A Systematic Review of Predictors, Moderators, and Mediators of Augmentative and
Alternative Communication (AAC) Outcomes for Children with Autism Spectrum Disorder

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Abstract

Documented variability in augmentative and alternative communication (AAC) intervention outcomes makes it difficult for clinicians to select systems most likely to be effective for individual children with autism spectrum disorder (ASD). The aim of this study was to identify child-related factors associated with AAC intervention outcomes through a systematic review of the research literature. A search was conducted of peer-reviewed research articles in which AAC intervention outcomes and associated factors were reported for children with ASD. The search yielded 965 titles and abstracts, of which 7 articles relating to 6 studies met criteria for inclusion. In total, 18 factors were examined, of which 9 were assessed as predictors (e.g., cognition, ASD severity, language use), 3 as moderators (e.g., joint attention, object exploration), and 6 as mediators (e.g., frequency of therapy, communication partner knowledge). Child characteristics associated with communication outcomes were pre-intervention cognition, severity of ASD, verbal imitation, vocabulary comprehension, object use, joint attention, language use, and two multi-dimensional measures of communication competence. This study suggests emerging evidence for predictors, but less is known about what factors moderate and mediate response to AAC interventions.

Keywords: Augmentative and alternative communication; Autism spectrum disorder; Communication; Predictors; Moderators; Mediators

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Despite advances in intervention for children with autism spectrum disorder (ASD), as many as 35% of those who receiving comprehensive early intervention programs commence school unable to speak in multiword utterances (Light, Beukelman, & Reichle, J, 2003; Rose, Trembath, Keen, & Paynter, 2016). Although there is a growing body of evidence that AAC can be effective in supporting communication development in minimally verbal children with ASD (Ganz, 2015), outcomes also reveal substantial individual variability, due in part to the (a) variety of AAC interventions (e.g., high vs. low-tech systems, static vs. dynamic display), (b) abilities of the communication partner (e.g., parents' capacity to implement interventions), and (c) heterogeneity among children themselves (e.g., varying levels of joint attention, cognition, and language use). This combination of factors makes it difficult to answer the question, What works best for whom and why in AAC intervention for children with ASD (Cafiero, 2011; Schlosser & Raghavendra, 2004). Having a better understanding of contributing factors will facilitate future research and support more children with ASD to develop communication skills.

Factors Associated with Response to Intervention

In the research literature, the terms *predictors*, *moderators*, and *mediators* have been operationalized in a variety of ways to describe factors associated with individual responses to interventions based on personal characteristics and socio-environmental factors. In the current review, predictors are defined as baseline characteristics that have a main effect on outcomes but no interactive effect, meaning that they predict outcomes regardless of the intervention used (Kraemer, Wilson, Fairburn, & Agras, 2002). Cognition, for example, has been identified as a predictor of outcomes across a range of interventions for children with ASD (Vivanti, Prior,

Williams, & Dissanayake, 2014). As a predictor, it does not, therefore, appear to tell us whether children will benefit more from one AAC system over another. Moderators, on the other hand, are defined as baseline characteristics that predict differential responses to interventions and aid in identifying for whom and/or under what conditions a factor has an effect on the outcome (Kraemer & Gibbons, 2009). For instance, children who enter intervention displaying frequent imitation of the clinician's gestures and actions may be responsive to a manual-sign intervention where imitation is important, whereas children displaying infrequent imitation may be more responsive to the Picture Exchange Communication System (PECS) (Bondy & Frost, 1994) in which prompting, shaping, and prompt fading is used. Mediators are defined as factors that are assessed during the delivery of an intervention that are associated with outcomes. In essence, they help to explain why and how an individual responds to an intervention, and may include frequency of therapy sessions, communication partner knowledge, intervention setting, sociodemographic background, family expectation, parent-therapist alliance, family stress and discord, father positive involvement, and social support (Vivanti et al., 2014). Although there is a growing awareness in clinical and research communities regarding the potential importance of these mediating factors in ASD research broadly, only a small number of studies have investigated these factors in relation to AAC interventions.

Predictors, moderators, and mediators of AAC outcomes. Numerous systematic reviews have examined the effectiveness of AAC interventions for children with ASD but only a small number (Flippin, Reszka, & Watson, 2010; Ganz et al., 2011; Ganz, Davis, Lund, Goodwyn, & Simpson, 2012; Ganz et al., 2014) have focused on identifying characteristics that predict, moderate, and mediate intervention outcomes. Ganz et al. (2012) completed a meta-analysis examining pre-treatment characteristics (predictors) associated with response to an

intervention with children with ASD using Picture Exchange Communication Systems (PECS) (Bondy & Frost, 1994). The authors reported that younger participants (i.e., preschool- age) who did not have additional diagnoses (e.g., intellectual disability or developmental delay) demonstrated greater communication skills following the PECS interventions than those who were older and had multiple developmental disabilities (Ganz et al., 2012). The results suggest that broad child factors (e.g., chronological age) have some value in predicting improvements in communication skills during intervention; however, given that the review by Ganz et al. is limited to one intervention (PECS), analysis was limited to predictors. To obtain a more thorough understanding of how a child responds across different AAC interventions, researchers need to look at a range of interventions and their associated outcomes.

In a subsequent review, Ganz et al. (2014) investigated the potential moderating effects of child age, intervention setting, and presence/absence of intellectual disability on response to three types of AAC intervention: PECS, speech-generating devices (SGDs), and a broader category of other picture-based systems. In all cases, AAC was shown to have an overall positive effect on speech outcomes, with SGDs and PECS having a larger effect than other picture-based systems. Furthermore, SGDs were reported to be more effective in individuals without a comorbid intellectual disability/developmental disorder, whereas PECS was more effective for those with ASD and these comorbid diagnoses. The review by Ganz et al. provides insights into potential moderating factors in regards to which children with intellectual disability/developmental disorder may respond better to SGDs versus PECS intervention and other picture-based systems; however, the findings are limited by the analysis of broad potential moderators such as age and presence/absence of an intellectual disability. There is a need for researchers to look beyond broad factors, such as cognition, to more fine-grained social-

cognitive predictors, moderators, and mediators of outcomes. The study by Ganz et al. was also limited by reliance on secondary data, which limited the scope of the meta-analysis to variables that could be readily extracted across all studies based on participant descriptions. There is a need for a systematic review of studies in which predictors, moderators, and mediators have been examined as part of the original study designs.

The review by Flippin et al. (2010) expanded on potential broad predictive measures (e.g., cognition) by focusing on social-cognitive factors. The authors performed a meta-analysis review of the empirical evidence for PECS and the potential pre-intervention child characteristics that predict communication outcomes for children with ASD). Characteristics found to predict responses to PECS intervention were joint attention, object exploration, and imitation. Participants who were somewhat able to verbally imitate before intervention, who demonstrated lower joint attention, and who had higher levels of object exploration at baseline were more successful communicators following the PECS intervention. The review by Flippin et al. provides insight into the potential value of social-cognitive factors, age, and co-morbidities as predictors of outcomes. Their analyses, however, were confined to PECS, meaning they could not draw conclusions about factors that moderate responses to a wider range of AAC interventions.

Although recent reviews have made valuable contributions to elucidating potential predictors, moderators, and mediators of AAC intervention outcomes, they were limited to a focus on broad predictors due to the challenges of extracting fine-grained information through secondary analysis and, in the case of Flippin et al. (2010), the focus on PECS, which precluded examination of findings relating to other AAC interventions. Therefore, to complement these efforts, the aim of the current review was to draw together findings from studies utilizing group-

based longitudinal and experimental designs, across AAC modalities, in which potential predictors, moderators, and mediators of intervention outcomes were examined and reported as part of the original study designs.

Method

Screening Inclusion Criteria

A systematic search of the literature was conducted to identify studies in which AAC intervention outcomes and associated factors were reported for children with ASD. To be included in the review, studies had to meet the following criteria: (a) had been published in English in a peer-reviewed journal; (b) included at least one child diagnosed with ASD (encompassing the various specific classifications presented in the fourth (American Psychiatric Association, 2000) and fifth editions of the Diagnostic and Statistical Manual of the American Psychiatric Association (American Psychiatric Association, 2013), aged 2-5 years, and without hearing and/or vision impairments; (c) included interventions that used aided or unaided AAC systems; (d) included intervention outcomes that were examined using group-based longitudinal cohort or experimental designs; (d) reported outcome measures that included intentional communication acts defined as verbal, or non-verbal acts using speech, gesture, or AAC; and (f) reported results that included a quantitative analysis of factors that may have been associated with response to AAC intervention.

Research examining potential predictors, moderators, and mediators is relatively new in the field of ASD in general and AAC in particular. Therefore, to capture as broad a range as possible of relevant studies, there were no selection criteria limits on publication years or geographic location, although restricting articles to those written in English may have affected geographical distribution of search results. Studies were deemed sufficient for inclusion if the

participants included at least one child with ASD of preschool age (the target population of the current review). Inclusion criteria and methods were also designed to avoid repetition of previous research. Specifically, single-case experimental studies were excluded, on the basis that although they are highly suitable for examining the effects of manipulating an independent variable (e.g., delivery of an AAC intervention) in individual studies, meta-analyses are required in order to examine the potential influence of predictors, moderators, and mediators across groups of participants. Given that several meta-analyses have been reported in recent years (Flippin et al., 2010; Ganz et al., 2011, 2012, 2014), analyses of single case experimental studies were excluded.

Search Strategy

In May 2016, studies were identified through five electronic databases (ERIC, CINHAL Plus, MEDLINE, Ovid, and PubMed), as well as hand searches of key journals and relevant authors. The following Boolean search terms were used: ((communicat* intervention) OR (communicat* therapy) OR (AAC)) AND ((ASD) OR (developmental disabilit*)). The hand search identified (a) publication lists of authors of extracted articles, (b) presentation titles from relevant conferences (e.g., International Society for Autism Research; INSAR), and (c) direct searching of relevant journals (*AAC Journal*, *Journal of ASD*). After duplicates were eliminated, a total of 965 articles were found through the database searches. The first author screened titles and abstracts against inclusion criteria, resulting in 47 studies. The remaining articles were examined at full-text level resulting in seven articles from six studies for inclusion in the review (See Figure 1). A second reviewer (a Ph.D. candidate in speech pathology) also reviewed the full set of 965 articles and independently short-listed articles for inclusion; this reviewer selected the same seven articles, constituting 100% agreement.

Insert Figure 1 here

Data Extraction

Tables 1 and 2 present a summary of the extracted data and findings for each of the seven articles across six studies. The first author extracted the following data from each study: (a) study; (b) participant description; (c) intervention overview (e.g., setting, AAC system); (d) outcome measure (e.g., frequency of communication, number of new words) (Table 1); (e) predictors, moderators, and mediators examined; and (f) findings relating to predictor, mediator, and moderator factors (Table 2). The second author independently reviewed each included article and the data presented in Tables 1 and 2. Any issues requiring clarification or disagreements were resolved through discussion. A formal process of independently extracting and checking reliability of data was not completed.

Insert Tables 1 and 2 About Here

Risk of Bias and Quality

Due to the small number of studies included in the review, there was a risk of overestimating effects. This risk is linked to the potential for publication bias arising from the fact that published research may favor research studies with positive results thereby potentially undermining the validity of any review (Vivanti et al., 2014). The strength of research design for each study was categorized according to the National Health & Medical Research Council's (NHMRC) Grading of Recommendations, Assessment, Development and Evaluation (GRADE) guidelines (NHMRC, 2016). The GRADE overall rating is based on components that should be considered when assessing a body of evidence, such as level of evidence, quality of evidence, statistics precision, size of effect, and relevance of evidence (NHMRC, 2016). NHMRC's GRADE provides "a systematic and explicit approach to making judgments about the quality of

evidence” (GRADE Working Group, 2004, p. 1493). Under the NHMRC evidence hierarchy, Level I studies are classified as systematic reviews of Level II studies, Level II studies are randomized controlled trials, Level III studies range from pseudorandomized controlled trials to comparative studies with/and without concurrent control, and Level IV studies are case series with either post-test pre-test/post-test outcomes (NHMRC, 2016).

Given that selection of study design does not in itself ensure research quality (e.g., a randomized control trial may still contain multiple risks for bias), studies were also evaluated using the Effective Public Health Practice Project (EPHPP) guidelines (Armijo-Olivo, 2014). EPHPP was chosen to guide quality analysis because it allows for the evaluation of multiple study designs, provides an explicit approach to making judgments about the quality of evidence, and has been used to assess research in order to promote decisions for clinicians and policy makers (Armijo-Olivo, 2014; Evans, Lasen, & Tsey, 2015). Using the guidelines presented by EPHPP (Evans et al., 2015), each study was assessed regarding its adequacy with respect to (a) addressing selection bias, (b) research design, (c) limiting confounders, (d) blinding, (e) data collection methods, and (f) accounting for withdrawals and dropouts from the study. Studies were rated as strong, moderate, or weak on each component, with each rating then combined to yield an overall quality rating of strong, moderate, or weak. For a study to be awarded a strong overall rating, it had to have at least four strong rating and no weak ratings. Studies with less than four strong component ratings and no more than one weak rating were considered to have an overall assessment of moderate. The authors individually evaluated studies against the EPHPP criteria and reached 85% on individual rating components and 100% on the overall rating score. Inconsistencies in the ratings were discussed until a 100% agreement was reached.

Results

Study Design and Quality

Of the seven studies, three were randomized control trials (Gordon et al., 2011; Yoder & Stone, 2006a, 2006b), two were prospective cohort studies (Brady, Thiemann-Bourque, Fleming, & Matthews, 2013; Vandereet, Maes, Lembrechts, & Zink, 2011), one was a quasi-experimental cohort study (Layton, 1988), and one was a retrospective cohort study (Pasco & Tohill, 2011). (Tables 1 and 2). Using the Effective Public Health Practice Project (EPHPP) (Evans et al, 2015), two studies reported across three articles (Gordon et al., 2011; Yoder & Stone, 2006a, b) received an overall rating of strong, while the remaining four studies by Brady et al. (2013); Layton (1988); Pasco and Tohill (2011); Vandereet et al. (2011) were rated as moderate. Applying the NHMRC levels of evidence, three studies were rated as Level II, one study was rated as Level III-I, two were rated as Level III-II, and one was rated as Level III-III. Table 3 presents the quality of evidence for each of the included studies, based on the EPHPP (Evans et al., 2015) and NHMRC (2016) ratings.

Insert Table 3

Participant Characteristics

The reviewed studies included a total of 319 participants aged between 18 months and 10 years. Of these, 245 were reported to have been diagnosed with ASD, three with pervasive developmental disorder—not otherwise specified (PDD-NOS), 23 with intellectual disability, and 48 with other disabilities (e.g., Down syndrome, opitz trigonocephaly).

AAC Intervention

The studies featured a range of aided and unaided AAC interventions, with three investigating PECS, one a speech-generating device (SGD), and three the use of manual sign.

Three studies involved intervention delivered in a classroom, two in university clinics, and one in the participants' homes. There were three intervention and four observational studies. Within these studies, PECS interventions were delivered to 126 children, 68 of which focused on manual sign; 15 interventions were focused on speech only; there were 17 Responsive Education and Prelinguistic Milieu Teaching (RPMT) interventions (in comparison conditions); and there were 93 other interventions (in isolation or combination) that were not explicitly specified by the original authors. The time span over which the intervention was provided ranged from 5 months to 2 years.

Outcome Measures

The seven studies examined a range of expressive communication outcomes. Of the total, six measured the number of words children produced using speech (Brady et al., 2013; Gordon et al., 2011; Layton, 1988; Vandereet et al., 2011; Yoder & Stone, 2006a, b), three measured the number of manual signs used (Brady et al., 2013; Layton, 1988; Vandereet et al., 2011), two reviewed the use of pictures (Brady et al., 2013; Pasco & Tohill, 2011), one measured the number of pictures accessed using an SGD system (Brady et al., 2013), and two examined a combination of communication modalities (Brady et al., 2013; Layton, 1988). Tools used to measure outcomes included language samples (Brady et al., 2013; Layton, 1988), video coding of observations (Gordon et al., 2011) and/or direct observation (Brady et al., 2013; Pasco & Tohill, 2011; Vandereet et al., 2011), criterion-based assessment (Pasco & Tohill, 2011), parent report (Vandereet et al., 2011), and norm-referenced assessment (Brady et al., 2013; Yoder & Stone, 2006a, b).

Examination of Potential Predictors, Mediators, and Moderators

A range of informal and formal assessment tools was used to measure potential predictors, mediators, and moderators of intervention outcomes. Factors were categorized as potential predictors, moderators, and/or mediators on the basis of the definitions outlined previously (e.g., timing of assessment, presence/absence of more than one intervention), taking into account the original authors' description of the methodology including analyses. Table 4 presents a summary of factors potentially associated with intervention outcomes across the studies, with similar factors categorized together. Note that where composite measures were used, both the composite factor and the constituent components (e.g., measures of imitation, play skills) have been presented in order to provide indications of skills that could be examined in further research.

Insert Table 4

Predictors. These were derived from (a) ASD diagnostic tools (e.g., Autism Diagnostic Schedule, ADOS; Lord et al., 2000), (b) norm-referenced language assessments (e.g., Preschool Language Scale (4th ed.) Zimmerman et al., 2003), (c) motor and cognition assessments (Psycho-Educational Profile, PER-R; Schopler, Reichle, Bashford, Lansing, & Marcus, 1990), (d) language sample analysis (e.g., Systematic Analysis of Language Transcripts; Miller & Iglesias, 2008), (e) play skills (e.g., Developmental Play Assessment; Lifter, 2001), and (f) observational measures (e.g., echolalia, verbal imitation). A composite predictor that used a combination of factors was employed in two studies: Brady et al. (2013) used the Intrinsic Symbolic Factor (ISF), a measure of foundational communication skills including use of gestures, vocalizations, and symbolic understanding, whereas Pasco and Tohill (2011) used the PER-R. As presented in Table 4, a total of six factors appeared to be associated with child outcomes.

Cognitive ability and severity of ASD symptoms. Cognitive ability was reported to predict response to AAC intervention in one study. In the study by Vandereet et al. (2011) participants who initially demonstrated the most significant cognitive delays acquired the smallest expressive vocabularies and favored manual sign mode over speech. Gordon et al. (2011) reported severity of ASD symptoms and found that participants with lower ADOS scores (i.e., more subtle ASD characteristics) demonstrated the largest increase in initiated communication acts using speech following AAC intervention.

Language and communication measures. Language comprehension, language use, and communication competence were factors found to predict response to AAC interventions. Language comprehension was a predictor in one study. Vandereet et al. (2011) reported that participants with lower vocabulary comprehension at Time 1 demonstrated smaller expressive vocabularies (less than 50 words) at Time 2 than those with higher vocabulary comprehension. Language use was found to be a predictor in Gordon et al. (2011)'s study. Participants with higher expressive language ability (on the ADOS) at the start of the study demonstrated the largest gains in spontaneous use of speech and pictures for communication following intervention. Communication competence was found to be a predictor of language acquisition in the Vandereet et al. (2011) study. Communication competence was quantified according to the ComFor indicator, which categorizes sense-making into the following categories: sensation, presentation, and representation. Vandereet et al. reported that those participants with higher ComFor scores demonstrated larger vocabulary gains using manual signs following manual sign intervention.

Composite measures. In two studies (Brady et al., 2013; Pasco & Tohill, 2001), researchers combined factors to form composite measures. Pasco and Tohill used the Psycho-

Educational Profile Total Developmental Age (PEP-R TDA) score, which examines imitation, perception, fine motor, gross motor, eye-hand integration, cognitive performance, and cognitive-verbal domains. The 16 participants who reached PECS Phase III during the course of the study had PEP-R TDA scores of 16 months and above, whereas six of the seven who had PEP-R TDA scores below 16 months prior to intervention were unable to progress beyond PECS Phase III. Brady et al. (2013) used a composite factor, Intrinsic Symbolic Factor (ISF), which is a construct of multiple indicators from the domains of non-verbal cognitive development, language comprehension, play level, and communication complexity. ISF was able to predict the number of different words at Time 2, and found that participants with higher levels of ISF and more adult input at home produced more words at Time 2.

Moderators. To be classified as a moderator in the current review, the study design had to include the administration of at least two interventions so that differential response to intervention could be determined. Three articles, two of which originated from the same study, analyzed child characteristics as moderators. These characteristics were joint attention, object exploration, and verbal imitation. Yoder and Stone (2006b) reported that children who had at least seven initiating joint attention acts at Time 1 demonstrated greater growth in the number of different non-imitative words they used at Time 2 following Responsive Education and Prelinguistic Milieu Teaching (RPMT) versus PECS. Participants who used at most one initiating joint attention act at Time 1 made greater gains in PECS versus RPMT. In addition, Yoder and Stone (2006a) reported that PECS intervention was more successful than RPMT for participants with higher levels of object exploration at baseline. Those with lower object exploration at baseline performed better in RPMT. In Layton (1988), the participants classified as high-level imitators at Time 1 performed better than those classified as low-level imitators on

all dependent language factors in all treatment conditions. Low verbal imitators produced fewer signs and words in the speech-alone treatment, compared to the other three conditions: manual sign, simultaneous sign and speech, and alternating sign and speech.

Mediators. Moderators are factors that are investigated after a study commences, and help to explain why and how an intervention was effective. The mediating factors explored in this review ranged from communication partners' impact to components of therapy. Five studies included analyses indicating four potential mediating factors.

Communication partner AAC knowledge and perception of AAC. Communication partner AAC knowledge and perception of AAC was explored in Vandereet et al. (2011), which suggested a potential mediating effect of fathers' knowledge of signs: The study reported that, following speech and sign intervention, fathers of participants who ultimately used more speech than sign (referred to in the study as Profile 4) knew significantly fewer signs compared to fathers of children who used a mixture of speech and sign (Profile 3). To explore communication partner perception of AAC, Vandereet et al. surveyed parents and speech-language pathologists on whether they perceived manual sign had positively influenced speech development. Speech-language pathologists and parents of children with lower levels of expressive language did not agree that the use of manual signs helped the participant to understand his or her communication partners unlike reports relating to children with higher expressive language.

Frequency of AAC exposure and adult input. Both Vandereet et al. (2011) and Pasco and Tohill (2011) reported on the frequency of AAC exposure. Vandereet et al. investigated the frequency of AAC use by speech-language pathologists during therapy sessions using a 5-point Likert-scale ranging from 1 (*never*) to 5 (*always*) and found no difference between outcomes and frequency of AAC exposure. Pasco and Tohill (2011) found that participants who did not reach

PECS Phase III (Group B) were given significantly more therapy sessions than Group A, which did reach Phase III. Brady et al. (2013) reported on adult input by analyzing communication partner input and amount of instruction at home and at school, and found that, one year later, there was a relationship between adult input at home and child communication outcomes but not between teacher input and child outcomes at school.

Discussion

Despite a rapidly growing body of research examining the effectiveness of AAC interventions for children with ASD, the current systematic review yielded only seven original research articles based on six studies in which factors that may predict, moderate, and/or mediate outcomes were analyzed. In total, 18 factors were analyzed, of which nine were examined as predictors (e.g., cognitive ability, ASD severity, language use), three as moderators (e.g., joint attention, object exploration), and six as mediators (e.g., frequency of therapy, communication partner knowledge). There were more than twice as many factors examined as there were studies suggesting that arriving at a refined set of empirically supported, clinically relevant factors that predict, moderate, and mediate AAC outcomes for children with ASD will require further concerted research efforts.

Out of the 11 factors that were examined as potential predictors, cognition was the most commonly assessed, featuring in four studies as either a direct measure or part of a composite measure (Brady et al., 2013; Gordon et al., 2011; Pasco & Tohill, 2011; Vandereet et al., 2011). To see cognition featured prominently is not surprising, given that it has also been highlighted in previous ASD intervention research (Ben-Itzhak, Watson, & Zachor, 2014; Kangas & Lloyd, 1988), as well as by Ganz et al. (2012) in their meta-analysis of factors that predict response to AAC interventions. A critical question is how to interpret this common finding in clinically

meaningful ways. Pasco and Tohill (2011), for example, found that participants who scored above 16 months based on the PEP-R TDA all mastered PECS Phase III, which requires discrimination between symbols, whereas six of the seven children with a total developmental age below 16 months did not. This finding should not be used to decide if PECS should or should not be administered; rather, as noted by Pasco and Tohill, it offers information to guide clinicians on intervention decisions with respect to what are the likely achievable outcomes when administering a PECS intervention. Cognition as a predictor has limitations, given that many children with ASD who receive AAC also have moderate-to-severe intellectual disability, with little variation in non-verbal cognitive scores (Iacono, Trembath, & Erickson, 2016). Furthermore, assessing cognitive ability in children who do not yet have access to an effective communication mode is challenging. In general, the majority of predictive factors identified in the current review were broad in nature (e.g., cognition, comprehension, chronological age). As such, the findings suggest a need for a greater focus on fine-grained factors that can differentiate outcomes within and between AAC interventions.

Despite the clinical importance of identifying factors that moderate differential response to interventions, only three across three studies were identified: object exploration, joint attention, and imitation. Yoder and Stone (2006a, b) revealed that higher rates of joint attention and lower rates of object exploration acts at pre-treatment were associated with participants' production of more object exchanges, joint attention acts, and non-imitative spoken words following RPMT -- a play-based, non-AAC intervention -- compared to the PECS intervention. More specifically, the tipping point where the children benefited more from PRMT versus PECS was found to be at seven joint attention attempts in the pre-treatment assessment. A key contribution here was the linking of hypothesized active ingredients of interventions (e.g., object

exchange in PECS) with readily assessable child factors (e.g., object exploration at baseline). This approach is not only theoretically driven but the findings also have potential clinical utility. It is important to note, however, that both studies involved the comparison of AAC and non-AAC interventions, meaning that while joint attention and object exploration were associated with response to PECS and may inform future research efforts, the factors themselves have not been established as moderators of differential response between AAC interventions.

In addition to identifying potential moderators, a key strength of the Yoder and Stone (2006a, b) studies was the use of a randomized group experiment design. As noted by Yoder and Compton (2004), it is imperative that research utilizes appropriate research methodologies to distinguish between change resulting *from* an intervention (proven experimentally) and change *within* an intervention (which may be due to the intervention or other factors not controlled for in the design). The majority of studies in this current review employed designs that only allow for the latter. Layton (1988) for example, examined the relationship between children's verbal imitation at baseline and outcomes following four types of intervention: sign-alone, speech-alone, simultaneous modes, or alternating between speech and sign. The participants were classified into high- and low-verbal imitators according to the number of correct approximations of sounds, words, and sentences the examiner had prompted prior to intervention. Participants in Layton's study classified as low-verbal imitators were found to produce fewer signs and words in the speech-alone treatment compared to the other three conditions. This finding provides insight into a potentially clinically relevant, moderating effect of imitation on AAC intervention outcomes; however, caution is required when interpreting these findings due to design limitation, which points to the need for greater consistency in the quality of research methodology used to examine factors that predict and moderate response to treatment.

To further understand the individual differences in AAC intervention outcomes and how those factors may influence how an intervention is administered, mediators should be explored. In this review, four potential mediators of intervention outcomes were identified: (a) communication partner knowledge, (b) perception of benefits of the AAC system being used (i.e., manual sign), (c) adult input at home, and (d) frequency of AAC exposure provided during therapy sessions. In addition to those factors found to be insignificant (duration of therapy, hours of parent training), these potential mediators offer insight into factors that can be manipulated during an intervention and thus warrant further exploration. Brady et al. (2013), for example, reported that children's use of language at home was associated with parents' AAC input, supporting the notion that communication partners play an important role in facilitating language development. Interestingly, no such relationship was identified in the school environment with teachers, but the authors noted that this was likely due to a ceiling effect (e.g., teachers consistently providing high levels of input). These findings illuminate the need for not only more understanding of these mediating factors but also careful interpretation of potential mediating effects in cases where a lack of association is due to ceiling effects in desirable skills.

Limitations and Future Research Directions

This systematic review presents preliminary insights and has limitations. Most notably, the review yielded only seven studies, and most of potential predictor, mediator, and moderator factors were examined in only one study. In addition, studies could have as few as one participant in order to be included in the review. Thus, the findings relate to participants with a range of diagnoses and a relatively wide age range. The small number of studies and the inclusion of participants without ASD limited the ability to draw broader conclusions with regard to factors that predict, moderate, and mediate outcomes for children with ASD. Another

limitation was the limited reporting of intervention protocols in the original studies. Although the type of intervention was defined, instructional practices (e.g., behavioral strategies) across the different types of interventions used were not always defined. Knowing not just the type of AAC (e.g., manual sign) but how it was taught (e.g., through behavioral strategies such as prompting and prompt fading vs. modeling signs) is important to understanding how intervention impacts AAC outcomes. Given that research in the field is still emerging, the findings may assist future researchers to identify potential factors for further investigation.

The findings must also be considered with respect to methodological limitations of the included studies. The use of a range of characterization and outcome measures, as well as methods for statistical analyses, makes comparing findings across studies difficult; and highlights the need for more detailed and consistent characterization across studies, including analyses of sub-groups based on communication and diagnostic characteristics. It is also noteworthy that the findings relied on analyses reported in the original studies as opposed to re-analysis or meta-analysis of the original data. Finally, in many cases, examination of predictors, moderators, and/or mediators was not the focus of an original study, which resulted in the need to make subjective judgments regarding the nature of the factors under examination.

With a view to facilitating collaboration across teams, researchers should consider making data sets more readily available, facilitating the establishment of larger databases to support more sophisticated analyses with greater statistical power. Furthermore, reiterating the sentiments of other researchers (Yoder & Compton, 2004; Yoder & Stone, 2006b), future studies must apply higher-quality research designs. When identifying potential predictors, moderators, and mediators, future researchers should also draw on clinical experience by investigating what clinicians consider to be critical components in AAC interventions, given their ability to

contribute clinical wisdom to understanding the issue, consistent with the evidence-based practice framework (Schlosser & Sigafos, 2009).

Conclusion

This review contributes to the evidence base in AAC interventions by identifying potential factors that offer insight into how and why children with ASD respond within and between different AAC interventions, as well as emphasizing the need to further explore these factors. Gaining insight into the factors that predict, moderate, and mediate response to an AAC intervention will help to develop a fine-grained understanding of what works for whom and why with regard to this particular intervention approach.

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Figure 1. Flow Diagram of Search Strategies

Table 1

Summary of Extracted Data from Included Studies

Study	Design	Participant characteristics	Intervention overview	Outcome measures
Brady, Thiemann-Bourque, Fleming, and Matthews (2013)	Prospective cohort study	93 children ($M = 50.3$; range: 36-61) with ASD (45), Down syndrome (15), other (33)	Observational data of children's use of multiple AAC systems at home and preschool ($M = 13.4$ months)	Number of different words spoken, signed, or selected on AAC device in home and scripted communication samples
Gordon et al. (2011)	Community-based group; randomized control trial	84 children with ASD ($M = 6.8$; range: 4-10)	Classroom-based PECS intervention, delivered in special needs settings classrooms with assessments at 3 time-points over 20 months	Frequency of child-initiated communication using IC-P, IC-S, or IC-PS to request objects or make social comments, observed during classroom activities
Layton (1988)	Quasi-experimental cohort study	60 children with ASD ($M = 61.75$; range: 3-9)	Children assigned to one of four conditions (manual sign, speech, simultaneous sign and speech, alternating sign and speech) delivered in 90 40-min daily sessions	Number of signs/words comprehended, produced, and spontaneously used during treatment conditions; number of signs/words produced in follow up session, three months after treatment
Pasco and Tohill (2011)	Retrospective cohort study	23 children with ASD (range: 5-6; mean not reported)	Participants attending special school who had been receiving PECS intervention for a minimum 12 months; therapy delivered by SLPs, sessions ranged from 28-33 sessions	Participants divided into two groups: Those who achieved PECS Phase III (Group A) and those who did not (Group B)
Vandereet, Maes, Lembrechts, and Zink (2011)	Prospective cohort study	23 children with ID ($M = 4.04$; range 3-6.05); 1 child later diagnosed	Children were exposed to simultaneous sign-speech interventions for between	Expressive vocabulary checklists in free play and scripted communication tasks; participants categorized into four

		with ASD	0 and 30 months ($M=10$ months)	profiles: (a) P1: <50 words expressed, (b) P2: > 50% of words expressed w/ isolated manual sign, (c) P3: >50% of their words with manual signs on one checklist but >50% with speech on another, (d) P4: >50% words using speech alone on all checklists
Yoder and Stone (2006 a,b)	Randomized group study	36 children ($M = 33.6$; range 21-54) with ASD (33) or PDD-NOS (3)	PECS vs. RPMT: 3 x 20-min sessions per week for 6 months; 15 hours of parent education	Frequency of nonimitative spoken communication acts, number of different non-imitative spoken words, object exchange, requesting, and joint attention

Note. ASD = autism spectrum disorder; AAC = augmentative and alternative communication; PECS = Picture Exchange Communication System; IC-P = spontaneously initiated communication using picture cards; IC-S = spontaneous communication using speech; IC-PS= spontaneous communication using both simultaneously; SLP = speech language pathologist; RPMT = Responsive Education and Prelinguistic Milieu Teaching; ID = intellectual disability; PDD-NOS = pervasive developmental disorder not otherwise specified

Table 2

Summary of Extracted Data from Included Studies

Study	Factors examined	Findings
Brady, Thiemann-Bourque, Fleming, and Matthews (2013)	Intrinsic symbolic factor (ISF): non-verbal cognitive development, language comprehension, play level, communication complexity	ISF predicted number of different words at Time 2
	Adult communication partner input and amount of instruction at home and at school	Parent input at home, but not teacher input at school, associated with child outcomes
Gordon et al. (2011)	Expressive language assessed with ADOS item A-1	Children with lower expressive language scores (higher ability) showed larger increases in spontaneous use of IC-PS
	Autism symptomology score (ADOS)	Children with lower ADOS scores showed the largest increase in IC-S. ADOS scores not associated with IC-PS
	Nonverbal developmental quotient (DQ)	Non-significant interactions with outcome measures
	Chronological age	Non-significant interactions with outcome measures
Layton (1988)	Children classified as high or low-verbal imitators on the basis of their number of correct approximations of sounds, words, and sentences prompted by the clinician	High-verbal imitators performed equally well in all treatment conditions on all measures; high-verbal imitators performed better than low-verbal imitators on all dependent language factors in all treatment conditions; low-verbal imitators produced fewer signs and words in speech-alone treatment, compared to the other three conditions

Pasco and Tohill (2011)	<p>Psycho-Educational Profile, Total Developmental Age (PEP-R TDA): Imitation, perception, fine motor, gross motor, eye-hand integration, cognitive performance, and cognitive-verbal</p> <p>Chronological age</p>	<p>All 16 children who achieved PECS Phase III had TDA scores of 16 months or above; six of seven children who achieved below Phase III had TDA scores of below 16 months; PEP-R TDA scores for Group A were significantly higher than B for every domain except cognitive-verbal</p> <p>No significant differences across profiles</p>
	Number of PECS therapy sessions	Number of PECS sessions significantly higher for Group B (less than Phase III)
Vandereet, Maes, Lembrechts, and Zink (2011)	<p>Cognitive skills based on standardized assessment and analyzed as developmental quotient</p> <p>Chronological age</p>	<p>Profile 1(P1) had significantly lower developmental quotient than Profile 3 (P3) and Profile 4 (P4)</p> <p>No significant differences across profiles</p>
	Initial vocabulary comprehension	P1 significantly lower initial vocabulary than P4
	Communication competence categorized according to the ComFor	Significant association between level of sense-making and vocabulary acquisition; P1 operated at sensation level; P4 highly related to higher levels of sense-making (presentation and representation levels)
	Frequency of manual sign during therapy	No difference between participant profiles and frequency of manual sign use during therapy sessions
	Speech-language therapy variables: age of onset of therapy, frequency of therapy, frequency of manual sign instruction, attitudes towards manual signs	No difference between participant profiles and age of onset or frequency of manual sign use; SLPs working with P3 and P4 indicated significantly greater support for statement that manual sign positively influences children's speech development; those working with P1 indicated significantly less support for statement that manual sign supports children to understand communication partners

	Parents' knowledge of manual sign	Parents' knowledge and use did not differ between profiles; except fathers of children with P4 knowing significantly fewer signs than those of children in P3
	Parents' attitudes towards manual sign	No significant differences between mothers and fathers on use of, or attitudes towards, signs
Yoder and Stone (2006a, b)	Object exploration	RPMT < PECS for children with higher object exploration at baseline for number of different non-imitative spoken words; RPMT > PECS for children with less object exploration at baseline for number of different non-imitative spoken words
	Therapy factors: session length, child attendance, hours of parent training Pre-treatment initiating joint attention	No correlation between session length, child attendance, or hours of parent training and either outcome measure RPMT > PECS in increasing object exchange and initiating joint attention, with the latter only for children who used at least 7 initiating joint attention acts pre-treatment; PECS > RPMT in increasing requesting in children with low level of initiating joint attention pre-treatment

Note. ADOS = Autism Diagnosis Observation Schedule; IC-PS = spontaneously initiated communication using picture cards; IC-S = spontaneous communication using speech; SLP = speech language pathologists; PECS = Picture Exchange Communication System; ComFor= an indicator of sense-making and perception of non-transient forms of communication at the levels of presentation and representation. The levels of sense-making are: sensation, presentation, representation; RPMT = Responsive Education and Prelinguistic Milieu Teaching

Table 3
Quality of Evidence Ratings

Study and NHMRC ratings	EPHPP quality of evidence						Overall rating
	Selection bias	Design	Confounders	Blinding	Data collection	Withdrawals/dropouts	
Brady et al., (2013) (Level III-II)	Moderate	Moderate	Strong	Moderate	Strong	Strong	Moderate
Gordon et al. (2011) (Level II)	Moderate	Strong	Strong	Moderate	Strong	Strong	Strong
Layton (1998) (Level II-II)	Weak	Strong	Strong	Moderate	Strong	Strong	Moderate
Pasco and Tohill (2011) (Level III-III)	Moderate	Moderate	Strong	Strong	Strong	Weak	Moderate
Vandereet et al. (2011) (Level III-I)	Moderate	Moderate	Strong	Moderate	Strong	Strong	Moderate
Yoder and Stone (2006 a,b) (Level II)	Moderate	Strong	Strong	Moderate	Strong	Strong	Strong

Note. NHMRC = National Health and Medical Research Council; EPHPP =Effective Public Health Practice Project

Table 4

Summary of Potential Predictors (Pr), Moderators (Mo), and Mediators (Me)

Study	Factors													
	Cognitive ability	ASD severity	Play skills / object exploration	Joint attention	Imitation	Communication complexity/competence	Motor skills	Language use	Language comprehension	Frequency of AAC exposure	Communication partner knowledge of AAC system (number of symbols)	Communication partner perception of AAC	Social interaction variable: adult input at home	Comprehensive measure (ISF)
Brady, Thiemann-Bourque, Fleming, and Matthews, 2013	Pr ^b		Pr ^b			Pr ^b			Pr ^b				Me	Pr ^b
Gordon et al., (2011)	Pr	Pr ^a						Pr						
Layton (1998)					Mo ^a									
Pasco and Tohill (2011)	Pr ^b				Pr ^b		Pr ^b			Me				Pr ^b
Vandereet, Maes, Lembrechts, and Zink (2011)	Pr				Pr	Pr			Pr		Me ^a	Me ^a		
Yoder and Stone (2006) (a, b)			Mo	Mo										

Note. ^a Found to have significant association with outcome measure under at least one intervention condition; ^b Composite measures examine multiple areas of development (e.g., PER-R includes fine motor, expressive language, etc.)