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A Case for Increased Rigor in AAC Research: A Methodological Quality Review

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Abstract

This comprehensive review reports on methodological quality of 162 single-case studies on augmentative and alternative communication for communication and challenging behavior in individuals diagnosed with autism or intellectual disabilities and with complex communication needs. Following review for inclusion criteria, documents were excluded if they failed to meet basic methodological standards. Each remaining study was evaluated for 10 detailed quality criteria. No studies met all standards without reservations. Only three of the included studies met all of the standards with reservations and the remainder met some but not all standards, with or without reservations. The included studies reported adequate detail for half of the quality indicators, but insufficient details for participant, setting, maintenance, and generalization, and social validity descriptions. An increased quantity and quality of research were found in over four decades. More recent studies have adequately reported half of the criteria investigated, including describing the materials, defining the outcome variables, describing baseline and intervention procedures, and evaluating procedural integrity. After identifying quality features, the authors report in more detail on low rated quality indicators particularly relevant to studies addressing social-communication interventions. The literature infrequently reported race, ethnicity, or home language. Future research should report characteristics of participants to ensure that research becomes representative of the population.

Key words: Augmentative and alternative communication; Autism spectrum disorder; Intellectual disabilities; Social-communication interventions; Methodological quality review; Design quality

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A Case for Increased Rigor in AAC Research: A Methodological Quality Review

Augmentative and alternative communication (AAC) addresses the needs of individuals experiencing complex communication needs characterized by impairments in speech-language production or comprehension. The term AAC has been used in professional literature since the early 1980's (Glennen & DeCoste, 1997; Lloyd, 1985) making carefully researched applications of AAC relatively new by scientific standards with respect to experimental validation (Reichle et al., 1991). Beukelman & Light (2020) projected that millions of individuals with complex communication needs either use or are candidates for AAC. Thus, the empirical examination of AAC has the potential to influence a significant constituency.

Social-communicative delays and/or differences represent core characteristics of many developmental disabilities (Johnston et al., 2012). As a result of increasingly earlier identification and an increased incidence in some disabilities, the number of persons with developmental disabilities with complex communication needs has grown in the past several decades. For example, ASD now constitutes 2.9% of children between 3 and 17 years (Health and Human Services Administration [HRSA] 2019) with approximately half either failing to develop speech or experiencing limited speech and language abilities (Tager-Flusberg & Kasari, 2013). Approximately 30% of children participating in early intervention have difficulty developing the spoken language skills needed to communicate with others, and likely require additional communication support, such as AAC (Rose et al., 2016). Most of these toddlers could benefit from AAC applications (Light & McNaughton, 2012; Shane et al., 2012).

When an individual with a disability also experiences complex communication needs, they are likely to experience both immediate and long-term impacts across their lifespan. Children with complex communication needs have communication delays that, without extensive

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intervention, will likely be compounded (Reichle & Wacker, 2017). Idiosyncratic communication strategies often develop in the form of challenging behaviors, contributing to reduced opportunities for social involvement (Reichle & Wacker, 2017). Thus, it is critical to identify practices resulting in the successful implementation of AAC to improve communication and collateral outcomes (Light et al., 2019a).

AAC Interventions

To maximize social communication skills, AAC applications (Light & McNaughton, 2012) have provided improved access to educational and community settings, regardless of chronological/developmental age ranges and disability types (Ganz et al., 2017, 2012). Strategies for implementing AAC, particularly high-tech applications, have evolved dramatically within a short period and require constant attention to enable practitioners to remain knowledgeable about the current evidence-base. In the context of this paper, AAC intervention refers to an intervention that incorporates AAC; that is, we are broadly referring to the use of AAC to support implementation of interventions for individuals with CCN.

Single-case experimental designs (SCEDs) have been used extensively to validate intervention strategies for persons with low incidence disabilities, particularly those with complex communication needs (Allen et al., 2017; O'Neill et al., 2018); the majority of studies on this population involve SCED rather than group research designs. Compared to group designs, SCEDs have the advantage that they can be applied when participants have heterogeneous characteristics in addition to their low incidence (Barton et al., 2016). Some SCEDs permit an experimental analysis within participants with replication across participants. This design type limits the demands on tight control of participant characteristics and allows a study to be completed with a smaller number of participants, albeit with the cost of limiting

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external validity (Smith, 2012).

Along with increasing acceptance of SCEDs has come a greater scrutiny of the methodology quality of studies that use these designs. Greater scrutiny has resulted in guidelines defining elements of acceptable SCED (Ledford & Gast, 2018; Council for Exceptional Children, 2014; Ganz & Ayres, 2018; Horner et al., 2005; Maggin et al., 2013; Reichow et al., 2008; U.S. Department of Education [USDE], 2017). However, most existing AAC literature reviews have not directly applied quality standards (Holyfield et al., 2017). Thus, the quality of the experimental methodologies and analyses used to derive and synthesize findings are not entirely clear (Ganz et al., 2017; Morin et al., 2018). Further, the communication disorder field itself has recommended that systematic reviews and meta-analyses be held to stringent quality standards in their implementation and reporting (Schlosser et al., 2007).

Methodological Quality and its Importance in AAC SCED Research

Scrutinizing methodological quality is important in advancing AAC for several reasons. First, more rigorous methodology will allow more exact replication of previously reported research. Second, at a practitioner level, it will permit a more exacting implementation of assessment and intervention strategies with fewer unintended consequences, which could otherwise be difficult to troubleshoot as a result of unclearly specified methodology. Third, both ethical and legal considerations require the use of evidence-based intervention strategies when they are available. The Every Student Succeeds Act (2015) and the Individuals with Disabilities Education Improvement Act (2004) require that educators employ good faith efforts to use evidence-based practices. The What Works Clearinghouse (WWC) (USDE, 2017) authored standards for evaluating the quality of SCED and between-group research. These criteria represent a cohesive and rigorous approach from a design standpoint (Maggin et al., 2013).

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Although the WWC standards are primarily designed for use in the WWC's own research review and synthesis efforts, they have also had a broader influence on the field and have been applied in systematic reviews of the SCED literature conducted independently of the WWC.

Comprehensive examination of methodological quality in AAC research relying on SCEDs has been limited. The National Clearinghouse on Autism Evidence & Practice (Steinbrenner et al., 2020) and the National Autism Center (2015) recently reported that AAC is evidence-based. Prior peer-refereed systematic reviews were limited in terms of the population examined, were not comprehensive with respect to communication modes evaluated, or are now outdated (Biggs et al., 2018; Holyfield et al., 2017; Morin et al., 2018; Shire & Jones, 2015; Therrien et al., 2016). Furthermore, while some reviews have evaluated the literature with respect to basic methodological quality standards (e.g., Steinbrenner et al., 2020), none have recently or comprehensively reviewed the quality of AAC intervention research methodology for individuals with ASD/ID. Two decades ago, literature reviews and position papers noted inattention to methodological quality, including in the field of AAC and with respect to maintenance, generalization (Schlosser & Braun, 1994; Schlosser & Lee, 2000), procedural/treatment integrity (Schlosser, 2002), and social validation (Schlosser, 1999). Thus, there is a clear need for a comprehensive systematic review that carefully attends to methodological quality, including how methodological practices have changed over time.

Identifying Important Methodological Variables

A range of methodological variables may influence the efficacy and acceptability of aided and unaided AAC applications for persons with significant developmental disabilities who also experience complex communication needs. Researchers must report participant descriptions, interventionist characteristics, treatment intensity, authenticity of settings, maintenance and

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generalization of skills, and social validity of the intervention, to allow others to replicate and assess external validity (Morin et al., 2018; Schlosser & Lee, 2000).

Heterogeneous Participants

Careful and detailed descriptions of heterogeneous participants should allow the aggregation of the data so practitioners are better able to identify for whom variations on AAC interventions are effective. It is important that participant descriptions include diagnostic and communication assessments, prior use of AAC and other modes, and pivotal skills that may enhance acquisition. This allows for aggregating similar participants to determine factors related to individualization of intervention such as communication modes and treatment modifications.

Generalization

Interventionists should consider the context-boundedness of an intervention, or the likelihood that skills will generalize beyond the contexts in which they were taught, and the proximity of the outcomes, or how closely they are tied to the skills initially taught (Sandbank, Chow, Bottema-Beutel, & Woynaroski, 2021). Generalization of learned skills to non-instructional contexts, people, exemplars, or materials and maintenance of skills over time represent important measures of the lasting effects of an intervention (Johnston et al., 2012). Important parameters of generalization include whether the situations in which generalization is to be probed received baseline opportunities, the range of different variable that are addressed in generalization opportunities, and whether stimulus characteristics (e.g., instructor) present during acquisition are also present during generalization probes, which might indicate degree of stimulus control rather than generalization per se (Reichle & Wacker, 2017; Schlosser & Lee, 2000). Important parameters of maintenance reporting include frequency of maintenance probes and the period of time over which maintenance data are taken (Neely et al., 2016).

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Schlosser and Lee (2000) sought to determine the effectiveness of interventions in augmentative and alternative communication emphasizing strategies that induce generalization and/or maintenance. Fifty single-subject experimental studies across a wide range of learner characteristics included 232 comparisons of experimental phases. Interventions were effective with respect to the acquisition of communicative behavior. However, generalization and maintenance data were difficult to interpret because only a small number of studies meeting quality standards reported generalization or maintenance data. The lack of evidence, along with a lack of specifiable approaches led the authors to call for the infusion of generalization (and maintenance) strategies into treatment during the acquisition phases of an intervention study.

Social Validity

The social validity of an intervention addresses the social significance of intervention goals, social acceptability of intervention procedures, and social importance of effects (Common & Lane, 2017; Kazdin, 1977; Wolf, 1978). Frequently, evidence pertaining to social validity goes unreported in AAC interventions (Logan et al., 2017). Considerations in addressing social validity include the dependent variables selected, degree of change in outcomes, implementation in authentic environments, cost, stakeholder satisfaction with the intervention, and the feasibility or contextual fit of the approach. Interventionists have a range of theoretical and methodological differences with respect to communication intervention strategies. Consequently, it is important that they have sufficient evidence-based choices to ensure a good contextual fit between evidence-based strategies chosen and what they feel comfortable implementing (Reichle, 2006). Systematic reviews may address information regarding the practicality of interventions to facilitate individualization of AAC strategies.

Treatment Acceptability and Contextual Fit

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Treatment acceptability and contextual fit have received extremely limited attention, yet reporting data regarding these features is important in considering the sustainability of an intervention. Contextual fit is the match between the strategies, procedures, or elements of an intervention and the values, needs, skills, and resources of those who implement and experience the intervention (U.S. Department of Health and Human Services, ASPE, 2014). This area bears directly on the extent to which interventionists' interest and skill in continuing to sustain interventions across time are affected as a result of the components of an intervention strategy. Contextual fit influences all stakeholders. For example, people with complex communication needs and their family members sometimes abandon or reject AAC systems because they find them to be unacceptable or impractical for reasons including difficulty programming, inconvenience of maintaining, ineffectiveness without adequate support, poor portability, and poor fluency compared to some other communication modes (Delarosa et al., 2012). Although contextual fit has been addressed in the AAC literature (e.g., Light et al., 2019b), it is less clear how consistently it has been addressed in practice.

Aims of this Systematic Review

The AAC literature has expanded rapidly (Light et al., 2019a), creating a need for systematic review of literature quality. Such assessments are a necessary initial step before synthesizing results across similar studies to better determine for whom, under what conditions, and for what outcomes AAC interventions are more or less effective. Consequently, the aims of the current article are to review methodological quality standards for SCED for a body of literature pertaining to AAC interventions for individuals with ASD/ID. We look specifically at the quality of literature that meets the basic quality standards promulgated by the What Works Clearinghouse because such studies are more likely to be included in systematic reviews and

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meta-analyses of SCED research on AAC interventions. We first provide overall assessments of methodological quality. We then give further detail on quality indicators that are most often under-reported and that are particularly relevant to this body of literature addressing social-communication intervention with persons who experience ASD/ID with complex communication needs, including (a) participant descriptions that include diagnostic and communication assessments, (b) setting characteristics, (c) generalization to non-instructional contexts, people, exemplars, or materials, (d) maintenance of acquired skills, and (e) social validity (e.g., significance of skills taught, authenticity of environments, people, and materials, and contextual fit of the interventions). Finally, we assess the progress of researchers in reporting these features over time. This information will provide AAC researchers guidance regarding areas of methodological quality on which to attend more closely in designing their studies.

Method

This paper reports a subset of articles identified via a larger, comprehensive systematic review and meta-analysis that reported the results of group and single-case research studies for AAC interventions for individuals with ASD or IDD of any age and for both communication and behavior outcomes for this population. The data reported here includes only those single-case design articles that met basic design standards with or without reservations for the first experimental figure presented in each article. The search and coding processes were conducted between 2018 and April 2020 (Figure 1). Summaries of the steps from the previous project methodology are provided in the sections that follow, with details that pertain to the studies in the current systematic review.

Eligibility Criteria

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Studies were screened during the title/abstract and full text reviews to determine if each document met the following criteria: (a) was written in English, (b) contained one or more participants with an intellectual delay or developmental disability with co-occurring complex communication needs (e.g., minimally- or non-verbal), (c) reported the results of an augmentative and alternative communication (AAC) intervention, (d) included a SCED or group design (later narrowed to those that included SCED for the purposes of this review), and (e) included a measure of social-communicative or social communicative and challenging behavior outcomes. Group design papers were excluded from this review because the methodological quality indicators for group and single-case research are different, prohibiting aggregation.

Literature Search and Inclusion/Exclusion Criteria

Literature searches were conducted by a professional reference librarian. The databases included Academic Search Complete, ERIC, PsycINFO, Conference Proceedings Citation Index – Social Science & Humanities (Web of Science), and Proquest Dissertations & Theses Global. The keywords were based on three focus areas of AAC: social-communication and behaviors, outcomes, and persons who experience ASD/ID with CCN. Search terms for each search engine are included in the larger study (PROSPERO registration: CRD42018112428). This search yielded 7,327 documents (after deduplication) that were reviewed for potential inclusion.

Documents were screened for inclusion/exclusion at four distinct points in the review process: title/abstract screening, full-text review, basic design quality standards review (WWC single-case design standards: U.S. Department of Education, 2017b), and dependent variable screening. For title/abstract screening, four raters reviewed the titles and abstracts of 7,327 documents applying inclusion/ exclusion criteria via Rayyan, an online citation management system (Ouzzani et al., 2016). A total of 1,758 documents met the criteria after title/abstract

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review and were screened with full-text inclusion/exclusion criteria by four raters using Rayyan. Subsequently, the 547 documents that remained after full-text screening were reviewed by applying basic design quality standards, following WWC criteria. Finally, 257 SCED documents were reviewed by lead authors to identify relevant dependent variables; during this process, the lead authors conducted a final review of each remaining document for inclusion/exclusion criteria.

Full Methodological Standards Coding

Given the comprehensive nature of this project, a large number of documents were acquired in the search stage that, in turn yielded a sizable corpus to which inclusion/exclusion criteria were applied. Because of different standards for group and single-case designs, the present review focused exclusively on the SCED studies. For each included study, we examined the first reported figure (provided that data met the inclusion criteria of the basic WWC design standards). Each document was given a rating of (a) met design standards, (b) met design standards with reservations, or (c) did not meet standards. The preceding review steps yielded 162 SCED articles, including a total of 522 participants, which were included in the full methodological standards analysis. Full methodological standards were developed drawing from expert methodological standards (i.e., Council for Exceptional Children, 2014; Horner et al., 2005; Reichow et al., 2008) and included review of document descriptions of (a) participants, (b) settings, (c) materials, (d) implementers, (e) procedures in baseline and intervention, (f) the dependent variable, (g) maintenance, (h) generalizations, (i) procedural fidelity, and (j) social validity description. Each dimension is summarized below and described in more detail in Appendix A.

Participant Standards

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Participant description standards included whether each document provided the contents and outcomes of assessment, chronological age, diagnosis, education services, and recruitment methodology. We also coded for race, ethnicity, and home language for each participant group (i.e., educator, parent of person with ASD/ID, peer or sibling, and person with ASD/ID) across 522 participants.

Setting, Materials, and Implementer Standards

Setting standards included whether each document described individuals in the setting, approximation dimension, arrangement of the physical space, familiarity of participants, and additional description of the context (e.g., classroom, grocery store, noise levels). Material standards included whether materials utilized in conducting the investigation were described. Implementer standards included whether a study provided the interventionist's educational background, degree of experience with the population and intervention, and familiarity with participants.

Baseline and Intervention Procedures and Dependent Variable Standards

The baseline and intervention procedures standards included reporting of procedures for both phases to a degree to allow for replication, including a description of session length, procedures, and behaviors of the interventionist. The dependent variable standards included reporting of an observable and measurable dependent variable, when discontinuous systems are used, and recording procedures.

Maintenance, Generalization, Procedural Fidelity, and Social Validity Standards

The maintenance standards included the number of data points collected after intervention and amount of time between collecting follow-up data and ending the intervention. The generalization standards considered the number of data points across phases and types of

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generalization activities. The procedural fidelity standards included reporting of procedural fidelity and percentage of agreement. The social validity standards included social significance, authentic settings for participants, types of social validity surveys, cost efficiency, and feasible intervention description.

Inter-rater Reliability (IRR)

Nine raters coded articles as described above. The raters included two professors in special education and seven doctoral students in special education with experience in conducting quality review, meta-analysis, and single-case research. At least two raters evaluated at least 20% of the included documents for each stage (title/abstract, full-text, basic standards screening, and full methodological quality standards review stages). Raters were trained coding each stage by a faculty trainer using the following steps. The coding rules were reviewed. Next each reviewer was assigned a small number of articles 3-5 to review independently. Subsequently, codes were compared across reviewers and discrepancies were discussed until consensus was reached. The process was repeated until each reviewer achieved at least 80% agreement with the faculty reviewer. Agreement was computed by adding agreements, divided by the sum of agreement and disagreements, then multiplied by 100 for a percentage. For full methodological review standards, IRR accuracy scores resulted in a mean agreement of 89.87% (range: 82%-96% across standards described in this section). Complete reporting of IRR is available in the larger study.

Data Analysis

A total of 162 included studies were analyzed and summarized by study design (i.e., multiple probe, multiple baseline, alternating treatment, ABAB, changing criterion, and other designs) and for each of the full methodological standards. Histograms were created to illustrate the numbers and proportion of documents that met the overall design standards and that met each

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of the specific standards without reservation, overall and by year. Five of the full methodological standards (participant, setting, maintenance, generalization, and social validity descriptions) were analyzed in greater detail. These five standards were selected given the low percentage of studies meeting each of these standards. Histograms were constructed to summarize the percentages of articles meeting each specific item of these standards.

Results

This systematic review aims to describe rigor-related components of the literature addressing AAC interventions for social-communication outcomes with persons with ASD/ID who have complex communication needs. Documents that met the basic standards were included in the full methodological review. The 162 single-case experimental design documents (see Appendix B) that were analyzed included 70 multiple probe designs, 48 multiple baseline designs, 22 alternating treatment designs, 21 reversal designs, and 1 ABCBC reversal design embedded within a multiple baseline design. Of the included documents, 49 (30%) were published in 2017 or later, 36 (22%) were published between 2013 and 2016, 33 (20%) were published between 2009 and 2012, 13 (8%) were published between 2005 and 2008, and the remaining 31 (19%) were published prior to 2005 (see Appendix C for a graphical representation of publication dates).

Methodological Standards

With respect to the full methodological standards, no documents met all of the standards without reservations. Three documents met all of the standards with reservations and 159 documents (98%) met some, but not all of the standards. Figure 2 reports percentages of studies meeting each of the methodological design standards without reservations by year. The most recent decade yielded substantial improvement in addressing materials and procedural integrity

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descriptions. Dependent variable, baseline, and intervention procedure descriptions have been reasonably high and constant over time. In the remainder of this section, we focus on the five standards for which most documents provided insufficient information. These standards included participant, setting, maintenance, generalization, and social validity descriptions.

Participants

Overall, 40 documents (25%) met all of the participant description standards, 41 documents (25%) met standards with reservations, and 81 documents (50%) did not meet standards. The proportion that met participant description standards without reservations remained low and constant over time. Regarding the participant description sub-criteria (see Figure 3), at least 87% of the studies adequately described participant ages, primary diagnoses, and educational services received. Approximately half of the documents met criteria for providing assessment data, defining inclusion/exclusion criteria, and describing the consent and recruit processes.

We extracted information about race, ethnicity, and home language for each of the 522 participants in the included studies. We coded for each sub-group of participant roles (i.e., person with ASD/ID [$N = 458$], educator [$N = 28$], parent of person with ASD/ID [$N = 17$], peer or sibling [$N = 19$]). Less than half of the included documents reported the race (44%), ethnicity (7%), or home-language (13%) of the participants (Table 1).

Setting

Overall, 10 documents (6%) met standards, 37 documents (23%) met standards with reservations, and 115 documents (71%) did not meet standards. The percentages of the studies that met the full design standards without reservation remained at a low level, between zero and approximately 25% of studies, each year and did not improve appreciably over time (Figure 2).

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Regarding the setting description sub-criteria (see Figure 3), most of the studies met the criteria of providing an adequate description of the context in which the procedures took place, participants' familiarity to the setting prior to the study, and presence of other individuals in the settings, with at least 62% of the studies providing this information. Fewer than 44% of the included studies met the sub-criteria regarding the description of the arrangement of the physical space and furniture and providing an approximate dimension of the space(s) where the intervention took place.

Maintenance

Overall, 19 documents (12%) met standards, 35 documents (22%) met standards with reservation, and 108 documents (67%) did not meet standards related to maintenance data collection and reporting. Few documents met this standard, with no improvement over time (Figure 2). The results for each maintenance sub-criteria revealed that less than half of the documents collected some maintenance data, only 25% of the studies reporting three or more maintenance data points; and less than 20% reported maintenance data collected at least 4 weeks beyond the final intervention session (Figure 4).

Generalization

The criterion of collecting three or more generalization data points during baseline, intervention or maintenance phases was met in only 20% of the documents. One document (1%) met standards, 57 documents (35%) met standards with reservations, and 104 documents (64%) did not meet standards regarding generalization data. As Figure 2 demonstrates, the quality of reporting on generalization did not improve across the years in studies examined. Only 45% of studies met the standards with reservation by collecting any generalization data. Studies rarely reported generalization data collected outside of the presence of persons associated with the

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intervention (see Figure 4).

Social Validity

Overall, 33 documents (20%) met standards, one document (1%) met standards with reservations, and 128 documents (79%) did not meet the social validity description standards. Few studies met standards without reservations across the time period scrutinized (Figure 2). Regarding the sub-components of social validity, 69% or more studies looked at social significance of the dependent variables, outcomes, implementation in authentic environments, and feasibility, but only 20% of the documents reported the efficiency and cost effectiveness of the intervention (see Figure 5).

Discussion

From the late 1970s through 2019, the number of SCED publications addressing AAC interventions for individuals with ASD/ID that met the basic WWC design quality standards has increased. In particular, the quality of AAC research addressing ASD/ID with respect to the reporting specificity of teaching material improved. Additionally, objective definitions of the dependent variable(s), the collection and reporting of procedural integrity and descriptions of the baseline and intervention conditions were increasingly more detailed with study recency. One exception was the consistency of reporting session length (reported by 73%-76% of documents).

The absence of race, ethnicity, and language of participants prevents assessment of whether study participants were representative of any larger population. Lack of information regarding these participant characteristics is a long-standing problem (Swanson & Hoskyn, 1998). Given the increasingly diverse population of students with disabilities, research must include participants who are representative of the population as a whole and must investigate challenges and impacts that differentially affect outcomes across culturally and linguistically

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diverse and exceptional students (Bal & Trainor, 2016).

For approximately half of the methodological standards, SCED publications either improved slightly or did not improve in terms of meeting standards for participants, setting, maintenance, generalization, instructional procedures, and social validity descriptions. Half of the articles did not provide information addressing participant assessment data, primary diagnosis, or age. When standardized and normed diagnostic and educational assessment summaries are not reported for study participants, it is difficult to determine for whom the outcomes are applicable. Consequently, there is a need for direct as well as systematic replication of many of the independent variables in studies reviewed (Tincani & Travers, 2019). Without greater methodological rigor these needed replications will be challenging. It is likely that participants with more significant needs may require more intensive or modified intervention approaches; however, this is unclear without further information regarding participants' skills and deficits prior to selecting an intervention strategy.

Articles often failed to provide adequate detail in describing settings where interventions were implemented. Although most studies provided information regarding the contexts in which the intervention took place and learner familiarity with the setting, many failed to describe setting aspects that included the presence or absence of other individuals during intervention opportunities; however, setting descriptions often lacked information regarding the presence of others.

Maintenance and generalization data were often not reported. When generalization data were described, relatively few studies examined generalization during each phase of the experiment. This is important to ensure that generalization instruction is incorporated at the point at which a learner begins acquisition training. Further, during baseline, generalization data

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ensure that the learner has not yet mastered the skill being taught in the presence of some stimuli. It is also important to know whether stimuli in the acquisition environment may be influencing performance if also present in a generalization context. Although prior investigations have identified AAC interventions as evidence-based for individuals with ASD (Iacono et al., 2016; Morin et al., 2018), they have been based primarily on the acquisition and fluent communication skill use. Unless new communicative skills have been mastered and maintained for a period of time, we believe they cannot be considered mastered.

Generalization is particularly critical for individuals with ASD given that generalization is recognized as a common challenge in this population (Brown & Bebkko, 2012). We found that a relatively small proportion of investigations comprehensively assessed maintenance and/or generalization. This finding is consistent with previous reviews (Biggs et al., 2018; Morin et al., 2018). To some extent, there was a propensity to test generalization across different perceptual attributes of referents (e.g., red and green apples) and across settings rather than across other generalization factors. Several of these included generalization across communicative functions (e.g., generalizing symbol(s) taught as requests to comments and vice versa). Additionally, little attention has been given to recombining or response generalization (Goldstein, 1983) or to cross-modal generalization. For example, if one learns to produce a symbol, it is possible that the learner could have gained collateral comprehension of the symbol and or comprehension of spoken words that accompanied it. While several studies have examined this phenomenon (e.g., Harris & Reichle, 2004), doing so was rare in the overall body of literature. Some articles did not provide baseline data on the use of a behavior to be taught under generalization conditions, to allow comparison during and after acquisition. This level of rigor is important if researchers aim to generate causal evidence with respect to generalization. Finally, we did not evaluate reports

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on the extent to which learners overgeneralized a newly taught communicative behavior (i.e., using a newly taught skill in the absence of relevant stimuli). For example, requesting assistance with difficult tasks but refraining from requesting assistance with easy tasks).

Typically, maintenance data were obtained during a very short time span at the conclusion of acquisition. We believe that meaningful maintenance data would more ideally cover a much longer time frame. Similar to previous literature (Biggs et al., 2018; Morin et al., 2018; Therrien et al., 2016), we found inadequate reporting of information on maintenance and generalization (Schlosser & Braun, 1994; Schlosser & Lee, 2000) and information on social validity information (Biggs et al., 2018; Morin et al., 2018; Schlosser, 1999; Therrien et al., 2016); although we also note that reporting has somewhat improved over the last decade.

Encouragingly, the literature has responded to earlier calls for improvements in areas of methodological quality such as procedural or treatment integrity (Schlosser, 2002). Additionally, the propensity to address social validity increased over time in the investigations reviewed; however, this variable continues to receive relatively sparse attention. That said, some features of socially valid implementation were noted in many of the studies. In particular, many studies reported AAC interventions that were implemented in authentic contexts; targeted outcomes were socially significant and improved to an acceptable degree; and gathered stakeholder reports that they were satisfied with the procedures, outcomes, and feasibility of the project. Unfortunately, much of this information was anecdotal and it was unclear who solicited it. If from the experimenters directly, stakeholder responses may have been biased in favor of providing socially desirable responses.

This work expands on and supports observations made by previous authors whose

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research focused on mid-to-high-tech AAC (Morin et al., 2018) or across all disability categories (Biggs et al., 2018; Shire & Jones, 2015). Other researchers have found that while much of the SCED research has reported age and diagnosis of participants, most did not provide adequate information about participant inclusion criteria and assessment results. This review may be the first to note, comprehensively, that SCED researchers in this focus area vastly under-report participant characteristics related to race, ethnicity, and language.

Limitations and Future Directions

Although the present study sought to provide a comprehensive review of the state of the literature related to adherence to quality indicators, it has several limitations. Inter-rater reliability, although acceptable, could have been higher. We believe this was lower than anticipated because authors placed methodological information in unusual locations in a manuscript, such as setting information placed in results. Sometimes the dependent measure specified in the methods section was not the same as reported in the graphs. Occurrences such as these increase the workload for readers and may compromise replicability if readers cannot easily extract the information from an article needed to replicate critical components of an intervention strategy. Another limitation of the present study is that we did not conduct a fine-grained analysis of materials, dependent variable, interventionist, baseline, intervention, or procedural integrity descriptions; however, summaries of these data are available in Appendix D. Finally, we considered only surface features relating to the cultural responsiveness of the studies.

Future research should focus on improving the quality of implementation and reporting of SCED research on AAC for individuals with ASD/ID. Given the heterogeneity of this population, more thorough descriptions of participants, settings, generalization, maintenance, and social validity would allow practitioners to better individualize AAC interventions and would

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allow aggregation of data, such as assessment results. This would allow researchers to determine what participants may need more intensive intervention or modifications. Additionally, researchers must report on factors relevant to the cultural and linguistic diversity of the sample and must include diverse representation in research pertaining to AAC applications with the populations that were the focus of this article (Bal & Trainor, 2016). Investigators must begin reporting not only surface features of participant descriptions, but also descriptions of the situations in which the participants are served, such as cultural histories, cultural rules, and power differentials. Furthermore, investigators need to engage in recruitment activities that increase the participation of non-dominant groups (Bal & Trainor, 2016). Future reviews should thoroughly investigate the cultural responsiveness of the primary study methodologies.

There are a number of pivotal skills (i.e., imitation, joint attention) that may affect the potency of early communication intervention strategies (Koegel et al., 2016). It is important for intervention researchers to clearly specify the status of these skills at the beginning and conclusion of intervention. If not already in a learner's repertoire, it is possible that they may be acquired during intervention. Further, if not present pre-intervention, it may be useful to consider concurrently teaching these skills. Because the status of these skills is inconsistently addressed, it has been difficult to ascertain their importance. There are reports in the literature reviewed of collateral and unintended gains as a result of early communication intervention, such as play, language comprehension, increased social interactions (Light et al., 2019a; Reichle et al., 2019). However, often, these skills are mentioned only anecdotally in the discussion section of the manuscript. Future research should report potential pivotal skills such as imitation and joint attention already in participants' repertoires to allow for greater procedural individualization, for example, using modeling with a learner who is proficient at imitating novel behavioral forms.

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With respect to materials specific to aided communication systems, there is a need to better specify the configuration of the learners' communication system. For example, the nature of the learners past experience with AAC and the current status of their vocal and verbal repertoire, including communication production and comprehension, is infrequently addressed. Thus, future reviews could provide more specific reporting of AAC-specific factors that may indicate predictors of responsivity to communication intervention.

One area that is infrequently reported and should be considered, in future reviews and meta-analyses, involves investigating the degree to which particular AAC strategies are associated with better long-term maintenance of skills and expanded generalization across practical contexts (Schlosser, 1999). It was rare to find intervention studies that followed maintenance longer than several weeks. However, as time passes, not only must skills be maintained but the circumstances under which the behaviors are used shift. Thus, conditions are created that require maintenance to be combined with generalization. Consequently, knowing how well new communication skills maintain across a longer period would provide insight in considering what type of acquisition criteria may assist in facilitating longer term maintenance. Finally, future reviews should strive to more comprehensively evaluate the feasibility and acceptability of approaches from the perspectives of caregivers and interventionists. Contextual fit for stakeholders may well be related to implementation fidelity and adherence to intervention protocols overtime.

Conclusion

This study found an increase in the reported quality of the literature over the years. Careful consideration of the factors presented here may improve the quality of the literature base, so that systematic reviews and syntheses can better inform service delivery, communication

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outcomes, and quality of life for those with ASD/ID and complex communication needs.

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Figure 1*PRISMA Flowchart*

Note: Flowchart based on Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Medicine*, 6(7): e1000097. doi: 10.1371/journal.pmed1000097.

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Figure 2

Percentage of Studies Meeting each of the Methodological Design Standards without Reservations, by 4-Year Period

Percentage of studies meeting overall extended design standards without reservations, by time period. The width of the bar corresponds to the number of studies published during the time period.

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Figure 3*Participant and Setting Description Sub-criteria***Participant Description Sub-criteria** **Setting Description Sub-criteria**

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Figure 4*Maintenance and Generalization Description Sub-criteria***Maintenance Description Sub-criteria** **Generalization Description Sub-criteria**

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Figure 5*Social Validity Description Sub-criteria*

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Table 1*Race, Ethnicity, and Home Language of Participants Groups*

Participant groups	Person with ASD/ID (n = 458)	Educator (n = 28)	Parent of person with ASD/ID (n = 17)	Peer or sibling (n = 19)
Race				
African American	29 (6.3%)	3 (10.7%)	1 (5.9%)	2 (10.5%)
Asian/Asian American	10 (2.2%)	--	--	2 (10.5%)
White/Caucasian	98 (21.4%)	10 (35.7%)	5 (29.4%)	14 (73.7%)
Dual-race (African American and Caucasian)	3 (0.7%)	--	--	--
Not specified/Other	318 (69.4%)	15 (53.6%)	11 (64.7%)	1 (5.3%)
Ethnicity				
Latinx/Hispanic/Spanish origin	22 (4.8%)	1 (3.6%)	3 (17.6%)	1 (5.3%)
Not Latinx/Hispanic/Spanish	5 (1.1%)	--	--	3 (15.8%)
Not specified	431 (94.1%)	27 (96.4%)	14 (82.4%)	15 (78.9%)
Home language				
English	32 (7%)	2 (7.1%)	2 (11.8%)	--
Korean	--	1 (3.6%)	--	--
Spanish	6 (1.3%)	--	--	--
Dual-language	13 (2.8%)	3 (10.7%)	2 (11.8%)	--
Amharic	1 (0.2%)	--	--	--
Dutch	4 (0.9%)	--	--	--
Reportedly “could not speak or understand English”	4 (0.9%)	--	--	--
Not specified: article is in English and published in English-dominant setting/country and no language is specified	381 (83.2%)	22 (78.6%)	10 (58.8%)	19 (100%)
Not specified: article is published in English, but the first author's affiliated country had a different dominant language	17 (3.7%)	--	3 (17.6%)	--

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Appendix A
Full Methodological Quality Standards

Full Methodological Quality Standards		
Criteria	Description	Score/Standard
Participant characteristics		
Race	African American/Black; Asian/Asian American; White/Caucasian; Dual-race (African American and Caucasian); Not specified/Other	NA
Ethnicity	Latinx/Hispanic/Spanish origin; Not Latinx/Hispanic/Spanish origin; Not specified	
Home language	Article in English and published in English-dominant setting/country and no other language identified as spoken by the participant; article published in English language but first author affiliated country has different dominant language; English; Korean; Spanish; Dual-language; Amharic; Dutch; The children’s primary care-takers could not speak or understand English	
Participants		
Participants	(a) Assessment	2=Meets This Standard:
	(b) Chronological Age	Includes all of these
	(c) Primary diagnosis	criteria.
	(d) Educational services	1=Meets This Standard
	(e) Inclusion and exclusion criteria	with Reservations:
	(f) Acknowledgment of informed consent and recruitment process	Operational descriptions of participants included at least the following criteria (a), (b), (c), but does not meet all of the requirements for a score of “2”. 0=Does Not Meet This Standard: Operational descriptions of participants were not reported.
Settings		
Settings	(a) Presence of other individuals in the setting specifically during intervention procedures and who they were	2=Meets This Standard: Includes all of the criteria.

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	(b) Approximate dimensions of the space(s) where the intervention took place	1=Meets This Standard with Reservations: Description includes the following criteria, but not (e). 0=Does Not Meet This Standard: Operational description of the setting includes none of the above criteria.
	(c) Arrangement of the physical space and furniture	
	(d) Description of the context in which the procedures took place (e.g., classroom, grocery store, noise levels, other stimuli)	
	(e) Participant familiarity to the setting prior to the study	

Materials

Materials	(a) qualities (e.g., size, color, dimensions, quantity) of any materials used in the study, including those specific to the targeted intervention	2=Meets This Standard: Materials description lists all of these criteria. 1=Meets This Standard with Reservations: Includes at least the following criteria, but not all criteria. 0=Does Not Meet This Standard: Operational description of the materials includes none of the above criteria.
	(b) description of how the materials worked (e.g., software)	
	(c) examples of materials or how to access them if not commercially available	

Interventionist Description

Interventionist Description	(a) interventionist's occupation	2=Meets this Standard: The interventionist description must include all criteria. 1=Meets This Standard with Reservations: Interventionist description includes at least 1, but not all of the criteria. 0=Does Not Meet This Standard: Interventionist description is not given or includes 0 of the above-mentioned criteria.
	(b) relationship to the participant	
	(c) education level	
	(d) experience/training are described, particularly as relevant for this intervention.	

Dependent Variables

Dependent Variables	(a) DV is observable and measurable as described	2=Meets This Standard:
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	(b) When discontinuous systems are used (e.g., interval systems), authors report sufficient information regarding the percentage of total observations for samples of the data to permit readers to ascertain approximate error	<p>All dependent variables meet all of the criteria: 1=Meets This Standard with Reservations: Dependent variable is described objectively/operationally but does not meet all of the criteria. 0= Does Not Meet This Standard: Difficult to determine what was measured.</p>
	(c) Sessions were video recorded	

Baseline & Intervention Descriptions

Baseline & Intervention Descriptions	(a) procedures for both baseline and intervention phases are provided to a degree to allow for replicability	<p>2=Meets this Standard: Procedural descriptions include (a) and (b). 1=Meets This Standard with Reservations: Baseline and intervention procedures both include at least one of the elements but is missing the others. 0=Does Not Meet This Standard: Neither of the criteria was included in the descriptions.</p>
	(b) session length, procedures, behaviors of the interventionist are described for both	

Maintenance

Maintenance	(a) there were at least 3 maintenance data points per level	<p>2=Meets This Standard: Includes both criteria. 1=Meets This Standard with Reservations: Maintenance data were collected after intervention was implemented, but there were fewer than 3 data points, and/or maintenance data were collected less than 4 weeks following the conclusion of intervention.</p>
	(b) maintenance data were collected at least 4 weeks following the conclusion of intervention.	

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		0=Does Not Meet This Standard: No maintenance data reported.
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Generalization

Generalization	(a) data addressing novel materials, persons, activities or settings were collected during baseline and intervention phases, related to generalization to non-instructional contexts, people, exemplars, or materials	2=Meets this Standard Includes criteria (a) & (b). 1= Meets This Standard with Reservations: Generalization data were collected only after the intervention was implemented and/or there were fewer than 3 data points for generalization. 0=Does Not Meet This Standard: No generalization data reported.
	(b) there are at least 3 generalization data points per phase	

Procedural Integrity

Procedural Integrity	(a) Procedural integrity/fidelity was collected on 20% of baseline and intervention data points	2=Meets This Standard: Materials description lists all of these criteria. 1=Meets the Standard with Reservations: Procedural integrity/fidelity was collected or reportedly collected for less than 20% of intervention data points and/or did not meet the minimum quality thresholds (80)% OR the study meets the minimum standards for intervention only, but not baseline. 0=Does Not Meet This Standard: Procedural Integrity data not reported.
	(b) Met the minimum quality thresholds (80%) for both baseline and intervention phases	

Social Validity

Social Validity	(a) social significance of the dependent variables (i.e. the target behaviors are	2=Meets This Standard: At least 4 of the
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	beneficial to the participant and relevant to the context)	<p>following criteria are met, including (required) (a) through (c)</p> <p>1=Meets the Standard with Reservations: At least one of the criteria is met, though not enough for a score of “2”.</p> <p>0=Does Not Meet This Standard: Fails to meet criteria for a score of “2” or “1”.</p>
	(b) the change in behavior or intervention effects were significant according to the criterion or goals set for individual studies (via checklist)	
	(c) the intervention contains a natural component for each participant (i.e. the interventionist is an individual that is present in the participant’s natural setting, or the intervention is implemented in the natural setting for at least one context, such as generalization)	
	(d) all individuals involved, who were surveyed, are satisfied with the procedures and outcomes (via checklist)	
	(e) the intervention was efficient and cost effective (as evaluated in a social validity checklist or report by implementer or another stakeholder)	

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Appendix B

References for Included Single-case Experimental Design Documents

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Appendix C

Number of Studies by Time of Publication (4-Year Period)

Number of studies by time of publication

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Appendix D

Standards Sub-criteria Descriptions

Material Description Sub-criteria

Dependent Variable Description Sub-criteria

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Interventionist Description Sub-criteria

Baseline Description Sub-criteria

Intervention Description Sub-criteria

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Procedural Integrity Description Sub-criteria