Research in Developmental Disabilities 34 (2013) 4404–4414

Contents lists available at ScienceDirect

Research in Developmental Disabilities

Review article

Comparisons of intervention components within augmentative and alternative communication systems for individuals with developmental disabilities: A review of the literature

Cindy Gevarter [a,*], Mark F. O'Reilly [a], Laura Rojeski [a], Nicolette Sammarco [a], Russell Lang [b], Giulio E. Lancioni [c], Jeff Sigafoos [d]

[a] University of Texas at Austin, USA
[b] Texas State University, San Marcos, TX USA
[c] University of Bari, Italy
[d] Victoria University of Wellington, New Zealand

ARTICLE INFO

Article history:
Received 10 September 2013
Accepted 10 September 2013
Available online 18 October 2013

Keywords:
Augmentative and alternative communication
Developmental disabilities
Autism spectrum disorder
Comparisons
Review
Single subject designs
Group experimental intervention
Intervention

ABSTRACT

Decisions regarding augmentative and alternative communication (AAC) for individuals with developmental disabilities (e.g. what AAC to use and how to teach a person to use a specific AAC modality) should involve consideration of different intervention component options. In an effort to elucidate such decisions and options, this review synthesized 14 studies, published between 2004 and 2012, comparing different AAC intervention components including different symbol sets, instructional strategies, or speech output within aided AAC systems, and different verbal operants within unaided AAC. Evidence supported the following: (a) different instructional strategies such as building motivation, using errorless learning, or adding video models to picture exchange interventions may improve the acquisition or rate of acquisition of picture exchange mands, (b) limited data supports training mimetic (imitated) or mand signs over tacts and (c) differences in symbol sets and speech output levels appeared to have little effect on AAC-based mand acquisition, but listener-based differences should be considered. These findings have implications for future research and clinical practice.

Contents

* Corresponding author at: Department of Special Education, 1912 Speedway, D5300, The University of Texas at Austin, Austin, TX 78712, United States. Tel.: +1 512 471 9857; fax: +1 512 471 2471.
E-mail addresses: cindygev@gmail.com, cindygev@utexas.edu (C. Gevarter).

0891-4222/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ridd.2013.09.018

1. Introduction

Augmentative and alternative communication (AAC) refers to the use of non-vocal communication systems and the associated intervention strategies that are implemented to teach AAC use (Beukelman & Mirenda, 2005; Sigafoos, Schlosser, & Sutherland, 2013). AAC is recommended for individuals who either have unintelligible or limited speech abilities, or who lack speech altogether (Sigafoos et al., 2013). Individuals with disorders that affect the functional use of speech, and therefore may be more likely to use AAC, include those with a variety of developmental disabilities such as autism spectrum disorder (ASD; Romski & Sevcik, 1997; Sigafoos et al., 2013). Implementing AAC with these individuals requires multiple instructional decisions such as selecting the type of system and elements within a system (e.g., specific graphic symbols to use), as well as the specific instructional strategies to implement (Schlosser & Sigafoos, 2006). Research has demonstrated the utility of different AAC approaches for individuals with developmental disabilities, including aided approaches designed to augment or replace language with systems such as picture books which are external to the learner, and unaided approaches such as manual sign (Mirenda, 2003; Sigafoos et al., 2013). Research comparisons of different intervention components within AAC systems (e.g. symbol set comparisons, instructional strategy comparisons) can also guide clinical decisions (Mirenda, 2003; Schlosser & Sigafoos, 2006).

In order to guide AAC clinical decisions for individuals with developmental disabilities, Schlosser and Sigafoos (2006) synthesized findings from comparative AAC single subject research. While their review included comparisons between different forms of AAC (e.g. aided and unaided AAC), it also emphasized the importance of comparing different components within interventions for specific AAC systems. Examples of such examinations included comparisons of instructional strategies for aided and unaided approaches (e.g. Bennett, Gast, Wolery, & Schuster, 1986; Berkowitz, 1990; Sigafoos & Reichle, 1992), different symbol sets or organization for aided systems (e.g. Hurlbut, Iwata, & Green, 1982; Kozleski, 1991; Reichle, Dettling, Drager, & Leiter, 2000) and varying levels of speech output on speech output devices or SGDs (e.g. Schlosser & Blischak, 2004; Sigafoos, Didden, & O'Reilly, 2003). Some studies were rated as inconclusive (e.g. Kozleski, 1991; Reichle et al., 2000), while others suggested no differences between conditions (e.g. Sigafoos et al., 2003; Sigafoos & Reichle, 1992). Several studies, however, supported differences that led to clinical recommendations. For instance, Bennett et al. (1986) reported that a progressive time delay was equally effective, but more efficient than a system of least prompts for teaching manual sign use. Schlosser and Blischak (2004) found that different combinations of speech and print-output did not affect the acquisition of expressive spelling with an SGD, but efficiency differed idiosyncratically. Hurlbut et al. (1982) reported generalization advantages of Rebus symbols over Bliss symbols.

The corpus of research focused on comparing intervention components within AAC systems has grown since Schlosser and Sigafoos' (2006) review. This growing body of research has included the use of a variety of techniques and methodologies that had not been employed prior to the Schlosser and Sigafoos' review. For example, recent research has involved functional analysis procedures to examine and compare AAC interventions (e.g. Normand, Severtson, & Beavers, 2008; Plavnick & Ferreri, 2011). Furthermore, new forms of AAC, such as the Apple iPad® (Kagohara et al., 2013), which have a myraid of different options and components had not yet appeared in the research literature. Given the increase in research and the appearance of new AAC approaches and options, an updated review of comparative research examining intervention components within AAC is warranted. The purpose of this paper will be to review single subject and group experimental studies published from 2004 to 2012 that compared AAC intervention components within systems in order to provide clinical and research recommendations.

2. Methods

2.1. Search procedures

The initial search used the Boolean terms (autis* or intellectual disab* or developmental disab*) and (compar* or alternating or versus or analyze or analysis) and (augmentative alternative communication). Additional searches were conducted in which the term (augmentative alternative communication) was replaced with specific terms such as (manual sign) or (speech output). The terms were used to conduct searches in the Cumulative Index for Allied Health Literature (CINAHL), Educational Resources in Education Clearinghouse (ERIC), MEDLINE, PsycINFO, and Proquest Dissertations and Theses databases. Corresponding to the submission date (January 2004) of Schlosser and Sigafoos (2006), a year limit of 2004–2012 was utilized. To supplement the database searches, an author search and a hand search of *Augmentative and*

Alternative Communication, which is the main journal for the AAC field, were conducted. References from related reviews (e.g. Hart & Banda, 2010; Lancioni et al., 2007; Nunes, 2008) were also examined.

2.2. Inclusion and exclusion criteria

Included studies met the following criteria: (a) included participants with developmental disabilities (e.g. autism and intellectual disabilities) regardless of age, (b) used a single subject design or group experimental design to compare at least two intervention components within an AAC system (e.g. elements of system and instructional strategies), (c) evaluated efficacy outcomes related to communication (i.e. expressive or receptive use of AAC) and/or collateral effects of AAC used (e.g. increases in vocalization) and (d) could be either a dissertation or peer-reviewed journal article published in English between 2004 and 2012. Studies with listener-based comparisons that could impact the effectiveness of an AAC system in terms of the reinforcement of communicative responses were included (i.e. Charlop, Malmberg, & Berquist, 2008). If dissertation data were later published in a journal, the dissertation version of the data was excluded (e.g. Plavnick, 2010). Studies without established experimental designs (e.g., Barton, Sevcik, & Ann Romski, 2006; Stephenson, 2009) were excluded. While studies examining the receptive identification of AAC symbols, and expressive spelling on SGDs were included due to having a relation to communication, studies examining only receptive academic skills, such as learning letter sound and name correspondence were excluded (e.g., Johnston, Buchanan, & Davenport, 2009). While the 2004–2012 criterion was based upon the January 2004 submission date of Schlosser and Sigafoos (2006), studies that appeared in the prior review were excluded (e.g. Schlosser and Blischak, 2004). Inclusion and exclusion criteria were initially applied by reviewing abstracts, and 22 studies were selected for further review. Ultimately 14 of the 22 studies met the inclusion criteria.

2.3. Data extraction and coding

Data from the 14 included studies were summarized in terms of: (a) participants, (b) AAC component comparisons, (c) design, (d) findings, and (e) certainty of evidence. For participant descriptions, primary diagnoses were used and age was coded by year, as age in years and months was not provided by all authors. Comparisons were qualitatively described and grouped into the following comparison groups: symbols, instructional strategies or speech output level for aided AAC, and verbal operants (i.e. communication targets) for unaided AAC. Designs were also coded qualitatively. Designs with alternating conditions and baselines were described as an alternating treatments design (ATD) and those without baselines were labeled multielement (Kennedy, 2005). When ATDs involved different instructional sets, they were labeled as an adapted alternating treatments design (AATD; Sindelar, Rosenberg, & Wilson, 1985; Schlosser & Sigafoos, 2006).

All AAC comparative findings were qualitatively described, and non-comparative results were excluded. These findings were summarized across effectiveness and/or efficiency of interventions for communication outcomes. For single subject designs with learner-based comparisons, effectiveness was defined as the degree to which individuals met or approached mastery criterion, while efficiency was defined as the rate at which mastery was obtained (Schlosser & Sigafoos, 2006). Visual analysis comparing rates of responding was used as a measure of effectiveness if mastery criterion was not provided. For single subject designs with listener comparisons, effectiveness was determined by visually comparing rates of correctly reinforced responses. For group studies, differences in effectiveness were determined by statistically significant responding between groups. A secondary outcome subcategory included collateral vocalization and maintenance or generalization.

Certainty of evidence was determined using methods adapted from Schlosser (1999) and Schlosser and Sigafoos (2006). General evidence appraisals can be made across all participants and outcomes, but previous research involving AAC and individuals with developmental disabilities has often supported idiosyncratic differences (Schlosser and Sigafoos, 2006; van der Meer, Sigafoos, O'Reilly, & Lancioni, 2011). The appraisal of evidence was made for distinct outcomes (e.g. efficiency versus collateral vocalization) in terms of support for either comparative differences or no differences between conditions across all participants, or for individuals (in single subject studies). Ratings of inconclusive, suggestive, preponderant, or conclusive were assigned. Conclusive ratings were given when there were strong consistent data patterns (significant differences for group studies), limited to no minor design limitations and adequate IOA and procedural integrity (i.e. above 80% for at least 20% of sessions). Findings demonstrating relatively consistent and strong patterns in data (or significant differences for group studies), with only minor limitations in design and adequate IOA and procedural integrity, or strong design and data with questionable IOA or procedural integrity, were rated as preponderant. Suggestive evidence included combinations of limited or inconsistent patterns in data, minor design limitations, or inadequate inter-observer agreement (IOA) or procedural integrity. Evidence was rated as inconclusive when there were no clear patterns (or no significant differences for group studies), insufficient data points, major design limitations, or combinations of multiple design limitations and inadequate IOA or procedural integrity. The quality of the research designs for the included studies was evaluated in terms of the extent to which the design controlled for sequence and carryover effects and prior experience (Schlosser, 1999, 2003; Schlosser & Sigafoos, 2006). For AATDs, attempts to randomly assign and equate instructional sets were also considered when evaluating the quality of the design (i.e. failure to randomly assign or equate sets would each considered a design limitation of AATDs). Similarly, group studies were also evaluated in terms of group randomization techniques.

2.4. Reliability

Summaries of the 14 included studies were created by the first author and the accuracy of a randomly selected subset of these summaries ($n = 4$; 29%) were independently checked by co-authors using a checklist adapted from Ramdoss et al. (2011). The checklist included questions regarding the accuracy of: (a) the participants, (b) AAC component comparisons, (c) the design, (d) comparative findings, and (e) the certainty of evidence. Inter-rater agreement (IRA) was calculated across 20 items on which there could be agreement or disagreement (i.e., 4 studies with 5 questions per study). Initial agreement was obtained on 19 items (95%), and discrepancies were discussed between authors until 100% agreement was obtained.

3. Results

Table 1 provides a summary of each of these 14 studies. The 14 studies included a total of 63 participants. Participants in the 13 single subject studies included 28 males and 6 females between 1 and 50 years of age ($M = 11.1$ years). Exact ages and genders for 29 participants in one included group study were not provided, but ages ranged from 4 to 6 years old, and means for the two groups were 5.5 and 5.6 years old (Carr & Felce, 2008). Across single subject and group studies, participants had primary diagnoses of ASD ($n = 51$; including autism and pervasive developmental disorder not otherwise specified [PDD-NOS]), intellectual disability ($n = 8$), developmental delays ($n = 4$). Designs included AATD ($n = 4$), combined ($n = 4$), multielement ($n = 3$), reversal ($n = 1$), multiple baseline ($n = 1$) and group experimental ($n = 1$). Studies assessed aided AAC symbol comparisons ($n = 4$), aided AAC instructional strategy comparisons ($n = 5$), aided AAC speech output comparisons ($n = 4$) and unaided AAC verbal operant comparisons ($n = 2$).

3.1. Aided AAC symbol comparisons

Four studies with 13 total participants examined whether the use of different symbols influenced the outcomes from Picture Exchange Communication System (PECS) training (Angermeier, Schlosser, Luiselli, Harrington, & Carter, 2008; Charlop et al., 2008; Jonaitis, 2011) or receptive symbol identification with an SGD (Koul and Schlosser, 2004). All four studies examined measures related to effectiveness and/or efficiency of interventions for communication outcomes and Angermeier et al. (2008) also assessed maintenance at a one-week follow-up. Two studies provided evidence that PECS acquisition did not generally differ based upon the use of low versus high iconicity symbols, or pictures versus photographs (Angermeier et al., 2008; Jonaitis, 2011). One study measuring maintenance also did not support an effect for symbol iconicity (Angermeier et al., 2008). Phase III data (i.e. requests involving discriminations between symbols) for both acquisition and maintenance were, however, inconclusive for a majority of participants in the Angermeier et al. (2008) study. In contrast, Koul and Schlosser (2004) provided suggestive evidence (limited by the number of IOA sessions and lack of treatment fidelity) that high iconicity symbols on an SGD were more likely to be receptively identified than low iconicity symbols. In another study involving learner and listener comparisons, it was unclear if adding braille to PECS symbols impacted the requesting rates of visually typical learners with autism who interacted with listeners with and without visual impairments (Charlop et al., 2008). There was preponderant evidence, however, that requests made with PECS with braille were more likely to be correctly reinforced by a listener with visual impairments than PECS without braille (Charlop et al., 2008).

3.2. Aided AAC instructional strategy comparisons

Five studies, with a total of 41 participants, evaluated the influence of different instructional strategies on AAC acquisition (Carr & Felce, 2008; Cihak, Smith, Cornett, & Coleman, 2012; Gutierrez et al., 2007; Plavnick & Ferreri, 2011; Wilson, 2007) and generalization (Plavnick & Ferreri, 2011). The studies by Carr and Felce (2008), Gutierrez et al. (2007), and Wilson (2007) focused on instructional strategies for teaching discriminated requests (i.e. requests involving an array of symbols to choose from; in these studies a field of two). Cihak et al. (2012) and Plavnick and Ferreri (2011) examined strategies for teaching the early stages of the PECS protocol (i.e. not involving discrimination). Two studies found advantages for specific strategies used to teach picture exchange (PE) or PECS in terms of effectiveness (Carr and Felce, 2008; Gutierrez et al., 2007), while three provided evidence for efficiency differences (Cihak et al., 2012; Plavnick & Ferreri, 2011; Wilson, 2007). Using a group experimental design, Carr and Felce provided suggestive evidence (limited by a lack of IOA and treatment fidelity data) that an error exclusion strategy (i.e. blocking incorrect response toward picture that did not correspond to available item) was more effective than error correction (i.e. redirecting toward correct picture after learner makes incorrect response) for teaching Phase III of PECS. Additionally, Gutierrez et al. (2007) provided preponderant evidence indicating that there were advantages to increasing the motivation to request one item in order to teach discriminated requests between two preferred items. In this study, three of the four participants correctly requested an item more frequently when they had been deprived of that item (i.e. there was an establishing operation or motivating reason to request), compared to when they had free access to the item (i.e. there was an abolishing operation in which there was no reason or motivation to request). In another study involving the teaching of discriminated requests, effectiveness comparisons involving stimulus fading strategies (fading out stimulus prompts used to highlight one symbol over another) and enhanced consequences strategies (greater levels of reinforcement for one) were inconclusive (Wilson, 2007). In this study, several sets of discrimination pairs (two items and

Table 1
Comparisons of different components within an AAC system or intervention.

Citation	Participants	Comparison and design	Effectiveness and/or efficiency for communication outcomes	Collateral vocalization, maintenance or generalization
Aided AAC symbol comparisons				
Angermeier et al. (2008)	Four males with autism ($n = 2$) and PPD-NOS ($n = 2$) ages 6–9 ($M = 7.5$)	PECS (phases I–III) low iconicity Bliss symbols compared to high iconicity PCS symbols. Combined ATD embedded in a multiple-baseline across participants	Phase I: conclusive for equal effectiveness and efficiency. Phase II: conclusive for equal effectiveness and efficiency. Phase III: conclusive for equal effectiveness and efficiency for one, inconclusive for three (no mastery and patterns unclear)	Maintenance: suggestive of no differences in phase II, inconclusive for phase III
Charlop et al. (2008)	Three males with autism ages 5–11 ($M = 6.47$)	PECS with braille compared to PECS without braille Combined multiple-baseline across participants and reversal	Preponderant that PECS with braille was more effective than PECS without braille in terms of receiving correct response from visually impaired trainer. Inconclusive with regards to effects of braille on learner's correct responses (increased for one without reversals, but inconsistent patterns for two with reversals).	–
Jonaitis (2011)	Three males and one female with developmental delays ($n = 2$) and ASD ($n = 2$), ages 1–3 ($M = 2$)	Boardmaker® picture symbols compared to digital photographs during phase III of PECS training. AATD	Preponderant that pictures and photographs were equally effective and efficient for discriminated requests for majority (similar performance with both conditions in the final sub-phase of training). Suggestive that both were equally effective for another (mastery only with the one picture symbol, but had high levels with photographs).	–
Koul and Schlosser (2004)	Two females with intellectual disabilities, ages 39 and 50	Low iconicity compared to high iconicity on an SGD ABACA/ACABA reversal designs	Suggestive that high iconicity symbols were more likely to be identified correctly than low iconicity symbols.	–
Aided AAC instructional strategy comparisons				
Carr and Felce (2008)	Twenty nine children with autism ages 4–6[a] (group 1 $M = 5.6$ group 2 $M = 5.5$)	Error correction compared to error exclusion (blocking incorrect response and only one item available) for PECS phase III with pairs of preferred items. Group experimental	Suggestive that participants taught using error exclusion had less errors than those taught with error correction, when selecting the correct picture corresponding to a desired item (as measured through correspondence checks).	–
Cihak et al. (2012)	Three males and one female with autism ($n = 2$) and developmental delays ($n = 2$), ages 3	Physical prompting compared to peer video model prior to physical prompting during PECS training. AATD	Conclusive that PECS with prompting and video modeling was more efficient. Inconclusive for effectiveness differences. Participants had increasing success with prompting only, but training with this condition was stopped when the other reached criterion.	–

Table 1 (*Continued*)

Citation	Participants	Comparison and design	Effectiveness and/or efficiency for communication outcomes	Collateral vocalization, maintenance or generalization
Gutierrez et al. (2007)	Three males and one female with autism ($n = 3$) and ID($n = 1$) ages 4–13 ($M = 7$)	PE discrimination training with two preferred items and an establishing operation for one item compared to training without establishing operation. Multielement	Preponderant that a majority (three of four) were more likely to use PE for items for which there were establishing operations, than for items for which there were no establishing operations. Fourth participant did not show differentiated patterns until difference in topographies added.	–
Plavnick and Ferreri (2011)	One male with autism, age 4[b]	Video modeling of PECS phases I and II with function preferred mands compared to intervention with non-function-preferred mands. Combined AATD with multiple probes across behaviors	Conclusive that function-preferred mands in both phases I and II of PECS were acquired more rapidly. Inconclusive with regards to effectiveness.	Generalization: preponderant function-based mands generalized more often to new settings than non-function-based.
Wilson (2007)	Three males all with ID and one with co-occurring cerebral palsy, ages 27–46 ($M = 34.3$)	Stimulus prompt fading compared to enhanced consequence fading for PE discrimination between two preferred items. Combined multiple baseline with reversals and embedded AATD	Inconclusive for effectiveness. Preponderant that there were idiosyncratic efficiency differences. One reached mastery with the first set using enhanced consequences, and stimulus fading for a second set. Another met criterion for two sets with enhanced consequences, while the other acquired three sets using stimulus fading procedures.	–
Aided AAC speech output comparisons				
Koul and Schlosser (2004)	Two females with ID, ages 39 and 50	Speech output compared to no speech output on an SGD ABACA/ACABA reversal designs	Inconclusive for speech output. There were not consistent patterns.	Collateral vocalization: inconclusive. There were not consistent patterns.
Raghavendra and Oaten (2007)	One male with cerebral palsy, age 11	Speech output compared to speech output/print, and print-only on an SGD with a spelling mode, during spelling intervention for six different sets of four words. AATD	Preponderant that all three conditions were effective for teaching spelling. Suggestive the print-only condition was more efficient than speech or speech-print. Inconclusive for comparisons between speech and speech-print conditions.	Maintenance: in conclusive. All words in the print-only and three words in speech condition were maintained. Only one session conducted for speech-print. **Generalization:** inconclusive. No generalization for any words.
Schlosser et al. (2007)	Four males and one female with autism ($n = 3$) and PDD-NOS ($n = 2$); ages 8–10($M = 8.8$)	SGD mands with speech output compared to SGD mands with no speech output (SGD with a display of symbols for four preferred items).	Inconclusive for both efficiency and effectiveness. None of the participants reached criterion in either condition before the end of the study, but participants improved over baseline in both conditions. Three of the five children exhibited slight differences in improvement across conditions (two improving more with the speech output and one without speech).	Collateral vocalization: inconclusive. Four did not vocalize in either condition, and one vocalized similarly in both conditions and baseline.

Table 1 (*Continued*)

Citation	Participants	Comparison and design	Effectiveness and/or efficiency for communication outcomes	Collateral vocalization, maintenance or generalization
		AATD		Maintenance: suggestive that three maintained higher mand rates in speech output condition, and two showed little difference.
Sigafoos et al. (2011)	One male with ID associated with Klinefelter syndrome, age 14	Mands with long speech output and short speech output on aniPod® SGD compared to paper-based representation of the iPod®.	Preponderant that mand rates were similar across all conditions in when augmented responses in all conditions were responded to, and mand rates stayed the same when AAC mands in one condition were extinguished (except for burst for extinguished condition).	Collateral vocalization: preponderant that rates were similar for all conditions, but placing one condition on AAC request extinction led to increase of vocalization in that condition.
		Multielement		
Unaided AAC comparisons				
Normand et al. (2008)	One male with autism, age 7	Sign rates under tact (impure) mand (pure and impure) mimetic (imitation) and control conditions. Multielement	Suggestive that mand and mimetic conditions produced higher rates of sign than tact or control.	–
Valentino & Shillingsburg (2011)	One male with autism, age 7	Sign rates under imitated, tact, mand, and intraverbal conditions all with a model during pre-probe sessions.	Inconclusive. The participant had similar increase in percentages of correct signs across conditions for all three signs taught.	–
		Multiple baseline across behaviors		

Note. ATD: alternating treatments design; AATD: adapted alternating treatments design; PE: picture exchange; SGD: speech generating device; ID: intellectual disability.

[a] Exact ages and gender not provided.

[b] Other participants in the study did not use AAC for mands.

their corresponding symbols) were created, but training of a pair using one strategy was discontinued if mastery criterion was met with a pair in the other condition (therefore unable to determine if the discontinued method would have been effective given more time). The study did, however, provide preponderant evidence for idiosyncratic efficiency. Specifically, one participant learned discriminated requests more rapidly with enhanced consequences, one with stimulus fading, and one mastered one set with one strategy and a second set with the other (Wilson, 2007). Also supporting efficiency differences, Cihak et al. (2012) provided conclusive evidence that adding a peer video model to the PECS Phase I training protocol increased the efficiency of acquisition. Additionally, Plavnick and Ferreri (2011) provided conclusive evidence that PE mands that were related to functionally preferred consequences (i.e. consequence types an individual most often sought out using gestural requests), in this case socially maintained attention, were acquired more rapidly than mands for non-functionally preferred consequences (in this case tangibles or escape from a task). Similarly, Plavnick and Ferreri, provided preponderant evidence that function-preferred mands generalized more often to new settings than non-function preferred mands.

3.3. Aided AAC speech output comparisons

Four studies, involving a total of eight participants examined the effects of speech output from an SGD on AAC response acquisition (Koul & Schlosser, 2004; Raghavendra & Oaten; 2007; Schlosser et al., 2007; Sigafoos et al., 2011). Three of these studies included measures of the participants' vocalizations/natural speech production (Koul & Schlosser, 2004; Schlosser et al., 2007; Sigafoos et al., 2011), and two of the four studies assessed maintenance and/or generalization (Raghavendra & Oaten, 2007; Schlosser et al., 2007). With respect to the effects of speech output, the findings were mixed and did not indicate any major or consistent effect on acquisition (Schlosser et al., 2007; Sigafoos et al., 2011). The findings related to the effects of speech output on receptive symbol identification and spelling were limited or inconclusive (Koul & Schlosser, 2004; Raghavendra & Oaten, 2007). Specifically, Schlosser et al. (2007) found little difference and no mastery with either condition (i.e. speech output versus no output), while Sigafoos et al. (2011) provided preponderant evidence of no differences in AAC requesting when the speech output was long or short, or when there was no output. Raghavendra and Oaten (2007) provided suggestive evidence (due to limited IOA and treatment fidelity data as well as the possibility that one of their conditions [print-only condition] may have been more novel) that print-only was more efficient than speech-print or speech-only for

teaching spelling to one participant. Results from the Koul and Schlosser (2004) study, assessing the effects of speech output on receptive symbol identification, were inconclusive due to limited IOA, no treatment fidelity data, inconsistent patterns without mastery, and limited control for sequence effects.

The effects of speech output from an SGD on vocalizations and natural speech production were either inconclusive or did not support differential effects of speech output (Koul & Schlosser, 2004; Schlosser et al., 2007; Sigafoos et al., 2011), while maintenance effects differed across participants (Schlosser et al., 2007) and generalization results were inconclusive (Raghavendra & Oaten, 2007). In terms of vocalizations, due to the limited number of vocalizations and/or inconsistent patterns, findings were inconclusive in two studies (Koul & Schlosser, 2004; Schlosser et al., 2007). Sigafoos et al. (2011) provided preponderant evidence, however, that while vocalization rates did not differ based upon the length or presence of speech output, extinction of SGD-based requests led to an increase in natural speech production. It is important to note that this study was limited to a single participant. Schlosser et al. (2007) provided suggestive evidence (due to limited data and no prior mastery with either condition during acquisition) that three participants had stronger maintenance of requests (i.e., mands) in the speech output condition, but there were no clear differences for other participants. In the Raghavendra and Oaten (2007) study, the participant did not show any generalization in any of the conditions and maintenance results were inconclusive.

3.4. Unaided AAC verbal operant comparisons

Two studies (with two total participants) evaluated the effectiveness of different verbal operant conditions such as mand (request), tact (label), intraverbal (question answering), mimetic (imitated) and control conditions, for producing signs (Normand et al., 2008; Valentino & Shillingsburg, 2011). Valentino and Shillingsburg's (2011) study provided inconclusive evidence regarding differences between mand, tact, and intraverbal conditions because there was high likelihood for carryover (verbal operant conditions interspersed) and manual sign was modeled in all conditions during "sign exposure" sessions occurring right before probes. The Normand et al. (2008) study provided suggestive evidence that a mand condition (deprivation of preferred item before condition; participant shown preferred item before it was placed out of sight; trainer asked "what do you want?" every 20 s) and a mimetic condition (no deprivation of preferred item before condition; item continuously available; trainer modeled sign every 20 s) produced higher rates of manual sign than a condition labeled as "tact" (no deprivation of preferred item before condition; item continuously available; trainer asked "what is this?" every 20 s) and a control condition (deprivation of preferred item before condition; item continuously available; trainer did not interact with participant). Their evidence was rated as suggestive due to the possibility for carryover, limited information on prior experience using sign in each condition, and lack of treatment fidelity.

4. Discussion

This review identified 14 studies that compared different AAC intervention components (e.g. types of symbols used, instructional strategies, presence or absence of speech output, and the type of communications skills targeted (e.g. mands versus tacts) on the effectiveness and efficiency of intervention, effects on vocalizations/natural speech production, and maintenance and generalization. Differences in terms of effectiveness were not clear across most studies, but in some cases there were efficiency differences. Findings were limited regarding differences in vocalization, maintenance and generalization. In general, evidence supported the following: (a) differences in symbol sets may not have clear effects on AAC-based mand acquisition, but listener responses may be affected in some cases, and limited data may suggest effects on receptive symbol learning, (b) speech output differences have not been shown to consistently affect AAC-based communication outcomes, (c) different instructional strategies (e.g. increasing motivation, adding video models) may provide advantages in terms of teaching PE and PECS, and (d) limited data supports training mands and imitated sign responses prior to tacts. These trends and findings need to be considered in light of the appraisal of evidence undertaken in this review. For example, several studies using rigorous multielement, AATDs, and combined designs provided preponderant to conclusive evidence for most outcome measures, while others (e.g. Normand et al., 2008) were limited to suggestive evidence. Evidence in other studies (e.g. Valentino & Shillingsburg, 2011) was inconclusive due to methodological issues. Despite limitations, the overall results of this review could be seen as providing evidence to support the fact that some intervention components may be likely to provide benefits for a majority of individuals, while other components may not lead to appreciable differences, or differ idiosyncratically.

With respect to the use of different symbol sets, limited data from one study in this review (Koul & Schlosser, 2004) suggesting differences based upon iconicity may be in line with previous research suggesting that more iconic symbols may provide advantages over less iconic in terms of receptive learning (e.g. Hetzroni, Quist, & Lloyd, 2002). This variable appeared to have little effect, however, on the acquisition of early stage (i.e. non-complex) AAC-based mands. More research in this area involving different popular symbol sets and SGD-based comparisons may be needed to provide more conclusive suggestions for practice. Moreover, even if differences in symbols do not affect the learner's acquisition, the effects of symbols on listeners' reinforcement of communication should be considered and further examined (Charlop et al., 2008). While Charlop et al. (2008) focused on how symbols can be designed to increase the likelihood of reinforcement from listeners with visual impairments, as some research has suggested that cultural or linguistic differences can affect symbol

interpretation (e.g. Huer, 2000) future research could explore how differences in symbols may impact communicative interactions between learners and listeners from culturally or linguistically different backgrounds.

With regard to the effects of differing amounts of speech output, more research is needed to determine whether or not the presence or absence of speech output, and the type (synthetic versus digitized) or amount (long versus short output) influences AAC acquisition, vocalizations and natural speech production, and/or generalization and maintenance. If speech output is not likely to affect the learner's acquisition or use of AAC, it may be important to consider whether or not speech output affects listener responsiveness (e.g. would a listener be more likely to attend to responses with or without speech output). Additionally, while the results related to speech output do not suggest clear differential outcomes in terms of AAC mands, there was little evidence to suggest that such output would be in any way detrimental to AAC users (e.g. did not decrease vocalization rates). Thus, there would be no contraindications for using SGDs as AAC options for individuals for whom this is a well suited and preferred option (van der Meer et al., 2011).

With respect to different instructional strategies, results suggest that blocking communication errors during training and increasing motivation to communicate for a specific item may aid in the acquisition of requests involving discriminations between different symbols (Carr & Felce, 2008; Gutierrez et al., 2007). Targeting functional requesting and using video-based interventions are also effective strategies that may increase acquisition rates (Cihak et al., 2012; Plavnick & Ferreri, 2011). In light of this, practitioners should implement strategies to boost motivation for specific communicative responses and consider errorless learning techniques (especially when teaching discrimination of mands for two preferred items), target mands for highly preferred consequences that already maintain behavior, and make use of highly visual (e.g., video modeling) teaching techniques (Sigafoos, O'Reilly, Schlosser, & Lancioni, 2007).

With respect to the types of communication skills (or verbal operants) taught, the evidence from this review suggests this can be an important variable in that some skills (e.g. mands and imitative responses) were acquired faster than other skills (e.g., tacts). This finding has been reported previously for vocal speech acquisition (Jennett, Harris, & Delmolino, 2008; Sundberg & Michael, 2001; Sundberg & Partington, 1998). However, the evidence base for this finding with regards to sign, from the studies in the present review, is limited as the studies making such comparisons provided only suggestive (e.g., Normand et al., 2008) or inconclusive evidence (Valentino & Shillingsburg, 2011). Findings regarding mands may be supported by prior research demonstrating that specific reinforcement (i.e. the kind used for mands) was more efficient for teaching signs than non-specific reinforcement (Goodman & Remington, 1993). The main clinical implication here is that AAC intervention for persons with developmental disabilities is likely to be more successful when the initial aim is to teach the person to request (mand) highly preferred objects, a recommendation that has long been made (Reichle et al., 1991). The role motor imitation plays in increasing sign rates may, however, need to be further evaluated. Additionally, the interaction between reinforcement value and response effort for learning signs may also be important to examine. For instance, a sign mand for a highly preferred item that is topographically difficult to produce could be compared to an easy to produce sign mand for a less preferred item.

5. Conclusion

In general, this review suggests that while some AAC intervention components may not present clear advantages or disadvantages for individuals with developmental disabilities, there may be benefits from selecting or incorporating certain AAC elements or instructional strategies. While future research should replicate and extend current findings, the review also highlights a number of areas that would seem important, but which were not addressed in the current cohort of studies. For example, none of the studies address the issues of symbol organization or access. As new types of AAC devices are developed, with different interfaces and tablet-based applications, such research would seem necessary. For instance, studies with typically developing children have compared corrective feedback and errorless guided instruction for teaching responses on SGDs with dynamic (i.e. interactive and changing) displays (Quach & Beukelman, 2010) and grid-based symbol organization with scene-based organization (Drager et al., 2004; Drager, Light, Speltz, Fallon, & Jeffries, 2003), but there appear to be no published peer-reviewed studies involving persons with developmental disabilities. Another neglected area is that of more advanced communication intervention including acquisition beyond a few specific mands for highly preferred objects, or studies teaching multiple discriminations, page navigation (Achmadi et al., 2012), and sentence construction. In the absence of such research, clinicians can still make use of well-established instructional strategies when setting out to teach AAC and then modifying these strategies in light of the unique characteristics of the AAC learner.

References[1]

Achmadi, D., Kagohara, D., van der Meer, L., O'Reilly, M. F., Lancioni, G. E., Sutherland, D., et al. (2012). Teaching advanced operation of an iPod-based speech-generating device to two students with autism spectrum disorders. *Research in Autism Spectrum Disorders, 6*, 1258–1264.

*Angermeier, K., Schlosser, R. W., Luiselli, J. K., Harrington, C., & Carter, B. (2008). Effects of iconicity on requesting with the Picture Exchange Communication System in children with autism spectrum disorder. *Research in Autism Spectrum Disorders, 2*, 430–446.

Barton, A., Sevcik, R. A., & Ann Romski, M. (2006). Exploring visual-graphic symbol acquisition by pre-school age children with developmental and language delays. *Augmentative and Alternative Communication, 22*, 10–20.

Bennett, D. L., Gast, D. L., Wolery, M., & Schuster, J. (1986). Time delay and system of least prompts: A comparison in teaching manual sign production. *Education and Training of the Mentally Retarded, 21*, 117–129.

[1] References marked with an asterisk indicate studies included in the synthesis.

Berkowitz, S. (1990). A comparison of two methods of prompting in training discrimination of communication book pictures by autistic students. *Journal of Autism and Developmental Disorders, 20*, 255–262.
Beukelman, D. R., & Mirenda, P. (2005). *Augmentative and alternative communication: Supporting children and adults with complex communication needs* (3rd ed.). Baltimore: Paul H Brookes Publishing Co.
*Carr, D., & Felce, J. (2008). Teaching picture-to-object relations in picture-based requesting by children with autism: A comparison between error prevention and error correction teaching procedures. *Journal of Intellectual Disability Research, 52*, 309–317.
*Charlop, M. H., Malmberg, D. B., & Berquist, K. L. (2008). An application of the Picture Exchange Communication System (PECS) with children with autism and a visually impaired therapist. *Journal of Developmental & Physical Disabilities, 20*, 509–525.
*Cihak, D. F., Smith, C. C., Cornett, A., & Coleman, M. B. (2012). The use of video modeling with the Picture Exchange Communication System to increase independent communicative initiations in preschoolers with autism and developmental delays. *Focus on Autism and Other Developmental Disabilities, 27*, 3–11.
Drager, K. D., Light, R., Carlson, J. C., D'Silva, R., Larsson, K., Pitkin, B., et al. (2004). Learning of dynamic display AAC technologies by typically developing 3-year-olds: Effect of different layouts and menu approaches. *Journal of Speech, Language and Hearing Research, 47*, 1133–1148.
Drager, K. D. R., Light, J. C., Speltz, J. H. C., Fallon, K. A., & Jeffries, L. Z. (2003). The performance of typically developing 2 1/2-year-olds on dynamic display AAC technologies with different system layouts and language organizations. *Journal of Speech, Language and Hearing Research, 46*, 298–312.
Goodman, J., & Remington, B. (1993). Acquisition of expressive signing: Comparison of reinforcement strategies. *Augmentative and Alternative Communication, 9*, 26–35.
*Gutierrez, A., Vollmer, T. R., Dozier, C. L., Borrero, J. C., Rapp, J. T., Bourret, J. C., et al. (2007). Manipulating establishing operations to verify and establish stimulus control during mand training. *Journal of Applied Behavior Analysis, 40*, 645–658.
Hart, S. L., & Banda, D. R. (2010). Picture Exchange Communication System with individuals with developmental disabilities: A meta-analysis of single subject studies. *Remedial and Special Education, 31*, 476–488.
Hetzroni, O. E., Quist, R. W., & Lloyd, L. L. (2002). Translucency and complexity: Effects on Blissymbol learning using computer and teacher presentations. *Language, Speech, and Hearing Services in Schools, 33*, 291–303.
Huer, M. (2000). Examining perceptions of graphic symbols across cultures: Preliminary study of the impact of culture/ethnicity. *Augmentative and Alternative Communication, 16*, 180–185.
Hurlbut, B. I., Iwata, B. A., & Green, J. D. (1982). Nonvocal language acquisition in adolescents with severe physical disabilities: Blissymbol versus iconic stimulus formats. *Journal of Applied Behavior Analysis, 15*, 241–258.
Jennett, H. K., Harris, S. L., & Delmolino, L. (2008). Discrete trial instruction vs. mand training for teaching children with autism to make requests. *The Analysis of Verbal Behavior, 24*, 69–85.
Johnston, S. S., Buchanan, S., & Davenport, L. (2009). Comparison of fixed and gradual array when teaching sound-letter correspondence to two children with autism who use AAC. *Augmentative and Alternative Communication, 25*, 136–144.
*Jonaitis, C. (2011). *The Picture Exchange Communication System: Digital photographs versus picture symbols* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses (PQDT) database (UMI No. 3455172).
Kagohara, D. M., van der Meer, L., Ramdoss, S., O'Reilly, M. F., Lancioni, G. E., Davis, T. N., et al. (2013). Using iPods® and iPads® in teaching programs for individuals with developmental disabilities: A systematic review. *Research in Developmental Disabilities, 34*, 147–156.
Kennedy, C. H. (2005). *Single-case Designs for Educational Research*. Boston: Allyn & Bacon.
*Koul, R. K., & Schlosser, R. W. (2004). Effects of synthetic speech output in the learning of graphic symbols of varied iconicity. *Disability & Rehabilitation, 26*, 1278–1285.
Kozleski, E. B. (1991). Visual symbol acquisition by students with autism. *Exceptionality, 2*, 173–194.
Lancioni, G. E., O'Reilly, M. F., Cuvo, A. J., Singh, N. N., Sigafoos, J., & Didden, R. (2007). PECS and VOCAs to enable students with developmental disabilities to make requests: An overview of the literature. *Research in Developmental Disabilities, 28*, 468–488.
Mirenda, P. (2003). Toward functional augmentative and alternative communication for students with autism: Manual signs, graphic symbols, and voice output communication aids. *Language, Speech, and Hearing Services in Schools, 34*, 203–216.
*Normand, M. P., Severtson, E. S., & Beavers, G. A. (2008). A functional analysis of non-vocal verbal behavior of a young child with autism. *The Analysis of Verbal Behavior, 24*, 63–67.
Nunes, D. R. P. (2008). AAC interventions for autism: A research summary. *International Journal of Special Education, 23*, 17–26.
Plavnick, J. B. (2010). *Establishing verbal repertoires in children with autism using function-based video modeling: Direct and collateral effects* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses (PQDT) database (UMI No. 3426808).
*Plavnick, J. B., & Ferreri, S. J. (2011). Establishing verbal repertoires in children with autism using function-based video modeling. *Journal of Applied Behavior Analysis, 44*, 747–766.
Quach, W., & Beukelman, D. (2010). Facilitating children's learning of dynamic-display AAC devices: The effect of two instructional methods on the performance of 6- and 7-year-olds with typical development using a dual-screen prototype. *Augmentative and Alternative Communication, 26*, 1–11.
*Raghavendra, P., & Oaten, R. (2007). Effects of speech and print feedback on spelling performance of a child with cerebral palsy using a speech generating device. *Disability and Rehabilitation: Assistive Technology, 2*, 299–308.
Ramdoss, S., Lang, R., Mulloy, A., Franco, J., O'Reilly, M., Didden, R., et al. (2011). Use of computer-based interventions to teach communication skills to children with autism spectrum disorders: A systematic review. *Journal of Behavioral Education, 20*, 55–76.
Reichle, J., Dettling, E., Drager, K., & Leiter, A. (2000). Comparison of correct responses and response latency for fixed and dynamic displays: Performance of a learner with severe developmental disabilities. *Augmentative and Alternative Communication, 16*, 154–163.
Reichle, J., York-Barr, J., & Sigafoos, J. (1991). *Implementing augmentative and alternative communication: Strategies for learners with severe disabilities*. Baltimore, MD: PH Brookes Publishing Company.
Romski, M. A., & Sevcik, R. A. (1997). Augmentative and alternative communication for children with developmental disabilities. *Mental Retardation and Developmental Disabilities Research Reviews, 3*, 363–368.
Schlosser, R. W. (1999). Comparative efficacy of interventions in augmentative and alternative communication. *Augmentative and Alternative Communication, 15*, 56–68.
Schlosser, R. W. (2003). *The efficacy of augmentative and alternative communication: Towards evidence-based practice*. New York: Academic Press.
Schlosser, R. W., & Blischak, D. M. (2004). Effects of speech and print feedback on spelling by children with autism. *Journal of Speech, Language & Hearing Research, 47*, 848–862.
Schlosser, R. W., & Sigafoos, J. (2006). Augmentative and alternative communication interventions for persons with developmental disabilities: Narrative review of comparative single-subject experimental studies. *Research in Developmental Disabilities, 27*, 1–29.
*Schlosser, R. W., Sigafoos, J., Luiselli, J. K., Angermeier, K., Harasymowyz, U., Schooley, K., et al. (2007). Effects of synthetic speech output on requesting and natural speech production in children with autism: A preliminary study. *Research in Autism Spectrum Disorders, 1*, 139–163.
Sigafoos, J., Didden, R., & O'Reilly, M. (2003). Effects of voice-output technology on requesting and vocalizations in three children with developmental disabilities. *Augmentative and Alternative Communication, 19*, 37–47.
Sigafoos, J., O'Reilly, M. F., Schlosser, R. W., & Lancioni, G. E. (2007). Communication intervention. In P. Sturmey & A. Fitzer (Eds.), *Autism Spectrum Disorders: Applied Behavior Analysis, Evidence, and Practice* (pp. 151–185). Austin, TX: Pro-Ed.
Sigafoos, J., & Reichle, J. (1992). Comparing explicit to generalized requesting in an augmentative communication mode. *Journal of Developmental and Physical Disabilities, 4*, 167–188.
Sigafoos, J., Schlosser, R. W., & Sutherland, D. (2013). Augmentative and alternative communication. In J. H. Stone & M. Blouin (Eds.), *International Encyclopedia of Rehabilitation* (Available online: http://cirrie.buffalo.edu/encyclopedia/en/article/50/).
*Sigafoos, J., Wermink, H., Didden, R., Green, V. A., Schlosser, R. W., O'Reilly, M. F., et al. (2011). Effects of varying lengths of synthetic speech output on augmented requesting and natural speech production in an adolescent with Klinefelter syndrome. *Augmentative and Alternative Communication, 27*, 163–171.

Sindelar, P. T., Rosenberg, M. S., & Wilson, R. J. (1985). An adapted alternating treatments design for instructional research. *Education and Treatment of Children, 8*, 67–76.

Stephenson, J. (2009). Recognition and use of line drawings by children with severe intellectual disabilities: The effects of color and outline shape. *Augmentative and Alternative Communication, 25*, 55–67.

Sundberg, M. L., & Michael, J. (2001). The benefits of Skinner's analysis of verbal behavior for children with autism. *Behavior Modification, 25*, 698–724.

Sundberg, M. L., & Partington, J. W. (1998). *Teaching Language to Children with Autism and Other Developmental Disabilities*. Pleasant Hill, CA: Behavior Analysts (Incorporated).

*Valentino, A. L., & Shillingsburg, M. A. (2011). Acquisition of mands, tacts, and intraverbals through sign exposure in an individual with autism. *The Analysis of Verbal Behavior, 27*, 95–101.

van der Meer, L., Sigafoos, J., O'Reilly, M. F., & Lancioni, G. E. (2011). Assessing preferences for AAC options in communication interventions for individuals with developmental disabilities: A review of the literature. *Research in Developmental Disabilities, 32*, 1422–1431.

*Wilson, D. M. (2007). *Procedures to facilitate discrimination of picture cards during communication training* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses (PQDT) database (UMI No. 3281625).