the participant selecting its corresponding icon on the iPad and simultaneously says the “name of item”.
4. Allows participant at least 20 seconds with item before removing it and saying, “My turn” (a 5 second initial sampling of the item is not subject to this criterion).

**Correspondence check:** After participant selects the icon, experimenter presents both items on a tray in front of participant and says, “Go ahead” or “Take it”

5.
   a. If participant reaches for correct item, allows participant access to item for at least 20 seconds.
   b. If participant reaches for or grabs an incorrect item, experimenter lightly blocks with participant access to item with experimenter’s hand, removes the item from the participant’s grasp, or withholds item out of participant’s reach and within 5 seconds implements “model-prompt-switch-repeat” error correction.

6. **Model:** Experimenter touches the correct icon
7. **Prompt:** Experimenter uses gestural prompt (points to correct picture) or full physical prompt (guides participant hand using hand-over hand guidance) to guide participant’s hand to touch the correct icon.
8. **Praise:** Experimenter says, “Good, that’s item name”
9. **Switch:** Experimenter turns the iPad over for at least 2 seconds.
10. **Repeat:** Experimenter Re-Presents the two preferred items out of reach of the participant.
11. Experimenter conducts another correspondence check after the participant selects the icon if there was an error correction procedure performed on the previous trial.
12. **Correspondence check:** After participant selects the icon, experimenter says, “Go ahead, take it”
13. Allows access to preferred item for at least 20 seconds after participant selects the correct icon of a preferred item.
Appendix M (Continued)

Treatment Integrity Checklist

PECS Phase IIIB iPad™ Training

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Did experimenter conduct correspondence checks for at least 4 out of 10 trials per session? Yes or No
Appendix N

Parent Questionnaire

1. Would paper icons or the Ipad be easier for you to use with your child in during your daily routine?
2. Generally, how did participation affect your child?
3. Did you see any positive difference at home (e.g., problem behavior is reduced; child is communicating more with you; child is speaking more)?
4. When going out in the community, would you rather have your child use paper icons or the Ipad to tell you what he/she wants?
5. If given training, how comfortable are you with using the Ipad application with your son/daughter? Please circle your choice using the numbers below

1 = very uncomfortable, 2 = somewhat uncomfortable, 3 = neutral, 4 = comfortable, 5 = very comfortable

1 2 3 4 5

6. My child learned picture exchange communication by participating in this study.
7. My child made meaningful progress through participation in this study.

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

1 2 3 4 5

8. I feel that the Ipad and the application is (circle one) expensive reasonably priced inexpensive

9. I would like to my child to continue using the PECS paper icon intervention after this study.

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

1 2 3 4 5

10. I would like my child to continue using the PECS Ipad application intervention after this study.

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

1 2 3 4 5

11. I am likely to tell other parents to try using PECS with their kids

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

1 2 3 4 5

12. After watching the video footage I feel that the (circle one) ipad paper icons interaction appeared to be a more natural interaction.
Appendix O

Pilot Participant Results Research Question 1

The Pilot Participant’s data showed little to no level change across all phases of the study. With the exception of the first session of the Baseline IIIA condition (60%), data ranged from 80% to 100% across all phases, indicating small variability in his performance. Data showed an upward trend in the first and second baselines. All other phases showed stability. He met mastery criteria for PECS Phase IIIA iPad™ condition during Baseline IIIA in only four sessions or 40 trials ($M = 85\%, \ SD = .17$) As a result, Baseline IIIB was instated and the Pilot Participant again met mastery criteria in this baseline condition in three sessions ($M = 90\%, \ SD = .10$). Upon further inspection with correspondence checks during treatment in the PECS Phase IIIB iPad™ condition, the Pilot Participant again met mastery criteria in three sessions or 30 trials ($M = 90\%, \ SD = .01$). During the final treatment phase, the Pilot Participant met mastery criteria for this phase in six sessions or 60 trials ($M = 95\%, \ SD = .08$). His data are not presented in the final summary figure of the multiple baseline design with the other participants’ graphs, as he was the pilot participant. See table below for the Pilot Participant’s summary of means, standard deviations, and range per condition.
Appendix O (Continued)

Pilot Participant Results Research Question 1 (Continued)

Table.

<table>
<thead>
<tr>
<th>Performance Summary for Pilot Participant</th>
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<tr>
<td>Baseline IIIA</td>
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<td>Mean (%)</td>
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<td>(SD)</td>
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<td>Range</td>
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Note. (SD) = standard deviation.

After visual inspection, Improvement Rate Difference (IRD) was calculated by visually identifying the number of improved data points between baseline and treatment. Only a comparison between Baseline IIIB and PECS Phase IIIB iPad™ and PECS Phase IIIB iPad™ multiple icons and tabbing conditions was made when identifying improved data points. The pilot participant was never exposed to the PECS Phase IIIA iPad™ condition because he met mastery criteria for the PECS Phase IIIA iPad™ condition during Baseline IIIA. Therefore, Baseline IIIA was considered not comparable to the other treatment conditions and not included in the analysis. During baseline, 67% of the pilot participant’s data points were improved and none of his treatment data points were improved.
Appendix O (Continued)

Pilot Participant Results Research Question 1 (Continued)

The IRD calculation yielded a value of -0.67, indicating no treatment effect (Parker et al., 2009). Please see figure below for a visual depiction of the Pilot Participant’s performance across all conditions of the study.

Figure. Independent Mands Across all Conditions for Pilot Participant
Figure 6. Independent Mands Across All Participants
Appendix P (Continued)

Independent Mands Across All Participants

Figure 6. Independent Mands Across all Participants (Continued)
Appendix Q

Pilot Participant Results Research Questions 2 and 3

The Pilot Participant exhibited generalization of independent mands across all four probes. Because he was the pilot participant, generalization probes were only conducted after the PECS Phase IIIB iPad™ condition and after the PECS Phase IIIB iPad™ multiple icons and tabbing condition. Results indicated high levels of mands emitted in a novel setting. The Pilot Participant accurately manded for preferred items for 90% and 100% of opportunities during the generalization probes for the PECS Phase IIIB iPad™ condition. Additionally, both generalization probes showed independent mands on 90% of opportunities for the PECS Phase IIIB iPad™ multiple icons and tabbing condition.

The Pilot Participant’s maintenance probes ranged from 80% to 100% of correct mands per number of opportunities per session. This sample of performance showed strong maintenance of skills when compared to the PECS Phase IIIB iPad™ multiple icons and tabbing condition (range 80% to 100%). Percentage of Overlapping Data confirmed that 100% of data in maintenance overlapped with the previous three data points in the final treatment condition (PECS Phase IIIB iPad™ multiple icons and tabbing).
Appendix R

Pilot Participant Results Research Question 4

Out of thirty trials (across three separate sessions), the Pilot Participant used paper icons to mand for preferred icons in only 10% of opportunities. Logically, the Pilot Participant used the iPad™ to mand for preferred items for the remaining 90% of opportunities. Therefore, his preferred mand topography was deemed to be the iPad™.

See Figure below to see the results of his bar graph.

**Figure.** Results of Mand Preference Assessment for Pilot Participant
Appendix S

Pilot Participant IOA and Treatment Integrity

Interobserver agreement was gathered for a total of 25% of sessions during Baseline IIIA, 33% of sessions during Baseline IIIB, 33% of sessions during PECS Phase IIIB iPad™ training, 100% of sessions during PECS Phase IIIB iPad™ multiple icons and tabbing training, 50% of generalization probes, 33% of maintenance probes, and 33% of mand preference assessment sessions.

Interobserver agreement across all conditions, generalization probes, and maintenance probes was 96% (range 90% to 100%). For the mand preference assessment, agreement was 100%. Treatment integrity across all treatment conditions was 98% (range 96.3% to 100%).


tolerance to decrements in reinforcer density. *Journal of Applied Behavior Analysis, 23,* 177-193.


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Schopler, E., Reichler, R. J., Bashford, A., Lansing, M. D., & Marcus, L.M., (1990). *The Psychoeducational Profile—Revised (PEP-R)*. Austin, TX, USA: PRO-ED.


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Earl and Hazel Wilson Scholarship, (2013).
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Earl and Hazel Wilson Scholarship, (2012).
Doug Sperber Research Grant Award, (2010)
Earl and Hazel Wilson Scholarship, (2010).

Publications:


VITA (CONT’D)

Selected Presentations


Dissertation Title: Effects of PECS Phase III Application Training on Independent Mands in Young Children with Autism

Dissertation Examination Committee:
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Co-Chairperson, Peggy Schaefer-Whitby, Ph. D.
Committee Member, Tom Pierce, Ph. D.
Committee Member, Catherine Lyons, Ph. D.
Committee Member, Scott Loe, Ph. D.