Meta-Analysis of PECS with Individuals with ASD: Investigation of Targeted versus Non-Targeted Outcomes, Participant Characteristics, and Implementation Phase

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Abstract

The Picture Exchange Communication System (PECS) is a widely used picture/icon aided augmentative communication system designed for learners with autism and other developmental disorders. This meta-analysis analyzes the extant empirical literature for PECS relative to targeted (functional communication) and non-targeted concomitant outcomes (behavior, social skills, and speech) for learners with autism, learners with autism and intellectual disabilities and those with autism and multiple disabilities. Effect size analyses were done using the Improvement Rate Difference method, an advanced metric. Effect sizes were independently analyzed for targeted and non-targeted outcomes, student age, learner disability, and number of phases in the PECS protocol acquired by learners. Results supported the judgment that PECS is a promising intervention method. Analysis also revealed that functional communication outcomes associated with the PECS protocol were most impacted, that preschool children and those with autism generally showed the strongest training effects, and that in general students who advanced through the most PECS protocol phases had the best outcomes.

Keywords: Autism spectrum disorders; augmentative and alternative communication; aided AAC; communication skills; social skills; interventions; meta-analysis; Picture Exchange Communication System

Meta-Analysis of PECS with Individuals with ASD: Investigation of Targeted versus Non-Targeted Outcomes, Participant Characteristics, and Implementation Phase

Autism Spectrum Disorders (ASD) include a range of developmental disabilities, including Autistic Disorder, Asperger's Syndrome, and Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS), that are most notably characterized by significant deficits in developmentally appropriate social and communication skills (American Psychiatric Association [APA], 2000). Many children with autism and PDD-NOS lack adequate speech or other forms of functional communication (APA, 2000). Thus, alternative and augmentative communication (AAC) systems and protocols have been developed as a way to allow individuals with severe communication disabilities to functionally communicate and make their needs and wants known to those around them (Mirenda, 2003). AAC systems vary widely and include modified sign language, speech generating devices, and visual or picture-based communication systems (Ogletree, Oren, & Fischer, 2007; Spence-Cochran & Pearl, 2012).

The Picture Exchange Communication System (PECS; Frost & Bondy, 2002) is visual AAC system and protocol. As the name implies, PECS is primarily a picture-based AAC system; advanced phases of PECS also use sentence strips in combinations with pictures, increasing both the complexity and potential utility of the communication (Frost & Bondy, 2002). PECS has been used primarily with children with autism and autism spectrum disorders (ASD) who have complex communication needs (CCN; i.e., unable to speak, speech is unintelligible, or speech is not spontaneous or functional) and whose needs are not adequately met by their current method or methods of communication (Ganz, Simpson, & Lund, in press; Lancioni et al., 2007; Pyramid Educational Consultants, 2011). However, the creators of PECS note that PECS can theoretically

be used by any individual with CCN, regardless of diagnosis (Pyramid Educational Consultants, 2011).

Research suggests that the highly visual nature of PECS may make it particularly well-suited for use with learners with ASD, who are more likely to be highly visual learners (Schopler, Mesibov & Hearsey, 1995). Further, the National Research Council (2001) recommends the use of symbolic and pictorial AAC systems when working with individuals with ASD. Additionally, the highly concrete and static of the PECS symbols may make them a particularly good choice for individuals with ASD, who tend to prefer highly concrete, consistent objects and stimuli (Heflin & Alaimo, 2007; Ogletree, Oren, & Fisher, 2007). PECS symbols have a one-to-one correspondence with objects, people, and concepts, thus reducing the degree of ambiguity in communication (Ganz, Simpson, et al., in press) and allowing for recognition of meaning instead of requiring recall (Heflin & Alaimo, 2007).

PECS has been shown to be an effective means of improving communication skills in many individuals with ASD in research studies, most of which have employed single case research (SCR) methodology (Ganz, Simpson, et al., in press; Hart & Banda, 2010; Tincani & Devis, 2010). Additionally, research indicates that PECS may be more effective than other forms of AAC for some learners (Hart & Banda, 2010). Furthermore, a recent meta-analysis of PECS, speech generating devices (SGDs), and other picture-based AAC systems found that PECS was significantly more effective than other forms of picture-based AAC, though approximately as effective as SGDs (Ganz, Earles-Vollrath, Heath, et al., in press). Additionally, PECS may be cheaper, more durable, and easier to transport than SGDs or other more complex forms of AAC, increasing its practical appeal (Ganz, Simpson, et al., in press). Clearly there is general empirical evidence to support PECS as an effective means of increasing communication in learners with

ASD (Flippin, Reszka, & Watson, 2010). Then again, a number of significant issues have yet to be addressed, including the differential outcomes of PECS training as a function of participant, phase and implementation of intervention, and environmental variables.

Previous Meta-analyses of PECS and AAC: State-of-the-art Technologies

With the recent advancement of meta-analytic techniques for SCR, the publication rate of meta-analyses has increased considerably in recent years (Maggin, O'Keeffe, & Johnson, 2011). Meta-analysis on PECS has followed this trend. To date, three meta-analyses have been published on PECS (Flippin, Reszka, & Watson, 2010; Preston & Carter, 2009; Tincani & Devis, 2010). While these analyses have examined different aspect of PECS, each effect size calculation used Percent of Non-Overlapping Data (PND; Scruggs, Mastropieri, & Casto, 1987).

PND has a strong history of use in meta-analysis. A recent review of meta-analytic procedures found that PND is by far the most widely used effect size in SCR (Maggin et al., 2011). PND is calculated as the percent of "intervention" phase data that exceed (in the intended direction) the single most extreme "baseline" phase data point (Scruggs & Mastropieri, 1994). This metric is similarly interpreted as the percent of intervention phase data that exceeded the single highest baseline or "A" phase data point. PND yields scores between 0 and 100%. Despite its wide use, methodological concerns have been associated with PND due to a lack of a known sampling distribution, which restricts the ability to calculate p-values and confidence intervals (CIs) around PND point estimates (Allison & Gorman, 1993; White, 1987). PND has also been criticized due to the fact that it uses a single point of data to summarize all phase data (Allison & Gorman, 1993).

To address the issues surrounding PND, new effect size calculation techniques have recently been promoted within intervention research (Parker, Vannest, & Davis, 2011). One of

these techniques is Improvement Rate Difference (IRD, Parker, Vannest, & Brown, 2009). IRD is currently emerging in meta-analysis literature for intervention research in schools. Currently, four meta-analyses have been published or are in press using this effect size (Ganz, Earles-Vollrath, Heath, et al., in press; Ganz, Earles-Vollrath, Mason, et al., 2011; Vannest, Davis, Davis, Mason, & Burke, 2010; Vannest, Harrison, Temple-Harvey, Ramsey, & Parker, 2010). IRD is modeled after "Risk Difference" from the medical literature and is a common output of logistic regression statistical modules (Parker et al., 2009). IRD is an overlap-based effect size (ES) applied to SCR data with the intent of improving on some of the now known limitations of PND. Ganz, Earles-Vollrath, Mason, et al. (2011) conducted a meta-analysis of AAC, including but not limited to PECS, using IRD methodology but did not examine the effects of participant and training characteristics on outcomes exclusively with PECS.

In a study of 166 published single case data sets (Parker et al., 2009) compared IRD with three other methods: PND, Kruskal-Wallis W, and R^2. This study found several advantages in using IRD relative to the other ES options: (a) accessible interpretation; (b) compatibility with visual analysis; and (c) known sampling distribution, for p-values and CIs. The ability to calculate p-values and express CIs is of particular interest given new practice guidelines for reporting effect size in SCR (Kratochwill et al., 2010).

The issue surrounding PND is also of concern to the analysis of PECS given a recent re-analysis of the Preston and Carter (2009) PECS meta-analysis using alternate ES techniques (Davis, Vannest, & Payne, 2010). Davis et al. (2010) found significant differences between the ESs originally reported by Preston & Carter (2009), and the newer more sensitive effect size, IRD. A re-analysis of moderators also showed a significant impact on the expression of intervention effects, a finding not shown on several of the moderators examined with PND alone.

This analysis found that ES calculation techniques such as IRD have the ability to show subtle intervention effects that are not apparent from PND. The Davis et al. (2010) re-analysis centered on comparing ES estimates and did not cover the functional implication of these differences in relation to applying PECS. Therefore, more research is needed to discuss the functional impact of how PECS is evaluated in meta-analysis.

Participant and Intervention Variables

Targeted versus collateral outcomes. The stated purpose of PECS is to increase functional communication in individuals whose current communication methods do not adequately meet their needs (Frost & Bondy, 2002). However, PECS has also been investigated as a means to affect other, collateral--or "non-target"—outcomes. The most common collateral outcomes examined include speech production (Flippin, Reszka, & Watson, 2010; Ganz, Simpson, & Corbin-Newsome, 2008) and problem or challenging behaviors (Charlop-Christy et al., 2002). Research on increased speech production as a function of PECS use has yielded mixed results (see Flippin, Reszka, & Watson, 2010 ; Ganz & Simpson, 2004; Ganz, Simpson, et al., 2008). There is also evidence that PECS may be helpful in decreasing challenging behavior in some learners (Buckley & Newchok, 2005; Charlop-Christy et al., 2002; Frea, Arnold, & Vittimberga, 2001), although research on this collateral outcome is limited and inconclusive (see Hart and Banda's 2010 PND meta-analysis). Relative to the unsettled nature of the extant literature on this subject the present study sought to investigate differential results for targeted versus collateral PECS outcomes.

Student age. To date, PECS research has predominantly focused on children, especially on preschool-age children (Ganz, Simpson, et al., in press; Hart & Bandara, 2010; Tincani & Devis, 2010), although researchers have also examined the efficacy of PECS in adolescents and

adults (e.g., Charlop-Christy, Carpenter, Le, LeBlanc, & Kellet, 2002; Ganz, Sigafoos, Simpson, & Cook, 2008; Lund & Troha, 2008; Tincani, Crozier, & Alazetta, 2006). Tincani and Devis (2010) did not find that PND differed significantly by learner age, Ganz, Earles-Vollrath, Mason, et al. (2011) found that IRD showed significant differences for the effects of AAC on preschool age, elementary school age, and secondary school age groups. The effect size significantly decreased with age, with younger learners generally benefitting more than older learners. This finding suggests the need to further investigate the effects of learner age on PECS outcomes, specifically using a state-of-the-art data analysis method.

Disability classification. Although PECS is primarily used with learners with ASD, it has also been evaluated when used with learners with other types of intellectual/developmental disabilities (IDD), either alone or co-morbid with ASD. Additionally, limited research has been conducted on the use of PECS with children with ASD who have co-morbid visual or hearing impairments (e.g., Ganz, Earles-Vollrath, Heath, et al., in press; Ganz, Earles-Vollrath, Mason, et al., 2011; Ganz, Simpson, et al., in press; Lund & Troha, 2008). Tincani and Devis (2010) grouped participants into an ASD group and an unspecified “other diagnosis” group” but found no significant difference in PND between the two groups. However, in their meta-analysis of AAC using IRD, Ganz, Earles-Vollrath, Heath, and colleagues (in press) found that learners with ASD alone (with or without co-morbid speech impairment) had significantly larger effect sizes than learners with ASD and co-morbid IDD. Learners with co-morbid ASD, IDD, and a sensory impairment had significantly lower effect sizes than both comparison groups. This suggests that the presence of multiple impairments may present significant barriers to the acquisition of communication skills through AAC. This presumption has significant implications relative to selecting an intervention for a learner with multiple disabilities.

Phase of PECS mastered. PECS consists of six phases of progressively complex training, starting with exchanging a picture with a communicative partner in order to obtain a desired item (Frost & Bondy, 2002). In many cases, especially in individuals with severe disabilities, only the first three phases of PECS have been taught (e.g., Angermeier, Schlosser, Luiselli, Harrington, & Carter, 2008; Carre, Le Grice, Blampied, & Walker, 2009; Bondy & Frost, 1994). Teaching through phrase three teaches picture exchange and icon discrimination but does not include teaching phrases (e.g., I SEE, I WANT), adjectives, or discrimination by color, shape, or other features.(see Frost & Bondy, 2002; Ganz, Simpson et al., in press). Meta-analyses by Tincani and Devis (2010) and Hart and Banda (2010) found that most participants in research studies only mastered the first three phases of PECS and that no participants in either set of studies mastered all six phases. Although PND scores did not significantly differ by highest phase of PECS mastered, PND scores were markedly lower for participants who only mastered the first phase of PECS (Tincani & Devis, 2010).

Purpose

The present study seeks to expand on the current meta-analytic research on the efficacy of PECS and potential participant and intervention variables that may impact learner outcomes. The use of an IRD method of data analysis provides a more statistically sensitive method for detecting between-group differences. Previous IRD analyses of AAC (Ganz, Earles-Vollrath, Mason, et al., 2011) suggests that participant variables may indeed impact outcomes, but these analyses have not been conducted with PECS alone. This study provides a methodologically rigorous meta-analysis of the impact of setting, phase of PECS mastered, pre-intervention speech abilities, learner age, and learner diagnosis on target and collateral outcomes in PECS, thus providing empirically supported guidance for both researchers and practitioners.

Research questions

1. Do mean IRD effect sizes for PECS outcomes differ based on (a) learner age, (b) learner diagnosis, (c) pre-intervention speech abilities, (d) training setting, or (d) phase of PECS mastered?
2. Do mean IRD effect sizes for PECS differ for targeted versus collateral outcomes?
3. Do the effects of the variables in question 1 differ for targeted versus collateral outcomes?

Method

Literature Search

A literature search was conducted, focusing on the use of AAC systems with individuals with ASD. *Academic Search Complete, ERIC, Psychological and Behavioral Sciences Collection,* and *Professional Development Collection* online databases were searched for literature published between 1980 and 2009. Keywords targeted initially included: *autis*, autism spectrum disorder*, ASD, pervasive developmental disorder*, PDD, PDD-NOS, Asperger*, Asperger syndrome,* and *Asperger's syndrome* and one of these keywords: *AAC, augmentative communication, alternative communication, augmentative and alternative communication, PECS,* and *Picture Exchange Communication System*. One hundred sixty-eight articles, books, book chapters, dissertations, and other literature were obtained as a result of this search protocol.

Procedures

Next, each document was assessed to determine whether or not it met all of the following inclusion criteria: (a) the participants were diagnosed with an ASD (i.e., one of the Pervasive Developmental Disorders in the Diagnostic and Statistical Manual, Fourth Edition—Text Revision [DSM-IV-TR]; APA, 2000); (b) the participants' target behaviors included social skills,

adaptive behavior, challenging behavior, communication, or academic skills; (c) PECS was implemented; (d) the study employed a single-case research design demonstrating experimental control (i.e., reversal, multiple-baseline, alternating treatment); (e) the data for at least one target behavior were displayed as line graphs; (g) the articles were published in high quality peer-reviewed journals; and (h) articles were in English. Group studies investigating the effects of PECS on individuals with ASD (e.g., Yoder & Stone, 2006a; 2006b) were not included in this meta-analysis; effect sizes resulting from single case studies are often two to three times larger than effect sizes from group studies; thus they cannot be meaningfully summarized together (Beretvas & Chung, 2008).

Eight-five percent of the documents were assessed for inclusion or exclusion by two independent evaluators. Most of the documents that were excluded were not in peer-reviewed publications (e.g., book chapters, dissertations), were not single case studies (e.g., large group studies, descriptions of interventions, case studies), or did not include participants with ASD. A few of the documents that were excluded were single-case designs that did not demonstrate experimental control (e.g., ABCD designs). When inclusion judgments between the two independent evaluators were in disagreement or one evaluator was unsure, a third researcher evaluated the document and the decision made by two of the three evaluators stood. Following this process, 13 articles were identified for inclusion in the meta-analysis.

Data Extraction

The 13 articles were each summarized, including study design, participant descriptions (number, sex, age range, diagnosis), settings, most advanced phase of PECS implemented, target behavioral outcomes, and summary of the results. This summary is found in Table 1.

[Table 1 about here]

Effect Size Measure

Line graphs for participants with ASD in the included articles were analyzed to determine an effect size, the Improvement Rate Difference (IRD; Parker, Vannest, & Brown, 2009), between baseline and the entire intervention phases, excluding generalization and maintenance data points. Although the use of IRD to analyze single-case research is recent (Schneider, Goldstein & Parker, 2008), IRD is calculated via the same means as "risk difference," which has been used to analyze the effects of medical treatment for some time (Armitage, Berry & Matthews, 2002; Altman, 1999; Sackett, Richardson, Rosenberg & Haynes, 1997). Risk difference is defined as a summary of treatment efficacy (http://www.cochrane.org/; Cochrane Collaboration, 2006).

IRD is the change in percent of high, or “improved,” scores from the baseline to the intervention phases (e.g., if the baseline phase has 20% high scores, and the intervention phase has 95% high scores, IRD will equal 95% - 20% = 75%. An improved score in the baseline phase (A) is one which is above some of the intervention phase (B) scores, and a low score in B is one that is below some A scores. If all of the B scores are above the A scores, IRD is 1.00. If the scores in A and B are the same, IRD equals zero (see Parker et al., 2009, for directions for calculating IRD).

IRD has a maximum value of 1.00, and a chance-level change between phases of .50 (Parker et al., 2009). Parker et al. determined general effect categories for IRD scores by comparing IRD to visual analysis results for 166 single case data sets, resulting in the following guide: IRD at about .50 or lower signifies small or questionable effects; between about .50 and .70 suggests moderate effects; and approximately .70 or .75 or higher are large or very large

effects. This meta-analysis of PECS research utilized IRD, with confidence intervals (CIs) to indicate precision and credibility of obtained IRD values.

Statistical significance

Statistical significance within moderator variables was calculated using the Mann-Whitney U (MW-U) statistical hypothesis test. MW-U is a non-parametric test that assesses differences between two independent samples (Siegel & Castellan, 1988). In cases where the moderator had more than two variables, each pairwise combination of variables was analyzed separately.

Inter-observer Agreement for Effect Size Calculations

The 13 articles each had more than one IRD phase comparisons for multiple participants and target behaviors, resulting in 104 IRD calculations. The numbers of improved (high) and not improved (low) data points in each phase on each graph and for each target behavior were counted, resulting in 416 total improved/not improved counts (or 4 per IRD calculations). Of the 416, 236 (57%) were independently counted by two of the authors. IOA was calculated by dividing the number of agreements (222) by the total number of improved/not improved counts (236) and multiplying by 100, resulting in an overall IOA of 94%. Disagreements were discussed and recalculated until both authors agreed. Once a high rate of agreement was attained (over 90%), the remaining IRD calculations were made by one author. The few errors that existed were due to difficult-to-view and inexact graphs and counting errors.

Results

Omnibus Effects

Overall, data from this study yielded 94 separate effect sizes from 13 studies. The mean IRD for all studies including *targeted* and *non-targeted* outcomes was .56 CI_{95} [.49, .62] with a

range of -0.51 to .95 (See figure 1). The wide range of scores found in this study supports the notion that PECS has potential to positively impact student outcomes, albeit additional factors may account for effects.

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Insert Figure 1 about here

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Targeted vs Non-targeted Outcomes. The first analysis examines the differential effect of PECS for *Targeted* outcomes in relation to PECS for *Non-targeted* outcomes (e.g. Challenging behavior, Socialization, and Speech communication). In this analysis, all *Non-targeted* variable outcomes were grouped together to facilitate comparison for the first analysis (See Figure 2). In a secondary analysis the *Non-targeted* variable was evaluated separately.

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Insert Figure 2 about here

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The *Targeted* variable included 52 separate effect sizes from 7 studies. The mean IRD for all studies of targeted outcomes was .65 CI_{95} [.59, .73] with a range of -0.20 to .95. The *non-targeted* variable included 42 separate effect sizes from 6 studies. The mean IRD for all investigations of non-target outcome was .45 CI_{95} [.35, .56] with a range of -0.51 to .92.

Within the *Non-targeted* variable, three categories of outcomes (Challenging behavior, Socialization, and Speech communication) were evaluated separately. Studies with *Challenging behavior* as the outcome included 10 effect sizes from two studies. The mean IRD for studies with *Challenging behavior* was .61 CI_{95} [.48, .73] with a range of .17 to .78. Studies with *Socialization* as the outcome included four effect sizes from two studies. The mean IRD for

studies with *Socialization* was .73 CI_{95} [.53, .93] with a range of .30 to .86. Finally, studies with *Speech communication* as the outcome included 28 effect sizes from five studies. The mean IRD for studies with *Speech communication* was .37 CI_{95} [.22, .52] with a range of -.51 to .91. Results from *Challenging behavior* and *Socialization* variables should be considered preliminary due to low numbers of studies evaluating these outcomes.

Statistically significant differences were detected between mean IRD values for the *Targeted* and *Non-targeted* variables. Studies that evaluated *Targeted* outcomes had a mean IRD value that was higher than studies with *PECS Non-targeted* outcomes; the difference in mean IRD for these variables is statistically significant (p = .010). When evaluating differences between mean IRD values for specific *non-target* outcomes, no statistically significant differences were detected.

Student age. Student outcomes were evaluated based on student *Age.* This variable assesses differences among students within *Preschool, Elementary,* and *Secondary* age ranges. Given the significant differences between *PECS targeted* and *PECS non-targeted* outcomes, this variable was divided to show differences in effect based on student age for both *targeted* and *non-targeted* outcomes (See Figure 3).

Insert Figure 3 about here

Statistically significant differences were detected when comparing mean IRD differences between *Preschool* age students for *PECS targeted* and *PECS non-targeted* outcomes (*p* = .00). No statistically significant differences were detected based on outcome for *Elementary* age (*p* = .56) or *Secondary age* (*p* = .21) students.

Within the *Targeted* variable, *Preschool* age students had 18 separate effect sizes from 8 studies. The mean IRD for *Preschool* age students with targeted outcomes was .79 CI_{95} [.71, .88] with a range of 0.11 to .95. *Elementary* age students had 29 separate effect sizes from 5 studies. The mean IRD for Elementary age students with targeted outcomes was .60 CI_{95} [.51, .69] with a range of -0.2 to .88. *Secondary* age students had 5 separate effect sizes from 3 studies. The mean IRD for *Secondary* age students with targeted outcomes was .49 CI_{95} [.27, .70] with a range of -0.2 to .88.

When comparing mean IRD differences in the *Age* variable for *Targeted* outcomes, statistically significant differences were detected between *Preschool* age and *Elementary* age students ($p = .000$). In contrast, no statistically significant difference was detected between *Preschool* age and *Secondary* age students ($p = .06$). Despite a large difference in mean IRD score between *Preschool* age and *Secondary* age students for targeted outcomes, results should be considered preliminary given the small sample of effect sizes for *Secondary* age students with targeted outcomes. No statistically significant differences were detected between *Elementary* age and *Secondary* age students ($p = .61$).

Within the *Non-targeted* variable, *Preschool* age students had 31 separate effect sizes from 6 studies. The mean IRD for Preschool age students with non-targeted outcomes was .48 CI_{95} [.38, .58] with a range of 0.09 to .88. *Elementary* age students had four separate effect sizes from two studies. The mean IRD for *Elementary* age students with non-targeted outcomes was .44 CI_{95} [-.19, 1.00] with a range of -0.51 to .92. *Secondary* age students had 7 separate effect sizes from 1 study. The mean IRD for *Secondary* age students with non-targeted outcomes was .32 CI_{95} [.05, .60] with a range of -0.10 to .82.

When comparing mean IRD differences in the *Age* variable for *Non-targeted* outcomes, statistically significant differences were not detected between *Preschool age* and *Elementary Age* (p = .47) or *Preschool age* and *Secondary age* (p = .24). Furthermore, no statistically significant differences were detected between *Elementary age* and *Secondary age* students for non-target behaviors (p = .25).

Disability category. Student outcomes were also evaluated based on *Disability Category*. This variable assesses differences among student with a single diagnosis of *Autism*, students with the diagnosis of *Autism and an Intellectual Disability*, and students with *Autism and Multiple Disabilities*. The *Disability Category* variable was also separated by *targeted* and *non-target* outcomes (See Figure 4).

Insert Figure 4 about here

Statistically significant differences were detected when comparing mean IRD differences between students with the single diagnosis of *Autism* for *Targeted* and *Non-targeted* outcomes (p = .005). No statistically significant differences were detected based on outcome for students with *Autism and an Intellectual Disability* (p = .59). Currently, no studies have examined PECS non-targeted outcomes for students with *Autism and Multiple Disabilities*, therefore no comparison could be made based on this category.

Within the *PECS targeted* outcomes variable, students with a single diagnosis of *Autism* composed a large proportion of the sample. Nine studies produced 43 effect sizes in the category. Studies that examined students with a single diagnosis of *Autism* have an average IRD of .69 CI_{95} [.61, .76], with a range of effect sizes from -0.20 to .95. Studies that examined students with

the diagnosis of *Autism and an Intellectual Disability* included a total of two studies and produced six effect sizes. Studies that examined students with the diagnosis of *Autism and an Intellectual Disability* had an average IRD of .59 CI_{95} [.42, .78], with a range of effect sizes from .33 to .85. Studies that examined students with the diagnosis of *Autism and Multiple Disabilities* included a total of one study and produced three effect sizes. Studies that examined students with the diagnosis of *Autism and Multiple Disabilities* had an average IRD of .44 CI_{95} [.25, .63], with a range of effect sizes from .40 to .48. When examining differences between mean IRD values for each of the diagnostic categories for *Targeted* outcomes, no statistically significant differences were detected.

Within the *Non-targeted* variable, the sample of studies that examined students with the diagnosis of *Autism* included five studies with a total of 38 effect sizes. Studies that examined students with a single diagnosis of *Autism* have an average IRD of .43 CI_{95} [.32, .54], with a range of effect sizes from -0.51 to .92. Studies that examined students with the diagnosis of *Autism and an Intellectual Disability* included a total of two studies and produced four effect sizes. Studies that examined students with the diagnosis of *Autism and an Intellectual Disability* had an average IRD of .64 CI_{95} [.39, .89], with a range of effect sizes from .39 to .85. To date, no studies have examined students with the diagnosis of *Autism and Multiple Disabilities* for PECS non-targeted outcomes. When examining differences between mean IRD values between students with a single diagnosis of *Autism* and students with *Autism and an Intellectual Disability*, no statistically significant differences were detected (p = .16).

PECS Phase Completed. Finally, student outcomes were evaluated based on *PECS Phase Completed.* This variable assesses differences among student outcomes based on the highest phase of the PECS intervention implemented. The *PECS Phase Completed* variable was

also separated by *Targeted* and *Non-targeted* outcomes. To date, no studies have implemented only phase one or the first two phases to examine non-target outcomes. In addition, no studies have examined outcomes based on implementation of the first five phases of the intervention protocol (See Figure 5).

Insert Figure 5 about here

When comparing mean IRD differences in the *PECS Phase Completed* variable for *Targeted* and *Non-targeted* outcomes, statistically significant differences were not detected for studies that implemented the first three (p = .10) or first four (p = .81) phases. A statistically significant difference emerged between *Targeted* and *Non-targeted* outcomes for studies that implemented all six phases of the intervention (p = .005).

Within the *Targeted* outcomes variable, few studies have implemented only phase one or the first two phases. A single study with one effect size exists that examines student outcomes when implementing only the first phase of PECS. This study had an IRD value of .45 CI_{95} [.16, .74]. Likewise, only two studies with two separate effect sizes examine student outcomes when implementing the first two phases of PECS. These studies have an average IRD of .63 CI_{95} [.18, 1.00], with a range of effect sizes from 0.40 to .86. Results from studies that implement only the first phase or the first two phases of PECS should be considered preliminary due to the low sample size. The sample of studies that implemented the first three phases of PECS includes eight studies with 39 separate effect sizes. Studies that implemented the first three phases of PECS have an average IRD of .65 CI_{95} [.57, .73], with a range of effect sizes from -0.20 to .95. The sample of studies that implemented the first four phases of PECS include two studies with

two separate effect sizes. Studies that implemented the first four phases of PECS have an average IRD of .33 CI_{95} [-0.18., .83], with a range of effect sizes from 0.11 to .64. The sample of studies that implemented all six phases of PECS include two studies with six separate effect sizes. Studies that implemented all six phases of PECS have an average IRD of .84 CI_{95} [0.72., .96], with a range of effect sizes from 0.15 to .94.

Statistically significant differences were detected within the *Targeted* outcomes variable, between studies that implemented the first three phases and studies that implemented all six phases (p = .02). No statistically significant differences were detected between studies that implemented the first three phases and studies that implemented the first four phases (p = .44). Studies that implemented only the first PECS phase and the first two phases were not assessed for statistical significance due to small sample sizes in each of these categories.

Within the *Non-targeted* variable, the sample of studies that implemented the first three phases of PECS include two studies with 4 separate effect sizes. Studies that implemented the first three phases of PECS for non-targeted outcomes have an average IRD of .78 CI_{95} [.66, .91], with a range of effect sizes from 0.75 to .85. The sample of studies that implemented the first four phases of PECS, include three studies with nine separate effect sizes. Studies that implemented the first four phases of PECS for *Non-targeted* outcomes have an average IRD of .33 CI_{95} [0.00, .66], with a range of effect sizes from -0.51 to .92. The sample of studies that implemented all six phases of PECS include one study with 29 separate effect sizes. Studies that implemented all six phases of PECS have an average IRD of .45 CI_{95} [0.35, .56], with a range of effect sizes from -0.10 to .87.

Statistically significant differences were detected when comparing mean IRD differences for *Non-targeted* outcomes between studies that implemented the first three phases and studies

that implemented all six phases (p = .01). No statistically significant differences were detected between studies that implemented the first three phases and studies that implemented the first four phases (p = .12). Additionally, no statistically significant differences were detected between studies that implemented the first four phases and studies that implemented all six phases (p = .54).

Discussion

By definition children and youth with autism spectrum disorders and other developmental disabilities present a variety of communication problems (American Psychiatric Association, 2000; Spence-Cochran & Pearl, 2012). These deficits range from a complete lack of communication skills to difficulty in using words, symbols and other means to interact with others (Ogletree, et. al, 2007). Without a doubt the needs of these individuals demand systematically applied evidence-based interventions. PECS is arguably the most popular and widely applied picture/icon assisted augmentative system for addressing this need. Indeed this ubiquitous picture/icon aided augmentative system is routinely used to address communication problems of learners with ASD and other developmental throughout the world. Moreover, PECS has been judged to be a “promising” communication intervention (see, for example, assessments conducted by the National Autism Center in 2009 and Simpson et al., 2005).

Yet, in spite of its wide scale use and acceptance there are numerous unanswered questions related to the utility and efficacy of PECS. Specifically, relatively little is empirically known about those learners who are most apt to demonstrate the best outcomes when PECS is used. The direct versus indirect outcomes that result from PECS use in particular is a poorly understood and unsettled issue. The present study adds to the understanding of outcomes linked

to PECS use and refines and improves on previous meta-analyses relative to targeted vs. non-targeted variables, user age, disability classification, and the number of PECS phases completed.

In aggregate this analysis generally supports that PECS users tend to make their strongest gains on targeted outcomes. PECS explicitly purports to be a method that improves functional communication, and indeed data from this study generally hold that learner gains, as measured by intervention effect size, are strongest in areas associated with functional communication. That this finding was generally consistent across student ages and disability types makes this inference all the more trustworthy. Thus, perhaps not surprisingly, PECS appears to be a promising augmentative system that generally has moderately positive effects on functional communication skills such as making interaction initiations.

At the same time it is significant that PECS has been implicated as a means of positively affecting other socially valid behaviors, albeit not directly connected to functional communication (e.g., Charlop-Christy et al., 2002). Of course it is logical to assume that student's behavior might be positively influenced by teaching individuals purposeful and utilitarian communication skills. A central plank of positive behavior support thinking is that enhancing the communication skills of children is key to decreasing problem behaviors (see, for example, Scott, Anderson, & Alter, 2012). Moreover, some studies have suggested that PECS's users may develop spoken language (Ganz & Simpson, 2004; Ganz, Simpson et al., 2008). This potential additional benefit of PECS has not only been intriguing and motivating but it has served as a strong mitigating factor that has argued against the notion that adoption of augmentative communication strategies may deter an individual from developing functional spoken language. The present study suggests that PECS likely has modest or uncertain effects on non-functional-language targets. We consider it prudent to adhere to this relatively conservative

conclusion. At the same time, however, we think it is also important to note that although non-targeted behaviors may or may not be improved through PECS use, there appears to be little indication that PECS has a negative influence on behavioral, social and speech targets. Moreover, wide effect size variability suggests that at least some PECS's users made strong gains in some non-targeted areas; and small sample sizes make the issue of the effects of PECS on non-targeted areas a topic that clearly warrants further study.

Findings of this meta-analysis accentuate that PECS appears to produce its most positive outcomes with young children. Preschool students performed significantly better than elementary age learners on targeted outcomes. Despite a relatively large difference in mean IRD score between preschool age and secondary age students for targeted outcomes these differences were not statistically significant. This finding was inferred to be the result of a small sample of targeted outcome effect sizes for secondary age students. Thus, functionally it appears that PECS's results generally tend to be most positive with younger children; and to become less robust with older learners. This finding is consistent with the general theme that interventions used at early stages of development frequently produce the best results (National Research Council, 2001). This pattern is a comparatively common outcome relative to application of a variety of early-stage interventions with children with ASD and other developmental disabilities (Boyd, Odom, & Humphreys, 2010). Clearly, this finding has implications for practitioners, especially those involved in early intervention work.

We also think it is reasonable to attempt to give explanation to the relatively modest gains made by older children. These outcomes may be the result of long-practiced and reinforced unconventional and less-effectual communication strategies of older children and youth (e.g., primitive gestures and vocalizations, tantrums). It is also possible that these findings reflect that

educators and families are more willing to accept poor communication skills from children who have failed to respond to previous intervention attempts. That is, weak returns on previous treatment efforts and long standing communication deficits may set the stage for less enthusiastic attempts to build functional communication skills and an indisposition to aggressively employ novel communication interventions with older students. Finally we speculate that this finding may at least in part be a function of reluctance on the part of some practitioners and families to use augmentative communication programs at points in children's development when they may be able to best benefit. This common reluctance is often based on the erroneous belief that adoption of augmentative communication strategies may interfere with development of spoken language (Spence-Cochran & Pearl, 2012).

Data from this study also shed light on the poorly understand and relatively infrequently addressed question of whether PECS's bodes equally positively for students with autism diagnoses when compared to learners with autism who also present with co-morbid intellectual impairments and multiple disabilities. Limited data in the extant literature and difficulty in interpreting the exact diagnostic classification of some learners in the existing PECS's literature make it imprudent to make strong conclusive statements regarding this question. However, generally speaking learners with diagnoses of autism and autism that was accompanied by mental retardation demonstrated moderate gains in functional communication as a result of using PECS. In aggregate students with autism accompanied by multiple disabilities showed small or questionable effects for functional communication as the result of PECS's use. However, small samples available for analysis make this question one that we think is best described as unresolved. Non-targeted outcomes for students with autism and mental retardation fell within the moderate effect size range. Students with autism and no reported intellectual or sensory

disabilities had effect sizes that suggested small or questionable results. The effects of PECS on non-targeted outcomes for students with autism and multiple disabilities were not evaluated because of a lack of data.

Anecdotal evidence and our collective experiences suggest that most learners and practitioners fail to advance through the entire six phases of PECS. Indeed, data used in this study revealed that few published studies implemented only the first or first two PECS phases. The majority of the studies' participants achieved mastery of the first three phases of PECS; the effect sizes for the functional communication targets described in these studies fall within the moderate effect range. Only two studies that implemented the first four phases of PECS were used in the targeted meta-analysis, thus the small or questionable effect size finding must be cautiously considered. Non-targeted effect size findings for studies that reached the third phase of PECS suggested moderate impact. Those studies that assessed non-targeted outcomes when phase four and phase six was achieved suggested small or questionable effects, although a small number of studies were used in this particular analysis, making this inference tentative.

The link between phase achievement in the PECS protocol and functional communication and other outcomes is both significant and poorly understood. While the present meta-analysis is a significant step towards better understanding this relationship our findings are preliminary. Common sense would suggest that as students advance through the PECS protocol they will demonstrate better functional communication and other outcomes, including behavior, social interaction skill development and speech. Following this logic one would assume that in Phase I (physical exchange) and Phase II (student learns to find a picture symbol from his or her communication book and travel to the communicative partner to request a desired item) learners will acquire basic communication skills that will form the foundation for more functional and

fluid communication as well as concomitant benefits. In Phase III (discrimination) one would assume that a learner might actually be in position to begin selectively and purposefully interacting with others to satisfy wants and needs. Moreover, it would follow that Phase III benefits might include progress on non-targeted behaviors such as social skills, behavior and even speech. Furthermore one might assume that this pattern and communication growth process will continue as students achieve skills associated with Phases IV through VI of the PECS protocol. While our results are preliminary in nature, and in some instances our inferences are based on limited and extrapolated data, they nonetheless appear to generally support the notion that students who learn more advanced skills in the PECS protocol show the best results. This tentative conclusion is, of course, exploratory in nature and thus warrants additional study.

Finally this study improves upon and refines pervious meta-analyses of PECS's outcomes (Flippin, et. al, 2010; Preston & Carter, 2009; Tincani & Devis, 2010) by using a more advanced and sophisticated effect size metric. Application of the Improvement Rate Difference (IRD; Parker, et. al, 2009) serves to both establish with increased confidence the reliability of findings of other meta-analyses and lay trustworthy empirical groundwork for analysis of follow-up questions regarding PECS outcomes, such as the correlation of PECS phase achieved and direct and non-direct effects.

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Figure 1. Forest plot of omnibus effects

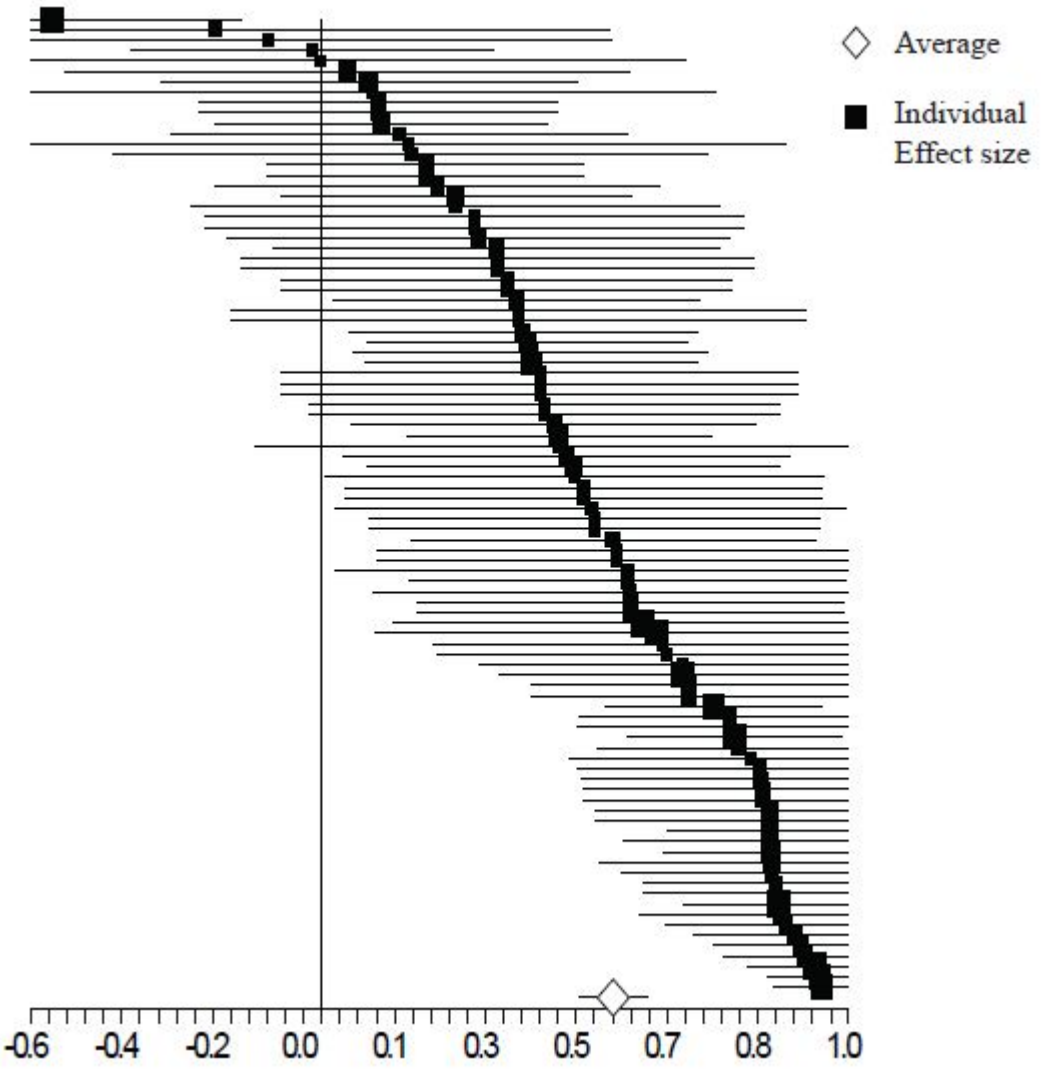

Figure 2. Forest plot of effect sizes based on targeted and non-targeted outcomes

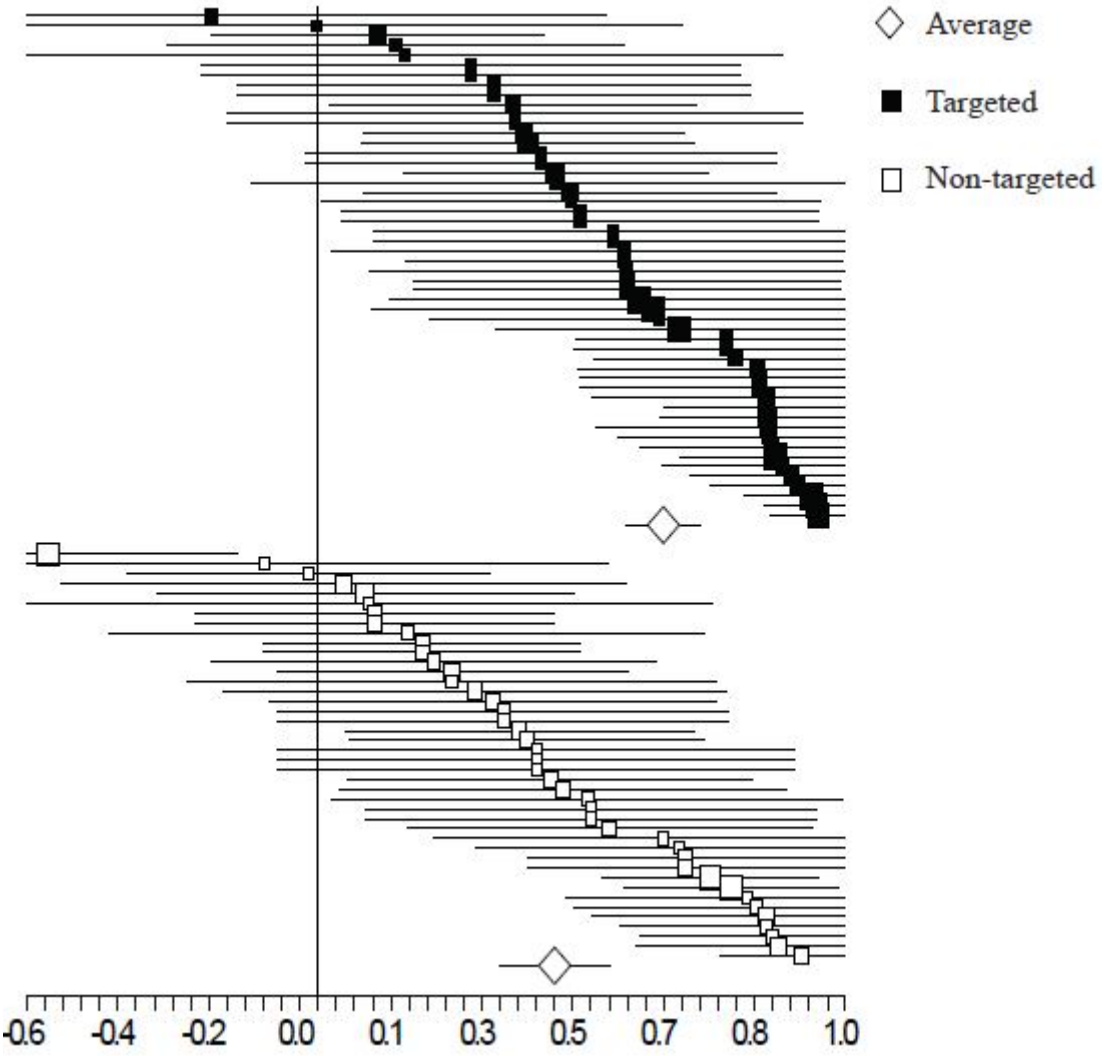

Figure 3. Forest plot of effect sizes disaggregated by Age. Effect sizes further separated by targeted and non-targeted outcomes.

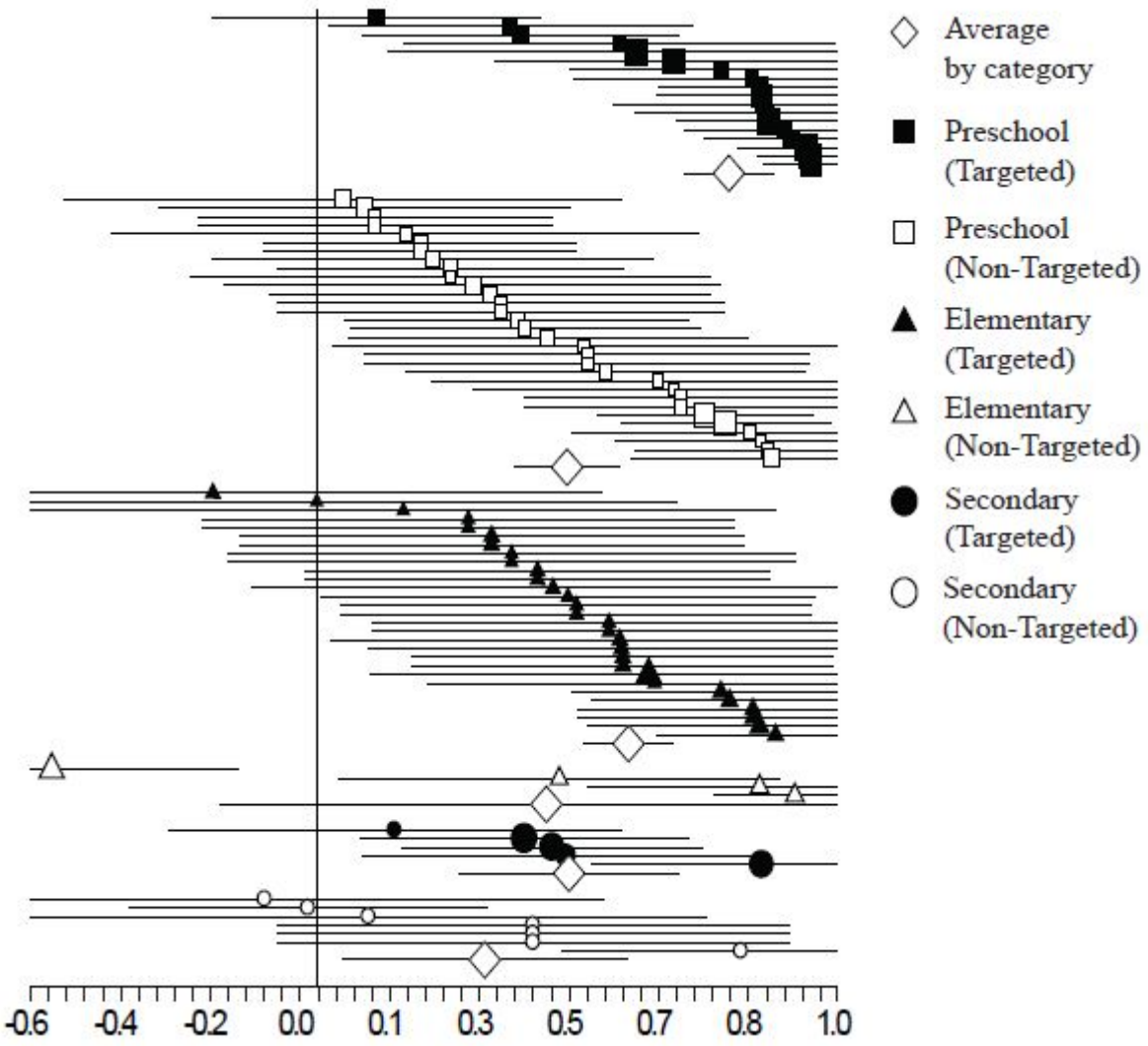

Figure 4. Forest plot of effect sizes disaggregated by student disability. Effect sizes further separated by targeted and non-targeted outcomes.

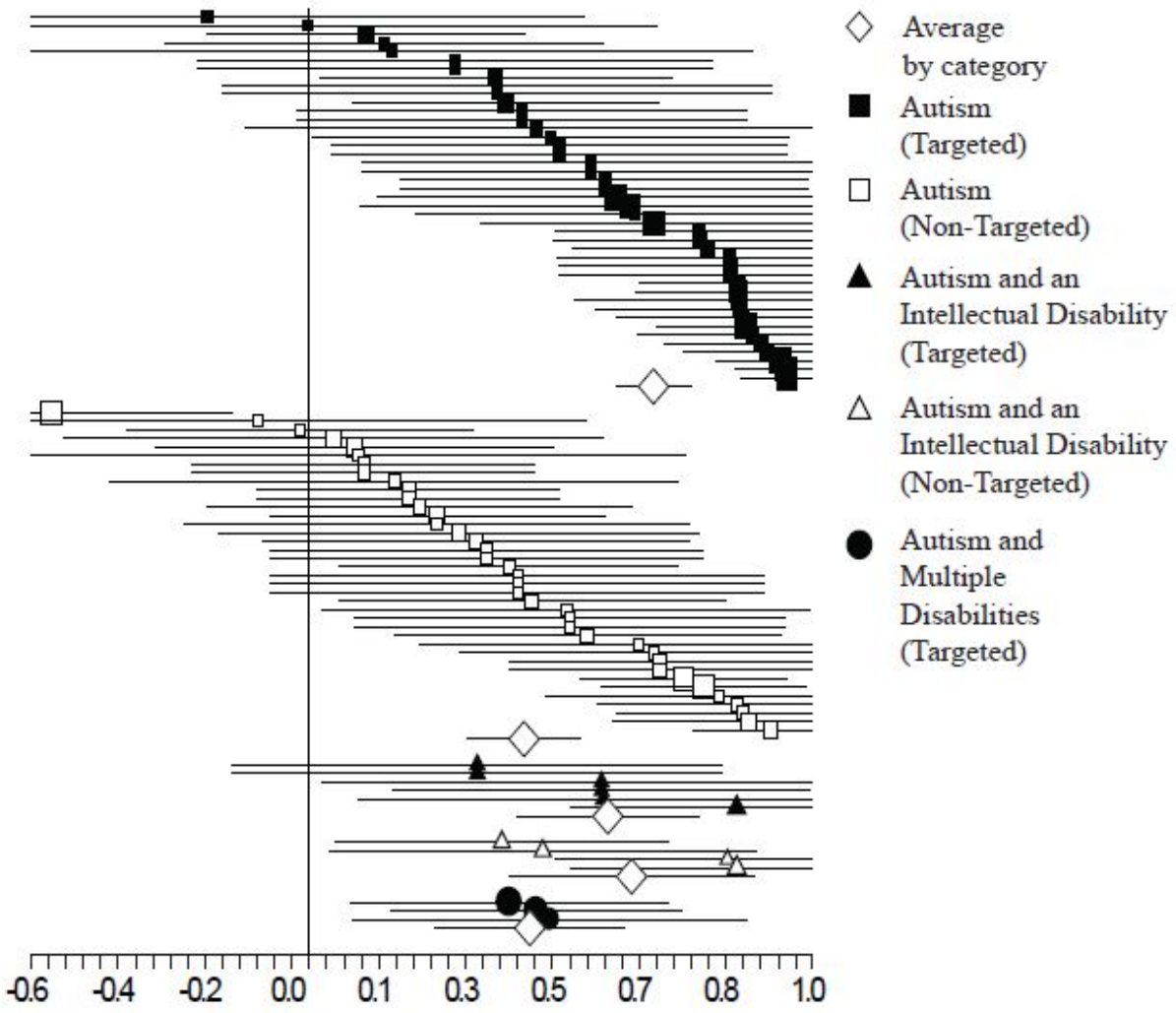

Figure 5. Forest plot of effect sizes disaggregated by highest level of PECS implemented. Effect sizes further separated by targeted and non-targeted outcomes.

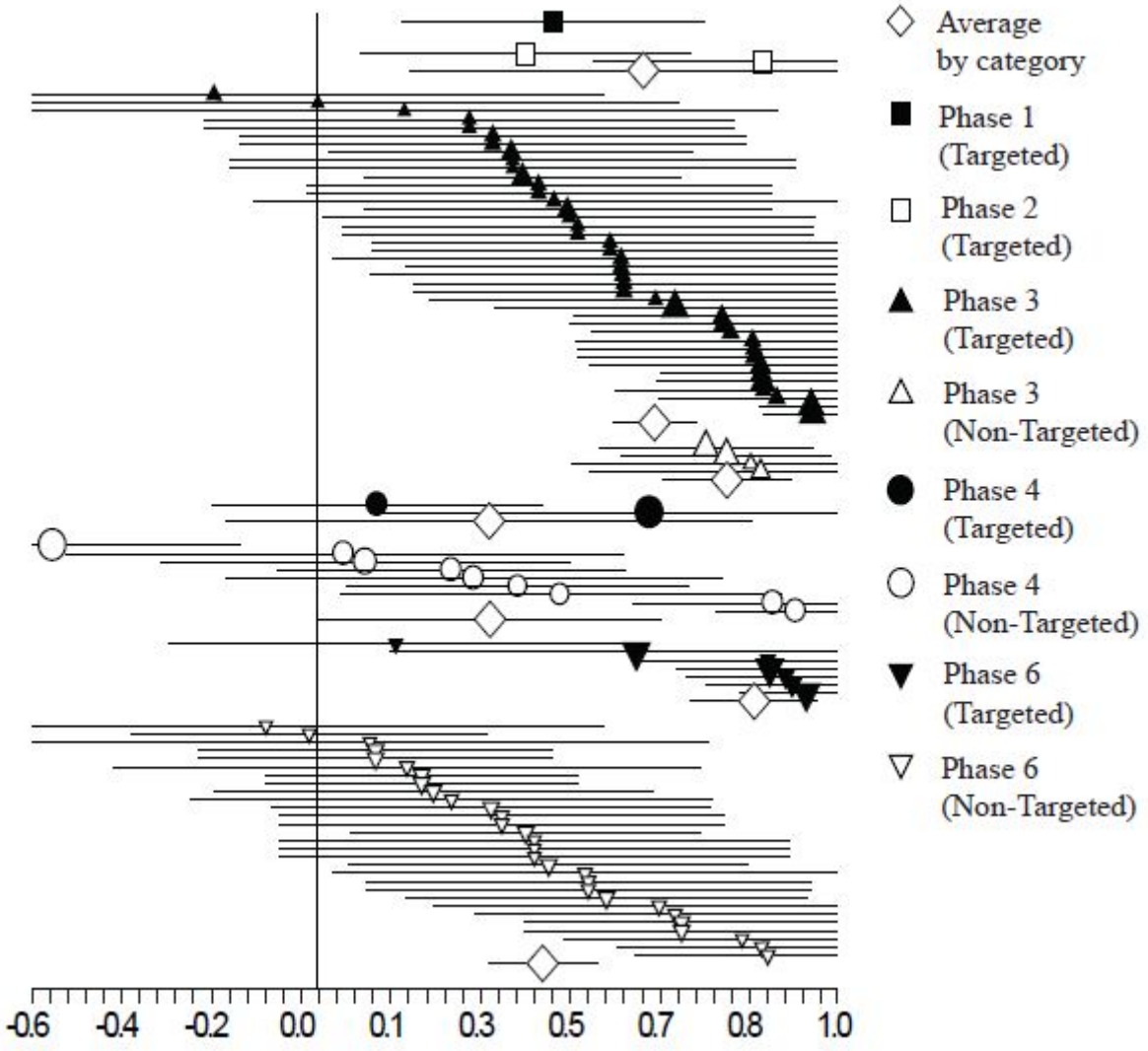

Table 1

Summary of Studies Included in Meta-Analysis

Authors	**Single-Case Design**	**Participant(s)**	**Setting**	**Target Behavioral Outcome(s)**	**Summary of Results**
Angermeier et al., 2008	AT with embedded MBD	Four boys with ASD ages 6, 7, 8, and 9 years	School (private assessment suite)	Symbol requests	Similar results were found for PCS & Bliss symbols; all participants mastered Phases I & II; Variable results for Phase III
Carre et al., 2009	MBD across participants	One male and one female with ASD age 5 years	School (separate room & self-contained special education classroom)	Spontaneous PECS requests	Mastery for all participants in Phases I & II. Less consistent results found in Phase III. Small increase of spontaneous initiations of PECS observed for all participants.
Chaabane et al., 2009	MBD across symbol categories	Two boys with ASD ages 5 and 6	Home	Independent improvisations of colors, shapes, and functions	Use of untrained symbols increased across categories; training implemented by parents.
Charlop-Christy et al., 2002	MBD across participants	Three males ages 3 to 12 years with ASD	Therapy rooms, classrooms, & home	Challenging behaviors & social-communication skills	All 6 PECS phases mastered by all participants. Social-communication skills increased. Challenging behaviors decreased.
Frea et al.,	MBD across	One male age 4	School	Frequency of	Disruptive behaviors

2001	settings	years with ASD	(general education preschool classroom)	disruptive behaviors and picture exchanges	decreased and communication skills increased.
Ganz & Simpson, 2004	Changing criterion	Two males and one female ages 3 to 7 years with ASD, ID	School (general education classrooms)	Percentage of independent picture requests, average words per trial, and percentage of trials with non-word vocalizations	All participants made progress toward mastery of PECS exchanges and verbal utterances. Skills generalized to other adults.
Jurgens et al., 2009	Multiple probe across participants	Three males ages 4 to 5 years with ASD, ID	School (special education preschool classroom)	Percentage of correct use of communication skills	Participants were able to request entrance into play using pictures.
Kravits et al., 2002	MBD across settings	One female age 6 years with ASD	Home; School (general education classroom)	Frequency of spontaneous language and social interaction	Spontaneous verbalization increased across 3 settings; verbalizations increased in 2 settings; social interaction increased in 1 setting
Lund & Troha, 2008	MBD across participants	Two males and one female ages 12 to 17 years with ASD, ID, VI	School (self-contained classroom)	Percentage of correct requests	One of three participants completed all phases. The other two participants showed improvement but did not reach mastery.
Marckel et al., 2006	MBD across descriptors	Two males ages 4 and 5 years with ASD	Home	Frequency of independent requests with	Number of improvised requests improved. Skills generalized

				adjective improvisation	across items, settings and people.
Tincani, 2004	AT	One male and one female ages 5 and 6 years with ASD, ID	School (self-contained classroom)	Percentage of picture requests and vocalizations	One participant responded more strongly to PECS while the other responded more positively to sign language. Vocalization increased for both participants.
Tincani et al., 2006 (two studies within one article)	MBD across participants	Two males ages 10 and 11 years with ASD	School (Separate room; self-contained classroom)	Percentage of independent picture requests and vocalizations	Both participants mastered phases I-IV of PECS. One participant displayed vocalizations during phase IV.
	AT	One male age 9 years with ASD	School (Separate room; self-contained classroom)	Percentage of vocalizations	Vocalizations reached mastery only in the contingent reinforcement phase.
Yokoyama, 2006	MBD across participants and Changing Criterion within Participants	Three males ages 5, 5, and 7 years with with ASD	Home	Percent of Trials with Correct Responding	All participants mastered the four target behaviors. Vocalization increased for all participants.

Note. Design Codes: AT = Alternating Treatment, MBD = Multiple baseline design. Participant codes: ASD = Autism Spectrum Disorder, ID = Intellectual Disability, VI = Visually Impaired. Summary of Results codes: PCS = Picture Communication Symbols