

Critical Review: Is augmentative and alternative communication effective in improving the communicative abilities of children with childhood apraxia of speech?*

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As the prevalence of childhood apraxia of speech (CAS) continues to rise, more clinicians are questioning what can be done for the children with CAS who have such severe impairments that their speech is not functional, and thus are struggling to communicate. This critical review examines the efficacy of augmentative and alternative communication (AAC) in improving the communicative abilities of children with CAS. Six articles were included in this review. Study designs included five single-subject designs and one case study. Overall, the results of this review provide suggestive evidence that AAC is an effective tool for improving the communicative abilities of children with CAS. Recommendations for clinical practice and future research are discussed.

Introduction

Augmentative and Alternative Communication (AAC)

Children with limited or no functional speech may benefit from methods that can create more communicative opportunities within their daily lives. Such opportunities offer these children the chance to gain more independence and become active participants within their interactions (Blischak, Lombardino, and Dyson, 2003). Augmentative and alternative communication (AAC) can be used to enhance the current communicative abilities of children who have complex communication needs and are available in a variety of forms (i.e., no technology, low technology and high technology systems) to suit the particular abilities and needs of each child. For children who possess some functional speech, Blischak et al. (2003) explain that instead of hindering speech development and use, AAC may in fact not only enhance general communication effectiveness, but also improve speech production and intelligibility. For this reason, clinicians are becoming increasingly interested in the potential use of AAC with children who have specific speech sound disorders, such as CAS.

Childhood Apraxia of Speech (CAS)

The ASHA Ad Hoc Committee proposed that, "Childhood apraxia of speech (CAS) is a neurological childhood (pediatric) speech sound disorder in which the precision and consistency of movements underlying speech are impaired in the absence of neuromuscular deficits" (ASHA, 2007). Throughout the past decade, the prevalence of CAS has increased (ASHA, 2007). As a result, the caseloads of speech-language pathologists are continuing to include a greater number of children with this condition. Hence, this motor-speech disorder has become of growing interest and importance for parents, caregivers, and public health practitioners.

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Further research to assist this heterogeneous population has become increasingly relevant and more practitioners are considering the effectiveness of using a two-pronged approach to intervention (Binger, 2007). While it is crucial that children with CAS receive intensive, on-going speech therapy to specifically target speech skills, the use of AAC in conjunction with traditional therapy would serve to address the functional communication needs of these children (ASHA, 2007). While some children with CAS may require AAC support as a short-term strategy until sufficient progress in speech therapy can be made, others with more severe impairments may need AAC as a primary mode of communication long-term.

A number of studies have been published evaluating intervention methods for children with CAS. However, little research has been conducted specifically examining the use of AAC with children with CAS, despite the fact that speech-language pathologists are using this two-pronged approach to intervention (Rupp, 2013). Therefore, it is important to critically examine current evidence supporting the effectiveness of AAC in improving the communicative abilities of children with CAS.

Objective

The primary objective of this paper is to review and critically evaluate the existing literature regarding the effectiveness of AAC in improving the communicative abilities of children with CAS. The secondary objective is to provide speech-language pathologists with evidenced based recommendations for clinical practice and future research.

Methods

Search Strategy: Journal articles related to the topic of interest were located using the following computerized databases: Scopus, PubMed, PsychINFO, and Google Scholar. Databases were searched using the following

key terminology: [(Childhood apraxia of speech) OR (apraxia) OR (apraxia of speech)] AND [(AAC) OR (augmentative and alternative communication) OR (speech generating devices) OR (intervention) OR (treatment)].

Additional related studies were obtained from the reference lists of previously searched articles. No limits were placed on this search.

Selection Criteria: The studies selected for inclusion in this critical review were required to include children (under 18 years old) with CAS. Studies were required to use AAC and investigate the efficacy of these strategies in improving the communicative abilities of children with CAS.

Data Collection: The results of this literature search yielded six articles congruent with the selection criteria. The articles consisted of five single-subject designs and one case study. All studies investigated the use of AAC as a tool for facilitating the development of the communicative abilities of children with CAS.

Results

Single-subject Design

Single-subject research designs can be considered high-level evidence designs since they involve participant(s) being exposed to control conditions in addition to treatment conditions. In these designs, the participants are able to act as their own controls. If these studies lack randomization or blinding of examiners, the strength of these designs decrease (Logan, Hickman, Harris & Heriza, 2008). This type of design is especially appropriate when examining children with CAS because it is such a heterogeneous group.

Luke (2003) conducted a longitudinal single-subject design that examined the effectiveness of speech generating devices (SGD) at improving the communication and language abilities of a boy aged 2 years, 7 months with severe CAS. Results of this study indicated that upon introduction of the SGDs, an immediate increase in the subject's communicative development (i.e., means of communication) was observed. Additionally, data indicated improvements in all linguistic variables (i.e., intelligibility/consistency of speech productions and lexical/grammatical development), however a latency effect of eight to nine treatment sessions was also reported.

Luke's (2003) A-B study design was appropriate for the philosophical underpinnings and purpose of the study, in addition to the population of interest. Over twelve

months, fifty treatment sessions (length: 45 minutes, intervals: 2-28 days) were analyzed and divided into three phases of intervention: phase A and phase B, with phase B separated into two parts. Phase A involved the use of verbal therapy methods and iconic gestures in order to improve the participant's communicative development. Phase A acted as a single baseline since this phase did not involve the use of a SGD, and no changes or increases were noticed with regards to the participant's linguistic and communication abilities. Due to the increase in the participant's language capabilities, phase B was divided into two phases to allow for the inclusion of the high-technology system. Gotalk 20+, the fixed display device, was used in phase B1, while DynaVox V, the dynamic display device, was used in phase B2. These devices were used as tools to support the participant's current abilities and facilitate the development of communication and speech. Data regarding means of communication (i.e., token and types), intelligibility/consistency of speech productions, and lexical/grammatical development were collected at the end of each phase (i.e., A and B) and were compared, which resulted in percentages depicting the efficacy of the intervention. All of the sessions were video-recorded and using ELAN (EUDICO Linguistic Annotator), the initial twenty minutes of each session were coded. Verbal productions were represented in IPA and expressions were represented orthographically. In order to establish if statistically significant differences in the trend-lines of Phase A and B existed, a binominal test was used. Data for Phase B1 and B2 were compared to baseline phase A and the percentage of non-overlapping data points was calculated.

Luke (2013) acknowledged that the external validity of the study was restricted and that it cannot be said with certainty that outside factors (i.e., maturation) did not contribute to the improvements in the participant's communication and language development. Luke (2013) addressed further concerns regarding the study's comparatively low internal validity since a basic A-B design is not an ideal research design. Although A-B-A designs can more clearly establish causality, due to practical limitations of the case study (i.e., inability to withhold the use of the SGD) an A-B-A design was not ethically appropriate. To compensate for the study's low internal validity, Luke (2013) extended his A-B design with three follow-up therapy sessions (in 3 month intervals) in order to increase the control of the design.

Despite these limitations, Luke (2003) provided thorough descriptions regarding the need for the study, the participant, and methodology. Areas of communication and linguistic development that were measured were clearly defined in addition to the selection criteria, which indicated that the subject was

an ideal candidate for a SDG (Luke, 2003). This level of detail will enable future researchers and clinicians the ability to easily replicate the method. The design of this study was appropriate for the population of interest and provided evidence to suggest that AAC may be beneficial in improving the communicative abilities of children with CAS. Considering the limitations outlined, this level I evidence, according to the Oxford Centre for Evidence-based Medicine Levels of Evidence (March 2009), requires further research to support the use of AAC with this population in clinical practice. As a result, this study provides suggestive evidence regarding the effectiveness of speech generating devices in improving the communication and language abilities of children with CAS.

Culp (1989) conducted a short-term single-subject design examining the effectiveness of the Partners in Augmentative Communication Training program (PACT) on the communicative abilities of a developmentally apraxic eight-year-old girl. Results of this study demonstrated some improvement in the participant's communication interactions skills.

Culp's (1989) study utilized PACT, a three-day day-camp intervention program. The participant, her mother, the classroom teacher, and the speech-language pathologist attended the published intervention program, which was directed at both AAC users and individuals who communicate with these users on a regular basis. Instead of focusing solely on communicative development as a whole, the program specifically targeted the functional development of communicative interactions. The program's design enables parents/caregivers and their child the opportunity to receive a preliminary interaction assessment in addition to training. Professionals attending the program (i.e., classroom teachers, speech-language pathologists) are also provided with training so this program can be continued throughout the year, and serve as a resource to clinicians who are developing individualized interaction facilitation programs.

In Culp (1989)'s study, through structured clinical observations a set of priority communication behaviours were categorized according to function, mode and discourse and were assessed in videotaped contexts using the PACT Interaction Profile. This profile was used consistently as both a pre-test baseline and as a 2-month posttest following the completion of the program. This profile provided information regarding the importance of child and partner behavior, in addition to the communicative system and contexts for communication. Informal observations by the participant's mother, classroom teacher, and speech-language pathologist provided additional information in

these areas, although since this information is subjective to bias, it should be considered with caution.

Data regarding *message frequency ratio* (i.e., child messages/partner messages), *child intelligibility ratio* (i.e., successful child messages/total child messages), and the frequency of various communicative functions (i.e., socializing, answering yes/no questions, answering other questions, offering information, requesting action, object, or assistance, requesting information, expressing feelings and attitudes, teases or pretends, etc.) were collected in the pre-test and post-test. Data revealed slight gains with regards to the communication interaction skills between the child and her mother. While the frequency of *offering information* showed a significant increase and the frequency of *other* increased slightly, all other communicative functions remained either the same or decreased in frequency (i.e., *answering questions*). Additionally, *no clarification* and *question asking* responses by the mother also decreased. While the mother dominated the communicative interaction in the pre-test, post-test data revealed that child messages increased and partner messages decreased, resulting in more evenly distributed conversational control. The child's messages were reported as slightly more intelligible, which the author found interesting since it occurred during longer and more complex messages when offering information as oppose to answering questions.

Culp (1989) thoroughly addressed the question of interest and clearly described the study's methodology, results, and recommendations for future research allowing for ease of replication. Controls for instructions and materials for pre-and posttest procedures were provided, which provided consistency of testing procedures.

Limitations of the study by Culp (1989) include lack of external validity and thus limited generalizability due to the small sample size. Although the case history of the participant was provided in detail, the inclusion criteria for the study was not discussed, aside from her diagnosis of CAS. Additionally, the lack of follow-up beyond the 2-month post-test data raises questions regarding gains and maintenance of the communicative skills. Considering both strengths and limitations this study provides suggestive level I evidence regarding the effectiveness of AAC as part of a multimodal communication system in improving communicative interactions in children with CAS.

Bornman, Alant, and Meiring (2001) described a single-subject design study examining the effectiveness of the Macaw Digital voice output system on the language and communicative abilities of a six and a half year old boy

with CAS. Results of the study indicated that introduction of the SGD assisted in facilitating communication and language development, specifically with regards to higher cognitive language functioning, in a child with CAS.

Bornman et al. (2001) conducted a baseline measurement A1 that consisted of the participant's mother telling her son a story using the Macaw. A second baseline measurement A2 was also taken which followed a similar trajectory, contained the same overlay, however the Macaw was pre-programmed by the researchers'. Following baseline measures, intervention began targeting the use of the Macaw to increase the cognitive demands placed upon the participant when being faced with questions and answers regarding narratives. Following training, a post-training baseline measurement (B) was taken using the same story from A2. Four weeks post intervention the post-withdrawal evaluation (A3) was completed. Bornman et al., (2001) did report on the fact that this story was more cognitively challenging than the story used in A1.

Data regarding *level/frequency of questions, appropriacy of answers, primary communication modality, and frequency of initiation attempts* were collected at both of the baselines (A1 and A2), post-training evaluation baseline (B), and post-withdrawal evaluation (A3). Transcriptions of the audio recordings used to gather and track data was useful in highlighting the questions that were asked to the child, as well as the answers he provided. Additionally, video recordings were used to analyze the primary communication modalities. The participant's responses were measured according to the level of questions asked by the child's mother: *Level 1 Knowledge, Level 2 Comprehension, Level 3 Application, Level 5 Synthesis, and Level 6 Evaluation*. Results of the study indicated that the AAC device was useful in facilitating communication and language development. Increases in AAC use, in addition to subjective gains with regards to spoken communication were observed. The percentage of *no opportunity to answer* and *inappropriate responses* sharply declined and a greater variety of responses was observed in post-training measures. In turn, an increase in child's appropriate responses, number of communicative modalities, and attempts was also observed. Child verbalizations, gestures, use of the Macaw, and frequency of initiation attempts increased. Additionally, the authors reported that when the participant was intelligible during interactions with a communicative partner, verbalizations decreased and the use of the SGD increased. An increase in the cognitive complexity of questions, variety, and frequency of questions directed at the child was seen.

Bornman et al. (2001) did report on a questionable result from the study. As the use of the SGD increased throughout the intervention period, verbalizations decreased. Researchers reported that this finding was unexpected since AAC was not intended as a replacement for natural speech. Additionally, the authors acknowledged that due to the small sample size the external validity of the study was restricted, which limited generalizability.

Despite the previously mentioned limitations, a thorough assessment was conducted by Bornman et al. (2001), using appropriate pre and post-intervention, multiple baselines (A1 and A2), and clear, detailed explanations were provided regarding candidacy for a SGD, the areas of language that were examined, and how the data were collected (i.e., audio and video recordings, verbatim transcriptions), making the study easier to replicate. The authors also provided thorough suggestions for future research hypothesis in this area. Inter-rater reliability was a strength in this article as the author reported inter-rater reliability of 82.8% for A1. Additionally, two raters scored A2, B, and A3 and a 100% correlation was reported. The participant's mother was informed that the study would be examining narrative context, however she was blind to the exact target of the study. The participant was tracked for two years once formal schooling began, resulting in important longitudinal data providing more strength to generalization and maintenance of intervention. The stories used in this study were taken from the Peabody Language Development Kit, ensuring that the samples were appropriate for the child's age. Additionally, the authors ensured that the stories could be translated into Afrikaans, taking into account language diversities since this was the mother's native language. Considering the strengths and weaknesses mentioned above, this study provides suggestive level I evidence regarding the effectiveness of a digital voice output device in facilitating communication and language development, specifically with regards to higher cognitive language functioning, in a child with CAS.

Waller, O'Mara, Tait, Booth, Brophy-Arnott and Hood (2001) conducted a longitudinal, detailed single-subject design, which quantitatively and qualitatively examined the impact of a narrative-based communication device on the communication skills of a dyspraxic ten-year-old girl. Results of this study indicated that the narrative-based communication device was effective in improving the child's communicative abilities.

The participant used the Talk:About AAC device for one year with a four-week break in between. During this time, the participant received weekly one-hour therapy sessions with her SLP, which focused on the use of her

AAC device. Additionally, the participant was seen twice a week by the research SLP or research special education teacher. The treatment consisted of four components: narrative writing, use of narratives with a third person, preparation for classroom work, and facilitation of use of the device within the classroom in group activities. A strength of this study was the nature of the environments (i.e., classroom and clinical therapy room) that were used to provide intervention. Despite the small sample size and therefore limited generalizability to larger populations, the multiple settings provide suggestive information regarding generalization to different environments.

Measurement and analysis by Waller et al. (2001) was thorough. Probe sessions were conducted at monthly intervals and the participant's use of her device was recorded and tracked weekly (i.e., vocabulary, buttons, contents, and narrative files). The Profiles of Development was used to gather information pre- and post-intervention, which demonstrates consistency of the methods used and data obtained. Additionally, an informal questionnaire was administered pre- and post-intervention to the participant's mother and classroom teacher, and post intervention to the participant's SLP. Waller et al. (2001) also created opportunities in which the participant used her device to communicate with research staff that was not directly involved with the current study. Following a communication exchange, another team member not involved in the study analyzed the interactions for communicative function, effectiveness and modality. Results of the study demonstrate that the AAC device had a positive effect on the content and frequency of the child's stories, in addition to her verbal, narrative, and social skills. It was reported that improvements in the child's self-esteem were also observed. Anne's desire to tell people about recent events and to initiate the writing of narratives increased and her pragmatic communicative skills improved as the study went on. An increase in natural speech output was reported and the child became less reliant on her device, only using it when misunderstood. Increases were seen in appropriateness of responses and ability to expand on topics and initiate, however receptive language abilities remained stable.

The study by Waller et al. (2001) demonstrated some strengths including the detailed description of the participant, methodology, and future research recommendations, which increases the ease with which this study could be replicated. The authors acknowledged the limited generalizability due to the small sample size, but strengthened their data by utilizing consistent pre- and post- test measures in addition to frequent monthly and weekly tracking. Waller et al. (2001) acknowledged that improvement in

the participant's language abilities cannot be solely attributed to intervention with the AAC device due to the design of the study and that other factors (i.e., maturation) may have impacted the results. Considering the weaknesses mentioned above, this study provides suggestive level I evidence regarding the effectiveness of literacy based AAC device in improving the communicative abilities of children with CAS.

King, Hengst, and DeThorne (2013) conducted a multiple-probe, single-subject research design. This study examined the effectiveness of an integrated multimodal intervention (IMI), incorporating traditional speech therapy in addition to AAC use, on natural speech, target speech sounds, and the quantity of natural and AAC speech with three boys (aged 4-8) who have CAS. Results of the study indicated that an increase in the quantity of natural speech produced as well as a slight increase in AAC use was evident in all three boys.

For baseline and IMI sessions, the three participants attended individual sessions, lasting approximately thirty-five to forty-five minutes long, approximately twice a week for nine to fourteen weeks. Between two and four baseline sessions were attended by the boys, in addition to between nine and twelve IMI sessions. IMI is an activity-based intervention approach that focuses on increasing the quantity and improving the quality of natural speech productions simultaneously by using a two-pronged approach to intervention incorporating AAC systems and natural speech and language. The IMI sessions were held in various environments: a university clinic, at school, or at home. The procedures for the IMI sessions and baselines were conducted in the same way and by the same individual each time. Three activities were completed in each baseline and treatment session: shared storybook reading, natural speech target drill, and structures play. The IMI sessions were the only time that the IMI components were integrated into these three activities. Treatment continued until 12 IMI sessions were reached or the participants achieved 90% (in two consecutive sessions) on the target speech sound in treatment words produced in the three activities in the IMI session.

Data collection involved coding all participant responses. Coding was completed by tallying all of the participant turns (productions), during all three activities, during each baseline and treatment (IBI) session. Productions were coded for whether natural speech or use of AAC was used and a frequency count was obtained every session. King et al. (2013) clarified that it did not matter whether productions were contextually or phonetically correct and that all productions were included in the tally. Video recordings were used in order to analyze child productions and

calculate a frequency count (i.e., natural speech and AAC use) per session.

Strengths of this study include the presence of both the generalization probe and the control probe, before or after every two to three sessions including the final maintenance session (one month post intervention). Additionally, data coding and analysis procedures were supported by video recording each session. The authors obtained good interater reliability of the coding procedures, with the average reliability score of 96% (range 87%-100%), and a two-step consensus process was used to transcribe the videos (using SALT). King et al. (2013) clearly identified coding and analysis procedures including treatment effect on the quantity of productions, treatment effect on the quality of productions, generalizations, and maintenance of treatment effects. Fidelity was also calculated in this study, revealing 95% compliance with the baseline sessions across all three participants and sessions in addition to 90% compliance with the IMI sessions across all participants and sessions. Another strength of this study was that the primary research question as well as the secondary questions were addressed and answered. Quality of natural speech, quantity of natural and AAC speech, generalization of natural speech improvements, and maintenance of natural speech improvements all resulted in favorable results. Results indicate that all three boys showed improvement from baseline to IMI condition with regards to accuracy of treatment words produced. All three participants showed increases in the total amount of natural speech from baseline to IMI sessions.

Limitations of the study involved limited generalizability due to small sample size. King et al. (2013) acknowledged that external validity could be strengthened with the use of larger sample sizes in addition to the implementation of experimental designs using control groups and randomization. Additionally, statistical analyses were not conducted, therefore the true validity of the results cannot be evaluated. Additionally, although a strength of the study was the thorough description provided for each participant in addition to the prerequisite criteria for the study, one quality all three boys had in common was their ability to imitate. Upon review, this raises concern as to whether the treatment would be effective for children who were unable to imitate. Despite these limitations, the study provides suggestive level I evidence that intervention that incorporates the use of speech generating AAC with traditional speech therapy can support communicative abilities.

Case Studies

Case Study Research Design

Case studies are appropriate research designs when examining a heterogeneous group, like children with CAS. Case studies can provide comprehensive descriptions of subjects, procedures, and outcomes, which are beneficial for validating existing theories, as well as increasing the ease of replication for future research. Since independent and dependent variables are not manipulated within these designs, no causal relationships can be inferred from these studies. The small sample size in case studies results in a lack of external validity, which limits the ability to generalize findings to larger populations (Backman, Harris, Chisholm & Monette, 1997).

Cumley and Swanson (1999) describe the outcomes of three case studies that examined how a multimodal AAC intervention approach was used with children who have CAS. Low and high technology aids were incorporated into three children's (preschool, elementary and junior high) intervention plans. Results of the study suggest that AAC aids and strategies may be effective in improving the functional communication skills of the three children. Findings revealed that success was observed in facilitating natural speech with these strategies and aids, in addition to creating more opportunities for facilitating language development, communicative competence, and academic achievement.

Study #1

The first participant was a preschool aged girl who was provided with a variety of high and low technology AAC aids to facilitate natural speech and gestures. AAC included theme-specific communication boards, a remnant book, and a WOLF voice output device. Although research utilized a case study design, this particular study included a single piece of single-subject data. The first participant's 50-word pre- and post- test measures revealed an increase in her MLU after incorporating the use of the WOLF. Results of the multimodal intervention suggest that AAC successfully supported her natural speech and gestures and additional findings suggested that her early language development was supported as well.

Study #2

The second participant was an elementary aged girl who was provided with low technology aids to support her natural speech by creating opportunities for her initiate interactions, set topics, and repair communication breakdowns. AAC included theme-specific communication boards, a symbol communication

dictionary, and a remnant book. At 8 years, prior to the start of traditional speech and language services, the participant was administered the *Hodson Assessment of Phonological Processes-Revised* (Hodson, 1986), in which she received a phonological deviancy score of 100 and a severity interval of profound. Following six months of speech therapy, a post-test measure was obtained revealing minimal progress. It was at this time a multimodal AAC intervention approach began.

Study #3

The third participant was a junior high boy who was provided with high and low tech AAC aids (i.e., memo writer and communication boards) to support his natural speech in different environmental settings (i.e., classroom and community). This participant was the only individual to receive both an AAC assessment in addition to a functional communication assessment. AAC assessment focused on the assessment of spelling and the use of a Sharp Memo Writer was suggested to support his communication needs. The functional communication assessment included the Functional Motor Speech Questionnaire, FMSQ, (a modification of the Communication Profile Questionnaire for Speakers with Motor Speech Disorders), which was completed by the participant himself, by the school personnel, and his parents. This tool observed the participant's communicative attempts, specifically his strategies to repair communicative breakdowns. Since informal observations are subject to biases, this information should be reviewed with caution. However, Cumley and Swanson (1999) supported the informal observations by calculating percentages of agreement between those who completed the FMSQ. Results suggested that within the classroom, the participant's boards were beneficial in supporting his natural speech for a variety of communicative functions: setting topics, requesting, and expression of thoughts and ideas.

Results of this study should be evaluated with caution. Firstly, the small sample size results in a lack of external validity and limits generalization to larger populations. Secondly, for all three studies there was inadequate, limited, detail regarding inclusion criterion for participants and means in which results were obtained. Additionally these studies did not gather enough quantitative data. Study 1 provided data regarding a 50-word pre- and post-test assessment measuring MLU. Study 2 administered a standardized test, which examined phonological processes before and after traditional therapy but did not provide data following the implementation of AAC. Study 3 only provided data for the percentages of agreement among those who completed the Functional Motor Speech Questionnaire, which is at risk of subjective biases. Since all three articles are case studies, any gains

observed cannot be confidently attributed to treatment. While researchers provided information for further research, they failed to acknowledge any limitations within their own study. As a result, this study provides equivocal level IV evidence regarding the effectiveness of a multimodal AAC intervention approach in facilitating natural speech in children with CAS.

Discussion

This critical review discusses the efficacy of AAC in improving the communicative abilities of children with CAS. All six studies reported positive gains in the communicative abilities (e.g., increases in natural speech, initiating, requesting, offering information, MLU, intelligibility, vocabulary, etc.) of all participants following the use of AAC. However, some studies provided more suggestive evidence than others. The use of stable, multiple baselines and thorough descriptions regarding participant candidacy for AAC and data collection methods, provided suggestive evidence for the studies conducted by Bornman et al. (2001) and King et al. (2013). Luke's (2003) A-B study design was appropriate for the philosophical underpinnings and purpose of the study and a binominal test was used in order to establish if statistically significant differences in the trend-lines of the baseline versus treatment data existed. An anomaly was described in the study by Bornman et al. (2001) regarding reports of decreased verbalizations as the participant's use of the SGD increased throughout the intervention period. Although improvements in all three participants were noted following treatment, the Cumley and Swanson (1999) case study provided equivocal evidence due to insufficient quantitative data regarding inclusion criterion for participants, treatment methods, and data collection measures. All studies contributed in providing valuable suggestions for future research and clinical implication. Overall results of these studies provide suggestive evidence for the effectiveness of AAC in improving the communicative abilities of children with CAS.

While analyzing the six studies included in this critical review, it is important to acknowledge some of the methodological limitations that did arise. All six studies used very small sample sizes, which results in poor external validity and limits generalizability. Low internal validity is another limitation since five of the six studies used a basic A-B research design. Although A-B-A designs can more clearly establish causality, Luke (2013) reported that due to practical limitations of his study (i.e., inability to withhold the use of the SGD) an A-B-A design was not ethically appropriate. Since children with CAS are such a heterogeneous population, concern also arises regarding participant selection (i.e.,

severity of CAS, comorbidities, etc.), and how other factors may impact treatment results. Another challenge across these six studies is that they all differed slightly with regards to their inclusion criteria, sampling procedures, and settings for both assessment and intervention. Overall, since all studies yielded similar gains with regards to the communicative abilities of the participants, there is suggestive evidence supporting the clinical relevance of AAC use with this population.

Clinical Implications

Given the findings of the six studies included in this critical review, there is suggestive evidence supporting the clinical use of AAC to improve the communicative abilities of children with CAS. This suggestive evidence supports the use of an integrated intervention model, incorporating the use of AAC in conjunction with traditional therapy, to address the functional communication needs of children with CAS who require AAC support as either a short-term or long-term strategy. However, future research is necessary to strengthen current evidence in order to support these recommendations for this heterogeneous population. Nonetheless, given the documented benefits of AAC use within the literature, and the reported communicative gains seen among the participants examined within this critical review, there is highly suggestive evidence that AAC use is not detrimental to the communicative abilities of children with CAS (i.e., inhibiting natural speech). Therefore, there is suggestive evidence that AAC is effective in improving the communicative abilities of children with CAS.

Additional research is necessary to address the limitations previously discussed within this review. Recommendations for future research include:

- I. The effects of AAC on the quantity of the communicative interactions of children with CAS.
- II. The effects of combining speech intervention and AAC intervention on the quality and quantity of speech productions in children.
- III. The effects of a multimodal AAC approach on the communicative abilities of children with CAS who lack imitation skills.
- IV. The specific types of AAC that is beneficial for improving the communicative abilities of children with CAS.

Conclusion

In conclusion, current literature provides suggestive evidence that AAC is effective in improving the communicative abilities of children with CAS. Although AAC use with this population suggests

clinical effectiveness, future research with larger sample sizes, randomization, blinding, good internal and external validity, and thorough follow-up measures is recommended before this evidence can be considered conclusive. Additionally, further research should explore more modern types of AAC (i.e., iPads with Proloquo2Go).

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