

**Systematic Review of Variables Related to Instruction in
Augmentative and Alternative Communication Implementation: Group and Single-Case
Design**

Joe Reichle¹, J. B. Ganz², James E. Pustejovsky³, Kimberly J. Vannest⁴, Margaret Foster⁵, Lauren M. Pierson⁶, Sanikan Wattanawongwan², Man Chen³, Marcus C. Fuller⁷, April N. Haas⁸, Bethany Hamilton-Bhat⁹, Mary Rose Salles¹⁰, S. D. Smith¹¹, and Valeria Yllades¹²

¹Department of Speech-Language-Hearing Sciences, University of Minnesota

²Department of Educational Psychology, Texas A&M University

³Department of Educational Psychology, University of Wisconsin-Madison

⁴Department of Education, University of Vermont

⁵Center for Systematic Reviews and Research Syntheses, School of Medicine, Texas A&M
University

⁶Department of Social Work and Communication Disorders, Tarleton State University

⁷Department of Education, University of Maryland Eastern Shore

⁸Life Skills Autism Academy, Plano, TX

⁹Department of Educational Psychology, University of Texas at Austin

¹⁰Department of Curriculum and Instruction, University of Alabama-Birmingham

¹¹Department of Elementary, Early, & Special Education, Southeast Missouri State University

¹²Galliant, San Antonio, Tx

Author Note

J. B. Ganz: <https://orcid.org/0000-0002-2080-102X>

James E. Pustejovsky: <https://orcid.org/0000-0003-0591-9465>

Kimberly J. Vannest : <https://orcid.org/0000-0002-2285-0837>

Margaret Foster: <https://orcid.org/0000-0002-4453-7788>

Lauren M. Pierson: <https://orcid.org/0000-0002-9086-3250>

Sanikan Wattanawongwan: <https://orcid.org/0000-0003-3479-5369>

Marcus C. Fuller: <https://orcid.org/0000-0003-0829-1597>

April N. Haas: <https://orcid.org/0000-0001-6465-2540>

Mary Rose Sallese: <https://orcid.org/0000-0002-4995-0440>

S. D. Smith: <https://orcid.org/0000-0002-9474-7185>

Valeria Yllades : <https://orcid.org/0000-0001-8756-2177>

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Correspondence concerning this article should be addressed to Sanikan

Wattanawongwan, Texas A&M University, 4225 TAMU, College Station, TX 77843. Email:

swattanawongwan@tamu.edu

ABSTRACT

Purpose: This article provides an analysis of group and single-case studies addressing augmentative and alternative communication (AAC) intervention with school-aged persons having autism spectrum disorder (ASD), and/or intellectual/developmental disabilities (IDD) resulting in complex communicative needs (CCNs). Specifically, we examined participant characteristics in group design studies reporting AAC intervention outcomes and how these compared to those reported in single-case experiments (SCED). Additionally, we compared the status of intervention features reported in group and SCED studies with respect to instructional strategies utilized.

Participants: Participants included school-aged individuals with complex communicative needs who also experienced autism spectrum disorder (ASD) or ASD with an intellectual delay who utilized aided or unaided AAC.

Methods: A systematic review using descriptive statistics and effect sizes was implemented.

Results: Findings revealed that participant features such as race, ethnicity, and home language continue to be under-reported in both SCED and group design studies. Participants in SCED investigations more frequently used multiple communication modes when compared to participants in group studies. The status of pivotal skills such as imitation was sparsely reported in both types of studies. With respect to instructional features, group design studies were more apt to utilize clinical rather than educational or home settings when compared with SCED studies. Additionally, SCED studies were more apt to utilize instructional methods that closely adhered to instructional features more typically characterized as being associated with behavioral approaches.

Conclusions: The authors discuss future research needs, practice implications, and a more detailed specification of treatment intensity parameters for future research.

Keywords: complex communicative need, ASD, ID, AAC intervention, participant characteristics, instructional features, systematic review

Systematic Review of Variables Related to Instruction in Augmentative and Alternative Communication Implementation: Group and Single-case Design

In the United States, approximately 1 in 44 children has been identified with autism spectrum disorder (ASD), according to estimates from CDC's Autism and Developmental Disabilities Monitoring (ADDM) Network [Data & Statistics on Autism Spectrum Disorder | CDC](#). ASD is reported to occur in all racial, ethnic, and socioeconomic groups, although minoritized groups are often diagnosed later, thus delaying access to services. Further, 1 in 6 (17%) children aged 3–17 years are diagnosed with a developmental disability, as reported by parents. This means that between 1.1 and 1.34 percent of children between 3 and 17 years of age experience intellectual delay and roughly 2-3 percent of children are diagnosed with ASD. The overall percentage of children and youth with developmental disabilities is approximately 5-7 percent (Zablotsky et al., 2017).

Some individuals with developmental disabilities require augmentative and alternative communication (AAC) to serve as an interim tool in acquiring speech, while others are likely to utilize AAC as a life-long tool in supplementing communication (Beukelman & Light, 2020; Hustad & Miles, 2010; Johnston et al., 2012). Recent reports suggest that between 0.5 and 1.5% of the population use AAC applications or would benefit from AAC (Beukelman & Light, 2020; Beukelman & Mirenda, 2005).

There are a number of reasons for considering an aided or unaided AAC system. Some individuals with developmental disabilities (a) experience a cognitive impairment that has resulted in a substantial delay in speech and/or language acquisition, (b) produce speech that is not sufficiently intelligible to be understood by most or by a critical subset of communicative partners, (c) have difficulty acquiring communicative behavior at a rate that allows them to

readily participate in a range of communicative exchanges, or (d) have word-finding or other memory limitations that make it difficult to construct messages commensurate with their ability to understand language morphology and syntax (Beukelman & Light, 2020). This range of potential communicative challenges and needs warrants consideration of the participant, instructional, and design variables in building on the evidence-based advances in augmentative and alternative communication (AAC).

Social-communicative challenges represent a distinguishing characteristic of persons with ASD and for many individuals diagnosed with an intellectual or developmental disability (IDD) (American Psychiatric Association [APA] Division of Research, 2013). The magnitude of the challenges to interventionists is more clearly understood when one considers that approximately 30% of children with ASD are minimally verbal and over half do not develop a substantial repertoire of spoken language (Tager-Flusberg & Kasari, 2013). Consequently, the applicability of AAC systems with this population is significantly greater than in the general population.

Child Characteristics Associated with AAC Acquisition

Individuals using AAC who have ASD and/or IDD are diverse. As a result, our knowledge regarding matching characteristics and precursor skills of individuals to strategies for AAC interventions is limited. For instance, one meta-analysis (Ganz et al., 2014) suggested that, while AAC applications had a universally positive effect on speech outcomes, speech-generating devices were more effective with persons who did not experience an intellectual disability and ASD, and the Picture Exchange Communication System, a low-tech exchange-based aided AAC system, was more effective for persons with ASD who also had intellectual or other developmental disabilities.

Few meta-analyses of educational or speech and language interventions report racial/ethnic composition of users. Gaias et al. (2020) reported that 27% of empirical investigations and 94% of meta-analyses did not report race/ethnicity. Their results further indicated that Asian, Native American, and Latinx populations are underrepresented in the research literature; and that race, ethnicity, or home language of participants is rarely reported. More specifically, with respect to AAC and individuals with ASD/IDD, Ganz et al. (in press) noted a similar lack of reporting of race, ethnicity, and home language in the empirical literature that uses single-case designs. Additionally, there is an underrepresentation of minoritized groups who experience ASD/IDD, their parents, and their educators in single-case studies. However, it is unclear whether this underrepresentation extends to group-design research in this specific area. This lack of racial and ethnic information could result in empirical research that is not applicable to the population as a whole and could inhibit the possibility of tailoring AAC interventions to be culturally sensitive to the needs of learners and their families.

With respect to age, ample literature has reported successful outcomes for young children with ASD and/or IDD who learn to use AAC (Ganz et al., 2011, 2014, 2017; Sievers et al., 2018). Older individuals are also responsive to intervention and should be eligible for AAC interventions, yet the literature on older individuals is sparse (Holyfield et al., 2017).

With respect to communication mode, it is possible that a learner's experience with a mode(s) being taught could have an impact on acquisition during intervention. To date, few studies have examined this topic with learners experiencing CCNs. Van der Meer et al. (2012) demonstrated that preference for a particular mode can influence instructional motivation with a particular communication mode. If the mode used by a learner prior to intervention is a mismatch to the communicative mode being taught, interference may be created in learning new symbols.

Alternatively, if a communicative mode used prior to intervention is a match to that being implemented during intervention, it may facilitate the acquisition of new symbols as a result of mode familiarity. Although communication mode may influence acquisition for some learners, this has rarely been investigated.

Regardless of communication mode being taught, there may be some skills that facilitate communication acquisition. Pivotal skills can be described as those that in and of themselves are not required to acquire AAC, but the presence of which may positively influence the acquisition of AAC skills. Additionally, these pivotal skills may play a role in the collateral acquisition of spoken communicative behavior. One of these pivotal skills is imitation. Gevarter et al., (2013) reported that learners with strong motor imitation skills also matched pictures well and did well with multiple types of AAC, while those with low motor imitation and more modest picture matching skills did better with picture-exchange systems (Gevarter et al., 2013). Flippin and colleagues (2010) reported a meta analysis to investigate pre-AAC intervention child characteristics that predict communication outcomes for young children with ASD and IDD. Participants who (a) were somewhat able to verbally imitate prior to intervention, (b) demonstrated lower joint attention, and (c) had higher levels of object exploration at baseline were more responsive to Picture Exchange Communication System (PECS) intervention.

Identifying instructional characteristics that influence intervention outcomes

There are a number of instructional characteristics, such as setting or number of settings in which intervention is implemented, that may influence intervention outcomes. For example, Brady et al. (2013) analyzed communication partner input and the amount of instruction at home and school. They reported that, 1 year later, there was a positive relationship between adult input at home and child communication outcomes, but not between teacher input and child outcomes

at school. Most research has been implemented in school or clinical settings (Biggs et al., 2019; Gervarter & Zamora, 2018; Holyfield et al., 2017; Logan et al., 2017; Therrien & Light, 2016) and infrequently in homes or other community settings (Shire & Jones, 2015).

Many instructional components, including strategies to evaluate preferences, specific prompting strategies, or sequencing of specific skills to be taught (Schlosser & Koul, 2015; Therrien & Light, 2016) have received limited attention. Only two meta-analyses (Ganz et al., 2017; O'Neill et al., 2018) included statistical aggregation with respect to this topic. Whether the learner could imitate or alternatively was taught to imitate as part of the intervention has not often been addressed. A number of prompting and prompt-fading strategies have some evidence of promise (Ganz et al., 2017; Holyfield et al., 2017; Shire & Jones, 2015; Therrien & Light, 2016). However, most existing systematic reviews have not statistically aggregated or compared results by instructional strategy. Ganz et al. (2017) conducted a meta-analysis limited to high-tech AAC, reporting that interventions including prompt-fading produced stronger effects than those that did not. As was the case with previously discussed variables, most reviews included heterogeneous populations of individuals with CCN (e.g., co-occurring with physical disabilities and speech impairment in addition to students with ASD and IDD; Allen et al., 2017; Biggs et al., 2019; O'Neill et al., 2018) making it more challenging to determine the relationship between learner characteristics and moderating variables such as prompt fading or certain pivotal skills (e.g., imitation; joint attention).

An important aspect of instructional strategies involves the general approach to implementation. Naturalistic intervention approaches, such as child-led instruction (Logan et al., 2017) and embedding AAC instruction within authentic activities (Gervarter & Zamora, 2018; Shire & Jones, 2015), are increasingly prevalent in AAC intervention. While researchers and

practitioners regularly call for implementing AAC in authentic environments, only a small proportion of studies have reported AAC implementation within authentic contexts and/or with natural communication partners (Biggs et al., 2019; Holyfield et al., 2017; Logan et al., 2017; Shire & Jones, 2015). Relatively few experiments have comprehensively examined outcome differences between authentic and contrived contexts (Ganz et al., 2017).

Selection of the AAC modes to be implemented during intervention research requires a number of considerations that include preference and relative efficacy of modes. Somewhat limited guidance is available regarding selection of communication modes for individuals who would benefit from AAC (Reichle et al., 2019). Researchers infrequently provide a rationale for the augmentative communication modes selected for implementation ().

Although some reviews, meta-analyses, and primary research studies have investigated the relative effectiveness of varied modes of AAC with individuals with ASD and/or IDD, in the aggregate, they have produced somewhat ambiguous outcomes (Achmadi et al., 2012; Ganz et al., 2014; Gevarter et al., 2013; van der Meer et al., 2012).

Outcomes other than acquisition are important in evaluating the efficacy of an intervention strategy. Some of these include generalization and maintenance outcomes. McLay and colleagues (2015) reported comparable acquisition regardless of communication mode selected, but better generalization and maintenance with options that involved selecting a graphic symbol versus unaided communication such as sign language. This might be the result of a lessened memory load with graphic symbols (Johnston et al., 2012). Further, low tech systems involving symbol exchange between communicative partners may facilitate joint attention skills among early communicators (Johnston et al., 2012).

Research Design Considerations

Existing research on AAC interventions has used a range of designs, including both single-case research designs (i.e., ABAB designs, multiple baselines across participants, multiple baselines across behaviors, alternating treatment designs) and between-group designs. However, many past systematic reviews of the AAC literature have focused exclusively on studies that use single-case research designs. Ideally, research syntheses that aim to inform evidence-based practice recommendations should take a comprehensive view of available research evidence, synthesizing and distilling findings from both single-case studies and group design studies. Paradigmatic differences between types of research designs make this a difficult task—particularly if different types of study designs tend to be implemented with different profiles of participants, different approaches to intervention, or different classes of dependent variables (Kratochwill et al., 2021). A necessary first step is to examine the characteristics of the available evidence base across both types of studies, to take stock of what research has been conducted and to consider the similarities and differences in features of the single-case studies and group-design studies that have been conducted.

Purpose and Research Questions

To address the current knowledge gap, the following research questions represent the focus of the current article:

- What is the status of research addressing participant characteristics in group design studies reporting AAC intervention outcomes for individuals with ASD and/or IDD who have CCN, and how does this compare to the reporting in single-case experiments, with respect to a) diagnosis; b) chronological age; c) ethnicity, race, and home language; d) the number or type of communication modes used prior to intervention; e) the prompts used, and f) the status of the learner's imitation use prior to intervention?

- What is the status of reporting intervention features in group design studies, and how does this compare to the reporting in single-case experiments, with respect to instructional strategies associated with more naturalistic as well as more behavioral intervention strategies (i.e., child or interventionist initiated, dispersed versus massed teaching opportunities, contrived versus embedded activity contexts, group versus one-on-one instructional formats, limited versus varied teaching stimuli, controlled versus natural instructional environments)?

Method

This review is part of a larger systematic review and meta-analysis of the AAC literature for individuals with ASD and/or IDD (Ganz et al., 2018). The literature search, coding, and analysis procedures were conducted between 2018 and 2020 and are described in detail in Ganz et al. (2020). We provide a summary of the methods pertinent to the current investigation as follows. Figure 1 displays a flowchart that summarizes the search and screening process of the review.

Literature Search

A professional reference librarian with 15 years experience conducted the literature search. Databases queried included *Academic Search Complete*, *ERIC*, *PsycINFO*, *Conference Proceedings Citation Index – Social Science & Humanities* (Web of Science), and *Proquest Dissertations & Theses Global*. We used keywords based on three focus areas of AAC, social-communication and behaviors outcomes, and persons who experience ASD/IDD with CCN. Search terms included keywords based on: [((augmentative or alternative) within one word (w1) communicat*) or “sign language” or manual sign* or speech-generating device* or SGD or “voice output communication aid” or VOCA* or PECS or “picture exchange communication

system” or AAC or “visual scene display” or “functional communication training”] AND [(down* w1 syndrome) or ((develop* or intellectual) w1 (delay* or disabil* or impair*)) or autis* or retard*]. This search yielded 7,327 documents that were reviewed for inclusion/exclusion criteria.

Inclusion/Exclusion Criteria

Inclusion/exclusion stages included title/abstract screening, full-text screening, basic design quality standards screening (What Works Clearinghouse [WWC] single-case design standards: Kratochwill et al., 2010, 2014, 2018), and dependent variable screenings. For title/abstract screening, four raters (doctoral students in special education) screened the titles and abstracts of 7,327 documents against inclusion/exclusion criteria using an online citation management system called Rayyan (Ouzzani et al., 2016). A total of 1,758 documents that met the inclusion criteria at title/abstract screening were included to the next stage. For full-text screening, four raters (doctoral students in special education) screened the full-texts of 1,758 documents against full-text inclusion/exclusion criteria via Rayyan. Documents meeting eligibility criteria included a total of 132 reports on group design studies and 547 reports of SCED studies. The remaining stages of review were tailored to the study design.

The 132 group design documents and 547 single-case studies were reviewed against basic design quality standards. For group designs, standards were modeled after relevant What Works Clearinghouse standards and included criteria for use of random assignment, attrition, and baseline equivalence of the analytic sample (WWC, 2020). The inclusion/exclusion stages (title/abstract, full-text inclusion/exclusion criteria, and basic design quality standards) are described in greater detail in a larger study (Ganz et al., 2020). A total of 59 group and 257 single-case design studies potentially meeting design criteria were reviewed by PIs to determine

dependent variables that were relevant for raw data extraction purposes; during this process, the PIs conducted a final review of each remaining document for inclusion/exclusion criteria. A total of 24 group designs met group design standards and included relevant dependent variables; these studies were included in the descriptive review. A total of 114 single-case studies met basic design standards and included relevant dependent variables. These were included in the descriptive review.

Coding Procedures

A total of 24 group and 114 single-case design studies were coded for variables related to: participant characteristics, instructional characteristics, and dependent variable characteristics. Seven doctoral student coders in the Special Education program were trained by a PI to code these variables. Participant characteristics were coded with regard to: (a) diagnosis (i.e., ASD, IDD), (b) chronological age, (c) race/ethnicity, (d) number of word/symbols/sign approximations produced prior to intervention, (e) communication status prior to intervention, (f) cognitive/IQ status prior to intervention, (g) ASD diagnostic assessment to establish ASD diagnosis, (h) communication mode(s) used prior to study, (i) imitation status, and (j) joint attention status. We also coded instructional characteristics with regard to (a) the intervention orientation (social behavioral, functional behavioral), (b) instructional features (i.e., environmental arrangement, preference/reinforcement assessment, reinforcement, modeling, verbal prompting, physical prompting, prompt fading, graphic prompt), and (c) intervention setting.

Across both group design and single-case studies, we examined whether participants received more instructional characteristics associated with behavioral intervention strategies versus those associated with more naturalistic intervention approaches. Indicators associated

with each of these approaches are described in Table 1 and were coded as mutually exclusive (e.g., participants were coded as receiving primarily interventionist-initiated or child-initiated learning opportunities).

Included articles were also coded for the dependent variable characteristics: (a) communicative function (i.e., behavior regulation, social interaction, joint attention), (b) expressive and receptive communication (i.e., communication production, communication comprehension), (c) communication mode (i.e., natural gesture, manual sign, low tech aided system, mid-to-high tech speech generating device, vocal, verbal), and (d) function of the challenging behavior (if challenging behavior).

For descriptions of each dependent measure refer to Appendix A.

Reliability

All reliability reported was implemented by computing agreements divided by agreements plus disagreements multiplied by 100%. Four doctoral students in the special education program coded title/abstract and full-text review. Each had substantial experience and expertise in conducting meta-analyses and systematic reviews around the topic of AAC. All raters were trained to code until they reached a minimum criterion of 80% agreement. Subsequently, all raters discussed any coding disagreements and reached consensus on disagreements. After doing this they resumed independent coding. Reliability was collected on 100% of all articles during the title/abstract stage with 88% agreement. Thirty nine percent (39%) of the articles for the full-text stage were independently coded yielding 88% agreement.

A total of three raters evaluated 132 group design documents and 547 SCED documents in the basic design standards screening stage. One rater was a professor in research methods and statistics who served as a PI for the project, and who has extensive experience and expertise in

meta-analysis. Another two raters were doctoral students in quantitative methods. All raters discussed the screening criteria and were trained to code using the screening form. After screening for basic design standards, investigators coded participant and instructional characteristics. Each reliability outcome was computed using item by item percentage agreement. A PI rater and resolved discrepancies following a thorough discussion among all raters. Reliability for each phase of the systematic review including design quality, participant, instructional, and outcomes variables are reported in Table 2.

Effect Sizes for Group Designs

For group designs, we calculated standardized mean difference (SMD) effect sizes and associated sampling variances from reported summary statistics, following standard methods. The Hedges' g estimator (Hedges, 1981) was used because many of the group design studies included a relatively small number of participants. In order to ensure reproducibility, the calculations were performed using scripts for the R statistical computing environment. Of the included group designs, only 12 studies provided sufficient quantitative information for effect size calculations.

Descriptive Analysis

For each variable that was the focus of the current investigation, the number and percentage of studies and the number and percentage of participants that provided data were tabulated and reported. Studies and participants were tabulated separately for group design studies and single-case studies. For analysis of effect sizes from group design studies, we created forest plots to illustrate the distribution of effect size estimates and calculated descriptive summary statistics. We refrained from conducting formal meta-analysis of the effect sizes due to the high degree of heterogeneity in the interventions and outcomes examined in the included

studies.

Software and reproducibility.

In order to ensure the accuracy and reproducibility of the investigation, all analyses were carried out in the R statistical computing environment. Datasets and computer code for replicating all reported analyses are made available in the supplementary materials ([REDACTED]).

Results

Variable outcomes are reported as a percentage in text and both percentage and number of studies and participants for SCED and group studies in Tables 3 through 7.

Participant Characteristics

Diagnosis. Fifty-seven percent of participants in group studies were diagnosed with ASD compared with 75% in SCED studies (including those with both ASD and IDD). Persons with IDD comprised 15% of group study participants and 32% of participants in SCED investigations. Diagnosis was not reported or unknown for 23% of participants in group studies.

Chronological Age. Figure 2 depicts the distribution of participant ages in studies using group designs. Notably, just under half of the studies involved participants who were five YO or younger. Group studies involving older participants often included a very broad range of ages. Among group studies, 32% of participants were between 0 and 3 years of age. In studies utilizing SCED, 19% of participants were between 0-3 years of age. Four and five year olds accounted for 16% of group participants and 32% of SCED participants. This trend was similar for proportions of 6-10 year olds which was 16% of group studies and 29% of SCED participants. Eleven to 14 year olds were sparsely represented in group studies comprising only 7% of the participants and double the percentage (12%) of SCED participants. Those who were 14 years and older

accounted for 30% of group study participants but only 8% of SCED participants.

Race/Ethnicity. Ninety-six percent of group design and 75% of SCED studies did not report participant race. With respect to ethnicity, 96% of group studies and 99% of SCED studies did not address participant ethnicity. Breakdowns of race and ethnicity that were reported are displayed in Table 3. With respect to race, the largest proportion of participants were caucasian in both Group and SCED studies, followed by African American/Black and then Asian American/Asian. In studies for which race categories were reported, the distribution of participants was similar across group design and single case studies.

Home Language was also scrutinized. Eighteen percent did not specify home language in group studies while 90% of SCED studies did not specify home language. Only among SCED studies were non-English home languages ever reported. A breakdown by specific language is displayed in Table 3.

Communication modes prior to intervention. Thirty-six percent of the participants in group design studies used two or more communication modes prior to research participation. However, communication mode prior to intervention was not reported for approximately 35% of participants (see Table 4). The most frequently used communication mode prior to intervention was verbalization which was utilized by 13% of the participants, while no participants were reported to use AAC only. In comparison, SCED studies reported a much larger proportion of participants (48%) who used 2 or more communication modes prior to study implementation. Pre-intervention communication mode was not reported in 14% of the participants in these investigations while verbalization (15%) was the most frequent communication mode used prior to intervention among those participating in SCED studies. In SCED studies, participants used a range of other modes prior to intervention, including 20% who used any aided or unaided AAC

mode as a singular mode prior to intervention. Use of mid- or high-tech communication aids was infrequently reported.

Imitation prior to intervention. Participants' imitation skills were rarely reported in either group (94% of participants) or SCED (70% of participants) studies. A further breakdown of imitation that was observed is enumerated in Table 4.

Instructional Characteristics

Settings. Clinics were the most frequent setting for instruction implemented in group design studies (31% of participants). For group design studies, classrooms were an infrequently utilized setting (22% of participants). However, classrooms were the most frequently used setting for studies employing SCED (35% of participants) followed by clinical settings (28% of participants). Home settings were the venue for 18% of participants in group studies but only 9% of the participants in SCED investigations. Approximately 29% of learners participated in interventions implemented in multiple settings in group experimental designs, compared to 22% of participants in SCED studies. A detailed breakdown of setting information is delineated in Table 5.

Instructional features. Features most often addressed in studies utilizing group designs included modeling (reported to be used with 73% of participants) and reinforcement (implemented with 71% of participants). With respect to SCED studies, reinforcement (92%), systematic arrangement of the environment (89%), and prompt fading (89%) were most often described. Somewhat less reported strategies used with participants in group studies included response prompts (verbal prompts were reported with 49% of participants, physical prompts with 62% of participants, and prompt fading with 50%). Among participants in SCED studies, a similar rate of modeling (65%) and verbal prompts (65%) were reported, with physical prompts

(55%), and preference assessments (51%) reported a bit less, and graphic prompts (6%) infrequently used. Preference assessments (10%) were infrequently implemented with group design participants. Table 5 provides complete delineation results addressing instructional strategies used.

Behavioral intervention strategies versus naturalistic strategies. Across both group and SCED studies, participants received more instructional characteristics associated with behavioral intervention strategies when compared with those associated with naturalistic intervention approaches. Our instructional indicators were coded as mutually exclusive (e.g., participants were coded as receiving primarily interventionist-initiated or child-initiated learning opportunities. Intervention strategies could always be coded for SCED studies, but were unreported for a fraction of studies using group designs. Detailed results are reported in Table 6.

Educator vs. learner initiated learning opportunities. Interventionists initiated learning opportunities for 56% of participants in group studies and 85% of participants in SCED studies (see Table 6).

Massed vs. distributed learning opportunities. There was an overwhelming reliance on massed instructional opportunities, rather than distributing trials among other learning objectives, in group (75% of participants) and SCED studies (89% of participants). Additionally, it was very common to use non-authentic instructional opportunities, as over 60% of participants in group studies and 82% of participants in SCED studies received contrived learning opportunities. Additional, more detailed results are contained in Table 6.

One to one instruction. In both group and SCED studies, over 70% of participants were the recipients of one-on-one instruction compared to small or large group instruction.

Limited number compared to varied learning opportunities. Teaching materials were

coded as “limited” or “varied”. This is the only indicator for which both group and SCED studies implemented naturalistic approaches more frequently than behavioral approaches. During the implementation of procedures in studies employing a group design, 60% of participants were provided with varied opportunities. This trend also held for participants in studies utilizing a SCED, as 62% received instruction utilizing varied stimuli. Similar percentages of participants in group design studies (54%) and SCED studies (48%) participated in controlled intervention contexts, rather than more naturalistic contexts. Opportunities embedded in natural instructional contexts occurred slightly more frequently (52%) for participants of SCED studies.

Communication outcomes: Modes and functions utilized during intervention. During intervention implementation, two or more communication modes (e.g., mid-to-high tech AAC plus verbalizations) were most frequently implemented for both group (89%) and SCED (42%) research participants. Aided AAC was implemented as the only communication mode for only 7% of the group participants but for 40% of the SCED participants. Sign language and gestures were taught to participants as the sole communication mode infrequently for both group (1%) and SCED (15%) study participants; this was a similar pattern for vocalizations and verbalizations for group (4%) and SCED (11%) study participants. Group studies more frequently were coded as “other” communication mode (2%) or not reported (10%) communication mode as the focus of intervention; this happened infrequently for SCED participants (1%). Table 7 provides a more detailed breakdown of information regarding communication modes and communicative functions.

Effect sizes from group design studies

Of the 24 included studies, only 12 provided sufficient information to calculate effect sizes. Many of these studies included results for multiple outcomes (i.e., multiple assessments or

multiple follow-up times) or multiple relevant treatment groups. We calculated and reported effect size estimates for all relevant outcomes and treatment groups. Within this subset, studies reported between 1 and 33 effect size estimates, with a median of 7 effect size estimates per study.

Figure 3 displays a forest plot of effect size estimates reported by each study, with studies ordered from smallest to largest average effect size estimate. Effect size estimates varied widely, both across studies and across outcomes within a given study. Across the 144 effect size estimates from 12 studies, effect size estimates ranged from -2.17 to 2.17, with a median of 0.22 SD. Averaging the effect size estimates within each study, study-level aggregated effects ranged from -2.17 to 0.69, with a median of 0.20. Due to the range of interventions and outcomes reported in these studies, we refrain from reporting a formal meta-analysis.

Discussion

This review uncovered numerous differences and some similarities in the participant characteristics, intervention implementation factors, and communication modes measured and reported when comparing reporting in group versus SCED. With regard to participant characteristics, race, ethnicity and home language continue to be infrequently reported. This represents a significant challenge. Many aspects of intervention are dependent on understanding the culture of the recipients of intervention and their families. Without basic information about the demographic diversity of participants, it is impossible even begin to consider this. Further, without addressing these variables, it is unclear the extent to which a given intervention is suitable for a particular learner.

With respect to communication mode(s) used prior to intervention we found that group studies were far less likely to report the status of the communicators prior to implementation than

were SCED studies. Further, nearly half of the SCED participants were reported to use 2 or more communication modes compared to approximately one third of the participants in the group studies. Not reporting communication mode used prior to intervention may be problematic in that prior exposure and use may prove to enhance performance during the implementation of the independent variable in studies focused on AAC intervention. We do not yet have a good understanding why these differences occurred; but, the findings suggest that it is somewhat difficult to compare results across these two types of research methodologies. Further scrutiny is needed to determine if there are certain population or methodological biases inherent in the two types of study designs or whether our findings represent a fluke of sampling.

Participant verbal and gestural imitation was seldom reported in either SCED or group studies. By reporting the status of imitation skills, researchers facilitate greater potential flexibility in response prompts that can be used to teach new skills. Learners who have mastered imitation often acquire new skills more quickly than those who do not and may be able to or are on the cusp of being able to learn using more vicarious learning strategies. For example, it is likely that individuals with ASD/IDD and CCN with prior verbal imitation skills may require lower dosage of AAC intervention (Flippin et al., 2010). Those with less developed motor imitation skills may respond better to picture exchange systems rather than high-tech AAC (Gevarter et al., 2013). Consequently, the disclosure of information regarding skills such as imitation can better inform both researchers and practitioners.

With regard to instructional practices, implementation settings varied across group and SCED studies. Group studies relied more on clinical settings (including university-connected labs) and infrequently in more authentic classroom and home settings. That said, while SCED studies more often involved implementation in classroom and home settings, they relied on

clinical settings in over 25 percent of the studies. Both research approaches implemented intervention across multiple settings in fewer than 25% of studies (less than 30% of participants). This could have negative implications for generalization and maintenance. Reliance on inauthentic settings is problematic given the greater maintenance of communication outcomes when AAC interventions are implemented in both school and home settings (Brady et al., 2013).

In this investigation we have organized some components of intervention into more developmental versus more behavioral in orientation. Given this characterization, behaviorally oriented instructional features were used more frequently in SCED studies, but were also implemented frequently within group design studies. This is not surprising given the high proportion of participants with ASD. Participants overwhelmingly received interventions in contexts that were interventionist-initiated, involved massed teaching opportunities, were incorporated within contrived activity contexts, and provided one-on-one instruction. Use of naturalistic approaches exceeded use of more structured behavioral approaches in only two areas. That is, teaching stimuli were more often varied, rather than limited, in both group and SCED studies, and implementation took place in natural instructional environments slightly more than half the time for SCED participants. Although naturalistic approaches are increasingly recommended and have been demonstrated to be effective (Bruinsma et al., 2020) particularly in promoting generalization and maintenance of interventions and learning, the research is yet to catch up to these recommendations, as noted by other authors reporting on the literature on AAC interventions (Ganz et al., 2017; Holyfield et al., 2017; Shire & Jones, 2015; Therrien et al., 2016).

This model of understanding environment-behavior relations can be applied across a broad variety of training and intervention strategies. More structured approaches such as discrete

trial training (DTT) can be analyzed and understood within a framework that includes motivating operations (MO). This same framework (e.g., Leaf & McEachin, 1999); can be applied to what have sometimes been referred to as naturalistic developmental behavioral interventions (NDBIs; Schreibman et al., 2015). Often included in this category are approaches such as incidental teaching (McGee, 2005), pivotal response training (PRT; Koegel & Koegel, 2019), and the Early Start Denver Model (Rogers et al., 2010). It is important to note that proponents of such approaches have consistently emphasized that they are fully consistent with applied behavior analytic principles and procedures, including the MO-A-B-C model (e.g., Schreibman et al., 2015). Thus, while minimizing distractions, teaching 1 to 1 etc. are often attributed to more behavioral approaches, these features are not absent from other approaches. Increasingly, investigators are recognizing the benefits of hybrid intervention strategies that combine methodological components that have traditionally been attributed to developmental and behavioral approaches.

The use of physical prompts, verbal prompts, and prompt fading is aligned with prior findings that prompting and prompt-fading are frequently implemented during AAC intervention (Ganz et al., 2017; Holyfield et al., 2017; Shire & Jones, 2015; Therrien & Light, 2016). The high prevalence in the use of tangible reinforcers is likely because implementers were focusing more on behavioral regulation (e.g., object requesting) than on more socially-oriented communication functions.

Future Areas of Research Need

Further research in a number of areas would better inform intervention practices in AAC with the population that is the focus of this investigation. We will briefly address some of these

areas that have recently received increasing attention in the mainstream of the language intervention literature.

Race/ethnicity/home language. The research community continues to do an underwhelming job of specifying race, ethnicity, and home language of participants. This information is important in order to determine if other variations of interest differ across populations. Additionally, a critical feature of selecting participants is balancing the distribution of participants' race, ethnicity, and home language. The current literature base excludes major components of the US population, which is a reflection of generations of racist and exclusionary policies and practices. Ethical researchers *must* address needs of minoritized populations (Maenner et al., 2020; Magaña et al., 2013). Researchers can increase trust through community-based rapport building (Steinbrenner et al., 2022), and by including diverse and disabled educators and parents across all phases of research (Kerkhoff et al., 2022; McNulty et al., 2019). Researchers must eliminate the exclusionary tactics, such as research sites based in majority-population settings, unavailability of appropriate language and translation services, and historically and currently racist practices and policies (Steinbrenner et al., 2022).

Cognitive/communication assessment features. In the studies reviewed, it was very difficult to attempt to compare the language and cognitive status of participants across studies. There are few standard assessment protocols used. Going forward, it would be helpful to identify a core set of recommended assessment tools for researchers to use in order to better facilitate comparison and generalization across investigations.

Pivotal skills. Imitation, as a mediator in establishing collateral gains resulting from AAC intervention has received limited attention, in spite of being frequently cited as associated with an increase in vocal/verbal output among those who are recipients of aided and unaided

communication intervention. Various elements of the extant literature have suggested that verbal imitation may be associated with the acquisition of collateral speech as a function of both unaided and aided communication systems (Johnston et al., 2012, Millar et al., 2006; Yoder & Layton, 1988).

In the current investigation, we did not directly examine receptive language skills. However, this is an important area for future scrutiny. Learners acquiring productive AAC skills have been reported to make corresponding gains in their receptive communication skills (e.g., Harris & Reichle, 2004). The degree of bidirectionality is also a topic that has been sparingly explored. To what extent is more prolific comprehension of spoken language associated with better performance during AAC production intervention? With the population that is the focus of this article, this topic requires further scrutiny. In many of the studies that were reviewed there was very limited information describing participants' language comprehension skills.

Treatment intensity. Currently, there is limited experimental literature addressing treatment intensity with persons with ASD and IDD who experience CCNs (Reichle et al., 2021). We know even less about how aspects of treatment intensity interact with learner characteristics (e.g., specific cognitive status, language comprehension and/or production proficiency, etc.). Further research in this area would allow interventionists to better individualize intervention protocols.

Maintenance, generalization and conditional use of treatment outcomes. There is little known about long term maintenance of newly taught communicative behavior. It is rare that communication maintenance is scrutinized beyond one month post intervention. When maintenance data are presented, it is often for a period of a week to a month. However, we also know that time post acquisition is a threat to maintenance. This represents a particularly

important topic among those who received functional communication training to address a problem behavior that served an important communicative function. After mastery, an identified set of competing socially unacceptable behaviors identified prior to training could reemerge if their reinforcement history becomes more attractive than that for the newly established communicative alternative. In part, this is why it is so important that, at the conclusion of acquisition, care be taken to examine natural maintaining contingencies (Stokes & Baer, 1977) that may be available in the environments in which the individual will operate. None of the articles reviewed examined this issue.

The possible interaction of communication mode with maintenance and generalization is a topic that has been rarely explored. For example, if a learner generalizes, was generalization supported by natural maintaining contingencies. If so, learners who generalize may derive a maintenance advantage in that they are locating contexts where use of a newly established behavior is apt to be reinforced which, in turn, will serve to maintain the behavior.

Put simply, conditional use means using a particular communication symbol when appropriate and refraining from using it when it is inappropriate to do so. Horner et al. (1986) described an early practical application of an instructional format “general case instruction” designed to concurrently establish conditional use. Since then several investigators have described applications in communication. In addition to what we have discussed thus far, general case instruction also utilizes multiple teaching examples that sample critical stimulus features comprising the concept being taught. For example, in teaching “apple”, red, yellow, green, big and little examples would be used. However, this paradigm has been used sparingly in the literature pertaining to the population that is the focus of this article, and was not fully executed in any of the investigations in the current analysis.

Navigation. In studies using speech generating devices (SGD), very few have addressed navigational skills that include scrolling, page linking, and managing pop-ups, among others. Few researchers have addressed the relative advantage of teaching navigation skills independently of early vocabulary skills during the early phases of aided AAC intervention. With the increasing sophistication of SGDs, this is a topic that merits additional attention.

Summary

The description of participant characteristics, including cognitive level, receptive and expressive communication skills prior to intervention, race-ethnicity, and prior interventions, are all relevant variables in interpreting the potential efficacy (including contextual fit) of an intervention protocol for a given learner. Currently, many of these parameters are not described or are poorly described in an alarming proportion of the research literature.

An important initial step in better understanding AAC intervention protocols is to be able to replicate the procedure described in a research study. Unfortunately, this would be challenging in many of the investigations that were the focus of this systematic review. Often, antecedent conditions prior to an intervention opportunity were not well described. Additionally, details of prompting and prompt fading strategies were often not clearly articulated. We also found that treatment intensity parameters summarized by Warren and colleagues (2007) were not available. Procedures to address longer term maintenance and generalization were often not addressed. When maintenance was mentioned, it was for a relatively brief period. Generalization analyses often focused on a single aspect (e.g, across setting). Generalization probes often contained a common stimulus (e.g, the interventionist who was also present during intervention). Consequently, it was difficult to differentiate good stimulus control from generalized performance.

It is important to acknowledge that the intervention landscape is changing due, in part, to the COVID-19 pandemic and advances in telehealth technology. These changes are apt to have significant implications for maintenance and generalization going forward. It is also likely to spawn substantial interest in studying reliability and fidelity with respect to parents and other stakeholders as prospective interventionists.

Finally, this study has several limitations. We did not perform a meta analysis as we have previously done so with SCED studies with respect to participant characteristics, instructional strategies, and design quality. There were relatively few group design studies with extremely heterogeneous participant- and intervention-related characteristics. Consequently, we chose to descriptively summarize and make comparisons between group and SCED studies where possible. All included studies met WWC criteria for design quality, which eliminated a number of investigations which could have had an impact on participant or instructional methodology outcomes.

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Data Availability Statement

Data results reported in the article can be found in Open Science Framework. The authors will upload all the files after submitting the manuscript.

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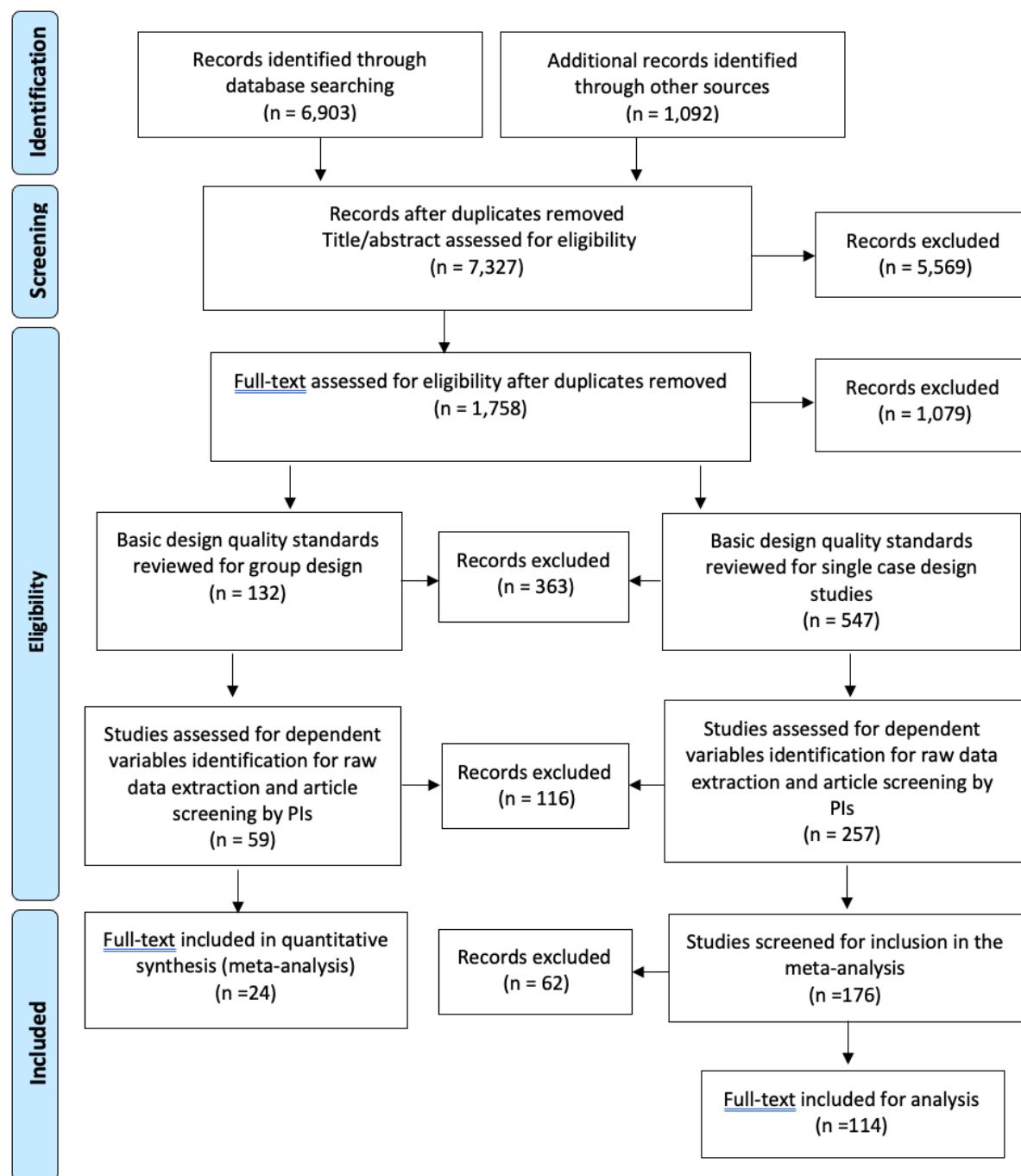
Figure 1. PRISMA Flow chart

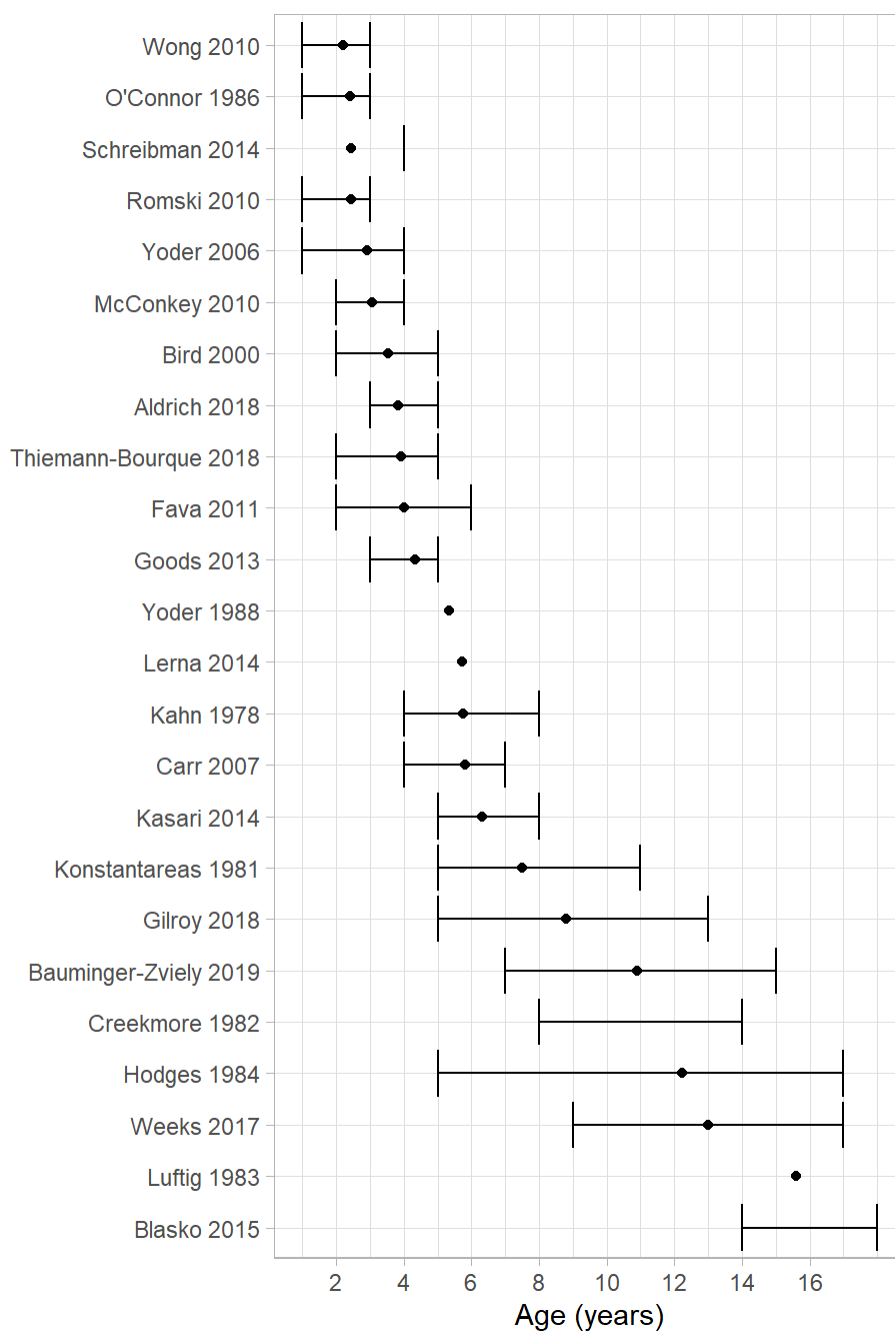
Figure 2. Mean age and age range of study participants

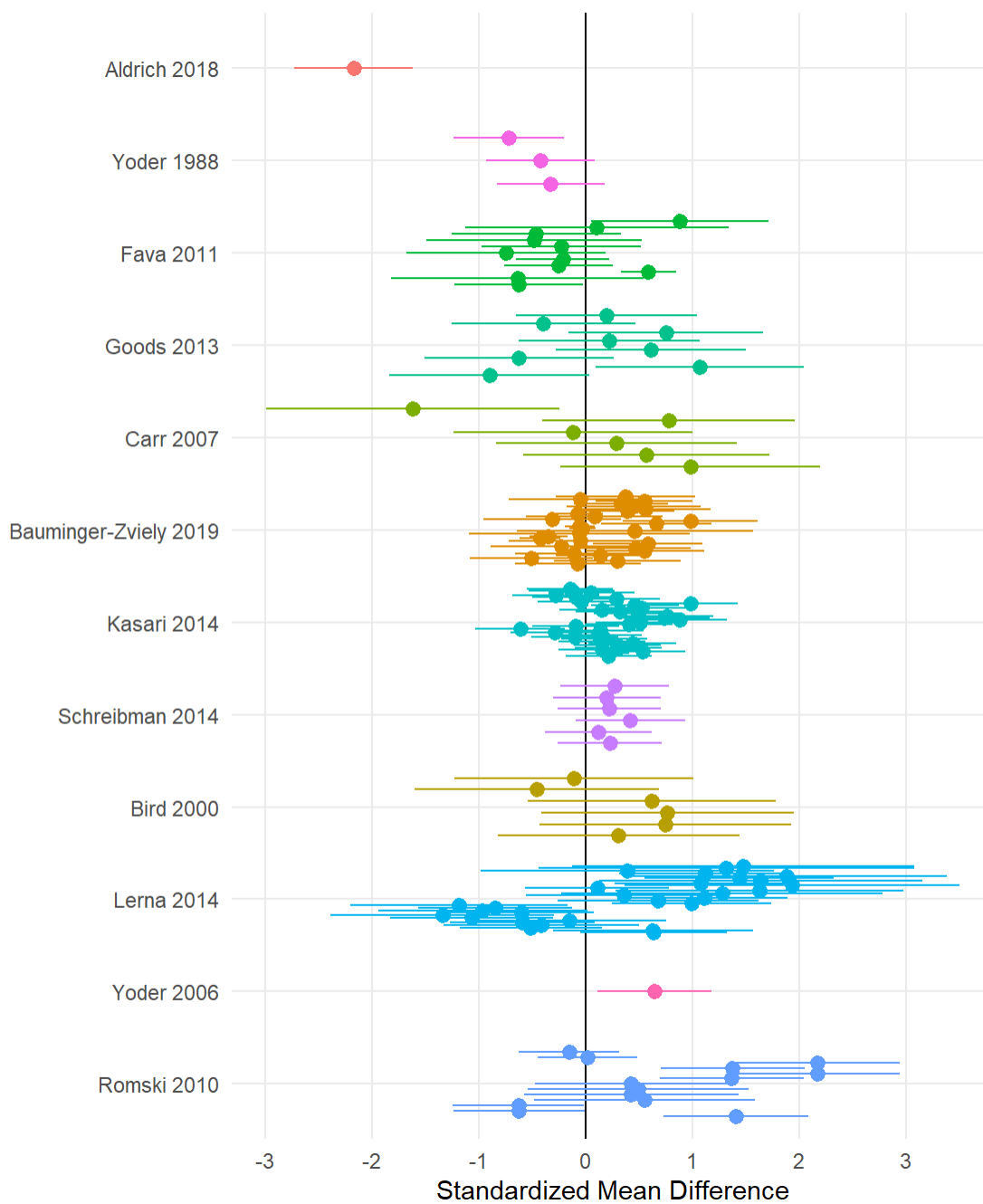
Figure 3. Forest plot of effect size estimates from group design studies

Table 1. *Characterization of Two General Intervention Frameworks for Early Communication Intervention*

Functional Behavioral Intervention Characteristics	Social Behavioral Intervention Characteristics
<ul style="list-style-type: none"> • Majority of teaching opportunities interventionist initiated • Largely massed trial teaching opportunities during early instructional phases • Activities used in training may be contrived • Primarily ONE TO ONE • Limited different teaching stimuli used during acquisition training • Distractions are minimized • In early phases, continuous schedule of reinforcement • Reinforcers often selected based on preference assessment 	<ul style="list-style-type: none"> • At least some of teaching opportunities are child initiated • Adults are responsive to child communicative overtures • Teaching opportunities are often distributed across the learner's daily routine. • Intervention opportunities are embedded in functional activities. • One to one instruction does not represent the only or even the primary method to deliver instructional opportunities. • A variety of different teaching situations, interventionists, teaching stimuli used to promote generalization. • Teaching typically occurs in authentic environments with other learners present.

Table 2. Reliability for each Phase of the Systematic Review Including Design Quality, Participant, Instructional, and Outcomes Variables

Stage of reliability			Group Design Studies		Single Case Study Design	
			Percent of documents coded	Percent Reliability	Percent of documents coded	Percent Reliability
Title/Abstract			100%	88%	100%	88%
Full-text			39%	88%	39%	88%
Design Quality Variables			77%	89%	20%	90%
Variables Outcomes	Participant Characteristic	Diagnosis	67%	82%	30%	96%
		Chronological Age	67%	86%	30%	100%
		Race/Ethnicity	67%	100%	43%	95%
		Communication modes prior to intervention	67%	91%	30%	93%
		Imitation prior to intervention	67%	93%	30%	96%
	Instructional Characteristic	Setting	72%	83%	20%	90-93%
		Instructional features	72%	77-93%	20%	83%-100%
		Behavioral intervention strategies versus naturalistic strategies	72%	80-97%	20%	89-97%
		Limited number compared to varied number of learning opportunities	72%	97%	20%	88%
	Communication Outcomes	Communication mode	72%	87%	22%	87%
		Communicative function	72%	73%	22%	89%

Table 3. *Distribution of participant characteristics*

Category	Group designs		Single case designs	
	Study N (%)	Participant N (%)	Study N (%)	Participant N (%)
<i>Diagnosis</i>				
ASD	17 (71%)	580 (57%)	85 (74.6%)	224 (67.9%)
IDD	4 (17%)	151 (15%)	41 (36.0%)	83 (25.2%)
Other	2 (8%)	30 (3%)	-	-
Unknown	4 (17%)	236 (23%)	-	-
ASD, IDD	-	-	16 (14.0%)	23 (7.0%)
<i>Age group</i>				
0-3 years old	13 (54%)	324 (32%)	37 (32.5%)	62 (18.8%)
4-5 years old	16 (67%)	162 (16%)	53 (46.5%)	105 (31.8%)
6-10 years old	12 (50%)	161 (16%)	54 (47.4%)	97 (29.4%)
11-14 years old	7 (29%)	67 (7%)	25 (21.9%)	39 (11.8%)
14 years older	6 (25%)	307 (30%)	16 (14.0%)	27 (8.2%)
<i>Race category</i>				
Not specified	23 (96%)	728 (71%)	86 (75.4%)	226 (68.5%)
White/Caucasian	4 (17%)	205 (20%)	29 (25.4%)	71 (21.5%)
Black/African American	3 (12%)	63 (6%)	14 (12.3%)	21 (6.4%)
Asian/Asian American	3 (12%)	21 (2%)	6 (5.3%)	9 (2.7%)
Native American	1 (4%)	3 (0%)	-	-
Indian American	-	-	1 (0.9%)	1 (0.3%)
Multi-racial	-	-	2 (1.8%)	2 (0.6%)
<i>Ethnicity category</i>				
Not specified	23 (96%)	914 (90%)	113 (99.1%)	310 (93.9%)
Not Latinx/Hispanic	1 (4%)	58 (6%)	2 (1.8%)	5 (1.5%)
Latinx/Hispanic	2 (8%)	49 (5%)	11 (9.6%)	15 (4.5%)

Category	Group designs		Single case designs	
	Study N (%)	Participant N (%)	Study N (%)	Participant N (%)
<i>Home language</i>				
English	17 (71%)	833 (82%)	11 (9.6%)	24 (7.3%)
Not specified: article is published in English, but the first author's affiliated country had a different dominant language	5 (21%)	168 (16%)	-	-
Not specified: article is in English and published in English-dominant setting/country and no language is specified	2 (8%)	20 (2%)	-	-
Amharic	-	-	1 (0.9%)	1 (0.3%)
Dual language	-	-	8 (7.0%)	11 (3.3%)
Dutch	-	-	1 (0.9%)	2 (0.6%)
Spanish	-	-	4 (3.5%)	5 (1.5%)
Not specified	-	-	103 (90.4%)	287 (87.0%)

Table 4. *Distribution of participant communication modes and imitation use*

Category	Group designs		Single case designs	
	Study N (%)	Participant N (%)	Study N (%)	Participant N (%)
<i>Communication modes prior to intervention</i>				
Manual sign language	1 (4%)	160 (16%)	8 (7.0%)	12 (3.6%)
Verbalization	3 (12%)	131 (13%)	27 (23.7%)	50 (15.2%)
2 or more categories	8 (33%)	371 (36%)	74 (64.9%)	158 (47.9%)
Not reported	12 (50%)	359 (35%)	15 (13.2%)	45 (13.6%)
Natural gestures	-	-	18 (15.8%)	32 (9.7%)
Vocalization	-	-	8 (7.0%)	14 (4.2%)
Low-tech aided AAC	-	-	8 (7.0%)	10 (3.0%)
Mid-to-high-tech aided AAC	-	-	4 (3.5%)	9 (2.7%)
<i>Number of communication modes prior to intervention</i>				
1 mode	4 (17%)	291 (29%)	63 (55.3%)	127 (38.5%)
2 modes	5 (21%)	299 (29%)	51 (44.7%)	82 (24.8%)
3 modes	2 (8%)	64 (6%)	32 (28.1%)	50 (15.2%)
4+ modes	1 (4%)	8 (1%)	14 (12.3%)	26 (7.9%)
Not reported	12 (50%)	359 (35%)	15 (13.2%)	45 (13.6%)
<i>Imitation use prior to intervention</i>				
Vocal/verbal imitation	1 (4%)	60 (6%)	28 (24.6%)	54 (16.4%)
Not reported	23 (96%)	961 (94%)	92 (80.7%)	230 (69.7%)
Gestural imitation	-	-	15 (13.2%)	31 (9.4%)
Limited imitation	-	-	11 (9.6%)	15 (4.5%)

Table 5. *Distribution of instructional characteristics*

Category	Group designs		Single case designs	
	Study N (%)	Participant N (%)	Study N (%)	Participant N (%)
<i>Instructional setting</i>				
Classroom	4 (17%)	220 (22%)	40 (35%)	115 (35%)
Clinic	10 (42%)	315 (31%)	31 (27%)	92 (28%)
Home	5 (21%)	181 (18%)	12 (11%)	31 (9%)
Multiple	4 (17%)	295 (29%)	25 (22%)	74 (22%)
Other	1 (4%)	10 (1%)	5 (4%)	15 (5%)
Not reported	-	-	1 (1%)	3 (1%)
<i>Instructional features</i>				
Graphic prompt	3 (12%)	121 (12%)	6 (5%)	21 (6%)
Modeling	15 (62%)	742 (73%)	75 (66%)	216 (65%)
Physical prompts	12 (50%)	634 (62%)	63 (55%)	183 (55%)
Prompt fading	13 (54%)	514 (50%)	103 (90%)	295 (89%)
Systematic arrangement	14 (58%)	454 (44%)	102 (89%)	294 (89%)
Verbal prompts	12 (50%)	504 (49%)	76 (67%)	216 (65%)
Reinforcement	19 (79%)	724 (71%)	106 (93%)	304 (92%)
Preference assessment	4 (17%)	104 (10%)	57 (50%)	168 (51%)
<i>Number of instructional features</i>				
0	3 (12%)	76 (7%)	-	-
1	1 (4%)	81 (8%)	2 (2%)	8 (2%)
2	2 (8%)	182 (18%)	4 (4%)	11 (3%)
3	5 (21%)	161 (16%)	6 (5%)	14 (4%)
4	1 (4%)	8 (1%)	14 (12%)	42 (13%)
5	6 (25%)	301 (29%)	38 (33%)	110 (33%)
6	4 (17%)	152 (15%)	36 (32%)	108 (33%)

Category	Group designs		Single case designs	
	Study N (%)	Participant N (%)	Study N (%)	Participant N (%)
7	2 (8%)	60 (6%)	14 (12%)	37 (11%)

Table 6. *Distribution of intervention strategy use*

Category	Group designs		Single case designs	
	Study N (%)	Participant N (%)	Study N (%)	Participant N (%)
<i>Number of behavioral intervention strategies</i>				
0	3 (12%)	158 (15%)	-	-
1	3 (12%)	118 (12%)	7 (6%)	19 (6%)
2	1 (4%)	12 (1%)	4 (4%)	13 (4%)
3	1 (4%)	61 (6%)	17 (15%)	45 (14%)
4	7 (29%)	345 (34%)	27 (24%)	84 (25%)
5	2 (8%)	24 (2%)	37 (32%)	101 (31%)
6	7 (29%)	303 (30%)	22 (19%)	68 (21%)
<i>Initiator of teaching opportunity</i>				
Child	6 (25%)	207 (20%)	17 (15%)	49 (15%)
Interventionist	14 (58%)	573 (56%)	97 (85%)	281 (85%)
Not reported	4 (17%)	241 (24%)	-	-
<i>Teaching opportunity distribution</i>				
Dispersed	2 (8%)	148 (14%)	12 (11%)	36 (11%)
Massed	19 (79%)	770 (75%)	102 (89%)	294 (89%)
Not reported	3 (12%)	103 (10%)	-	-
<i>Activity context</i>				
Contrived	15 (62%)	610 (60%)	93 (82%)	270 (82%)
Embedded	6 (25%)	308 (30%)	21 (18%)	60 (18%)
Not reported	3 (12%)	103 (10%)	-	-
<i>Instructional format</i>				
Group	4 (17%)	185 (18%)	10 (9%)	30 (9%)
Not reported	2 (8%)	91 (9%)	-	-
One-on-one	18 (75%)	745 (73%)	104 (91%)	300 (91%)

Category	Group designs		Single case designs	
	Study N (%)	Participant N (%)	Study N (%)	Participant N (%)
<i>Teaching stimuli</i>				
Limited	9 (38%)	396 (39%)	41 (36%)	124 (38%)
Not reported	1 (4%)	10 (1%)	-	-
Varied	14 (58%)	615 (60%)	73 (64%)	206 (62%)
<i>Instructional environment</i>				
Controlled	13 (54%)	549 (54%)	54 (47%)	160 (48%)
Natural	8 (33%)	327 (32%)	60 (53%)	170 (52%)
Not reported	3 (12%)	145 (14%)	-	-

Table 7. *Distribution of communication outcomes*

Category	Group designs		Single case designs	
	Study N (%)	Participant N (%)	Study N (%)	Participant N (%)
<i>Communication modes during intervention</i>				
2 or more categories	20 (83%)	913 (89%)	47 (41%)	139 (42%)
Low-tech aided aac	1 (4%)	61 (6%)	18 (16%)	57 (17%)
Mid-to-high-tech aided aac	1 (4%)	10 (1%)	26 (23%)	75 (23%)
Manual sign/natural gestures	1 (4%)	15 (1%)	19 (17%)	50 (15%)
Verbalization/vocalization	1 (4%)	39 (4%)	14 (12%)	36 (11%)
Other	1 (4%)	17 (2%)	-	-
Not reported	3 (12%)	98 (10%)	1 (1%)	3 (1%)
<i>Aided AAC VS. unaided AAC</i>				
Exclusively aided AAC	17 (71%)	881 (86%)	62 (54%)	187 (57%)
Exclusively unaided AAC	6 (25%)	118 (12%)	26 (23%)	71 (22%)
Exclusively verbalization/vocalization	1 (4%)	39 (4%)	14 (12%)	36 (11%)
Not reported	3 (12%)	98 (10%)	1 (1%)	3 (1%)
Both aided and unaided AAC	-	-	20 (18%)	59 (18%)
<i>Vocalization/Verbalization</i>				
Vocal/verbal	1 (4%)	39 (4%)	43 (38%)	118 (36%)
Not vocal/verbal	23 (96%)	999 (98%)	79 (69%)	234 (71%)
Not reported	3 (12%)	98 (10%)	1 (1%)	3 (1%)
<i>Number of Communication modes</i>				
1 mode	5 (21%)	142 (14%)	68 (60%)	193 (58%)
2 modes	19 (79%)	905 (89%)	29 (25%)	86 (26%)
3+ modes	2 (8%)	70 (7%)	22 (19%)	64 (19%)
Not reported	3 (12%)	98 (10%)	1 (1%)	3 (1%)

Category	Group designs		Single case designs	
	Study N (%)	Participant N (%)	Study N (%)	Participant N (%)
<i>Communication systems</i>				
Comprehension	3 (12%)	67 (7%)	5 (4%)	16 (5%)
Production	22 (92%)	978 (96%)	107 (94%)	310 (94%)
Both	5 (21%)	94 (9%)	6 (5%)	13 (4%)
Not reported	5 (21%)	129 (13%)	2 (2%)	6 (2%)
<i>Communication functions</i>				
Behavioral regulation	9 (38%)	242 (24%)	61 (54%)	169 (51%)
Joint attention	4 (17%)	72 (7%)	21 (18%)	62 (19%)
Social interaction	9 (38%)	440 (43%)	18 (16%)	55 (17%)
Multiple	3 (12%)	119 (12%)	12 (11%)	34 (10%)
Not reported	13 (54%)	629 (62%)	4 (4%)	14 (4%)

Appendix A

Definitions of Participant Characteristics, Instructional Characteristics, and Communication Outcomes

Participant characteristics

Communication modes prior to intervention

(i.e., natural gesture, manual sign, low tech aided system, mid-to-high tech speech generating device, vocal, verbal). The medium through which communicative behavior is expressed. If one DV is categorized that contains multiple modes (e.g., “requesting” that includes verbal and AAC), check all of them

- **Manual sign language:** an unaided system that relies on no equipment and instead relies on the learner’s own body to produce communicative acts. An action that includes a specific handshape, location where the sign is produced and movement pattern that adheres to a sign language or sign system (e.g. ASL, Signed English).
- **Verbal:** Intelligible words or word approximations
- **Natural gesture:** Natural gestures that may or may not include a facial expression (e.g. head shake yes or no), but exclude intelligible manual signs or sign approximations. May include the muscles beneath the skin of the face that purposely conveys emotional state to a communicative partner (e.g. frowning, smiling).
- **Vocalization:** Production of sound, sound combinations that are not intelligible word approximations. Examples: Sound- Air passing that vibrates the vocal cords that can be heard. This excludes wheezing, snorting, grunting and whistling.
- **Manual sign language:** unaided communicative acts that rely on the learner’s own body and that are part of a formal sign language or system (e.g. American Sign Language, Signed English, Seeing Exact English)
- **Low tech aided AAC-**An application of a graphic communication mode that does not require electrical power or batteries to operate and do not have the capability to produce synthesized or digitized speech (e.g. graphic symbols housed in a wallet, a laminated card housing graphic symbols, a three-ring binder housing graphic symbols).
- **Mid-to-high tech aided AAC-** An application of an aided communication system. *High tech* applications involve the use of electrical or battery power. Typically, they permit the use of digitized (mid-tech). Additionally, high tech allows synthesized text to speech, environmental control and may support email and computer access applications. Additionally, they allow unlimited vocabulary, encoding capability, prediction, a variety of access methods, and permit linking any symbol to any other symbol location displayed (e.g., Tobii Dynavox, Prentke-Romich products).

Imitation use prior to intervention

- **Vocal/verbal imitation:** The replication or partial replication of sound, sound combinations, or spoken word approximations that was produced after a spoken model.

To be coded it should be reported as a pre-intervention assessment (or baseline) implemented or a reliable report that occurred prior to the implementation of the independent variable.

- **Gestural imitation:** The replication or partial replication of an action produced by another after modeled behavior. To be coded, it should be reported as a pre-intervention assessment (or baseline) implemented or a reliable report that occurred prior to the implementation of the independent variable.

Instructional characteristics

Instructional features

- **Graphic prompt:** Interventionists provide graphic stimuli (e.g., picture, printed word, product logo) that provide learners with information about how to engage in the target behavior (e.g., task analysis checklist, following a recipe transition picture card).
- **Modeling:** Modeling of communication used (e.g., verbally demonstrating contextual words, demonstrating use of AAC to make a comment): Interventionist produces a behavior offering an opportunity for the learner to replicate the behavior. The dependent measure should specify whether the learner is required to produce an exact or partial replication.
- **Physical prompts:** Interventionist comes in physical contact with the learner to help them produce a behavior being taught (e.g., hand-over-hand assistance to make an SGD selection; tapping a learner's hand to cue him to begin to pick up an object).
- **Prompt fading:** Prompt fading strategies used in which the delivery of a prompt is delayed affording the learner an increased period of time in which to emit an independent target response (e.g., time delay, least-to-most prompt fading, most-to-least)
- **Systematic arrangement:** The interventionist systematically arranged the environment (use of communicative temptations, such as enticing, having preferred materials in sight)
- **Verbal prompts:** Verbal prompts provided to prompt communication: Interventionist produces statements to direct a learner's behavior. Examples: ,You might need to try it a different way, Write your name. "What do you want?" "Say, ' ____'." "Let me know if you want anything." "Tell me if you need anything." A typical SD required to initiate the task is NOT a verbal prompt (e.g., "point to ____," "put the ball on ____," "choose/pick ____")
- **Reinforcement:** Reinforcement provided to promote communication (e.g., social praise for speaking, providing items requested).
- **Preference assessment:** Preference/reinforcer assessment was conducted before or throughout intervention.

Communication outcomes

Communication modes during intervention

- **Low-tech aided aac:** Aided communication that does not require electrical power or batteries to operate and does not have the capability to produce synthesized/ digitized speech (e.g., graphic symbols housed in a wallet, board, notebook, folder etc).
- **Mid-to-high-tech aided aac:** Relies on graphic symbols displayed in a battery powered system that produces digitized or synthesized speech.
- **Manual sign:** unaided communicative acts that rely on the learner's own body and that are part of a formal sign language or system (e.g. American Sign Language, Signed English. Seeing Exact English).
- **Natural gestures:** head shake yes or no, frowning, smiling, pointing, proffering a cup to have it refilled; leading an individual to an object/event and more idiosyncratic gestures such as putting fist on one's nose to communicate "need a tissue")
- **Verbalization:** Intelligible words or easily guessed word approximations
- **Vocalization:** Production of sound(s), sound combinations that are not intelligible word approximations (excludes wheezing, snorting, and whistling that do not require use of vocal cords)

Communication systems

- **Comprehension:** Deriving meaning (understanding) utterances produced by others using speech, gestures/sign, or graphic symbols (e.g., parent says, "get your shoes" and child travels to bedroom and retrieves shoes). The participant demonstrates receptive understanding through action in response to the interventionist's language output
- **Production:** The emission of sounds, sound combinations, spoken words, gestures (including facial expression), manual signs, graphic symbols (e.g. miniature objects, object remnants (e.g. a button representing a shirt), photos, pictures, product logos, printed words, or combinations of the preceding to influence a communicative partner's behavior

Communication functions

- **Behavioral regulation:** Communicative act emitted to obtain or maintain access to an object, activity or person; or to escape or avoid contact with an object, activity, or person (e.g. requesting a hug, asking to go for ice cream, protesting bath time, protesting the offer of a food item; requesting help; requesting a break).
- **Joint attention** - In a joint attention communicative act emitted to direct a partner's attention to an object or event external to the communicative partners (e.g. providing requested information that is not in the context of an effort to increase turn taking comment, naming objects in the environment; requesting information). A joint attention act can also spontaneously comment on or name, for example; an object e.g. "dog"), person (e.g. "dog"), action (communicating "run" as a dog runs by the speaker or communicative partner), attribute (while looking at a group of green apples the learner

sees one red one and communicates “red”), or adverbial (a dog is moving slowly and learner communicates “slow”).

- **Social interaction:** A communicative act emitted to direct attention to oneself. Communicative act emitted to direct a partner’s attention to oneself (e.g. reciting story passages [where the objective is more taking turns than the importance of the information, telling a knock-knock joke, greetings, calling- “hey look at me”; requesting another’s attention).