Critical Review:
Can Augmentative and Alternative Communication (AAC) speech-generating devices (SGDs) improve communication in children with nonverbal autism spectrum disorder?

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This critical review examines the literature on the efficacy of speech-generating devices (SGDs) for improving communication in children with nonverbal autism spectrum disorder (ASD). A total of seven studies were selected and reviewed including multiple baseline across participants designs and an ABCACB multiple-treatment reversal design. Overall, the results are suggestive of positive outcomes regarding improvements in communication with the use of SGDs for children with nonverbal ASD.

Introduction

Autism spectrum disorder (ASD) refers to a lifelong neurodevelopmental disorder characterized by restricted and repetitive behaviours, interests, and activities as well as difficulties with social interactions and communication (American Psychological Association, 2021). ASD occurs in every racial, ethnic, and socioeconomic group, but is known to be four times more common in males than females (American Psychological Association, 2021). As of 2018, approximately 1 in 66 children in Canada are diagnosed with ASD and approximately 1-2% of Canadians are on the autism spectrum (Autism Ontario, 2021). ASD is considered to be a "spectrum" due to the heterogeneity in both the way the disorder is presented and the severity of which the individual is effected (American Psychological Association, 2021). Expressive communication skills are one of the heterogeneous characteristics of ASD as at one end of the spectrum, individuals may present as talkative and long-winded, whereas the other end of the spectrum will present as mute (van der Meer, et al., 2014). Approximately 20-30% of individuals diagnosed with ASD are considered to be nonverbal and lack any functional communication (Chen, Wang, Lee, & Su, 2016).

Augmentative and alternative communication can be defined as systems that are put in place to either supplement or replace existing communication for individuals with speech impairments (Strasberger & Ferreri, 2014). Children with ASD who are nonverbal or minimally verbal are often taught to use AAC systems in order to communicate (van der Meer, et al., 2013). Research has been able to demonstrate that individuals with ASD who have limited speech are able to be successful when learning how to communicate using unaided or lower-technological AAC systems (van der Meer, et al., 2014) but studies are more limited in individuals with nonverbal ASD using higher technological AAC. There are two styles of AAC systems: aided and unaided. The unaided systems do not require any external devices, such as with manual signs, whereas aided systems do require external devices, such as with picture exchange communication systems (PECS) or speech-generating devices (SGDs) (Strasberger & Ferreri, 2014). SGDs are considered to be higher technological AAC systems as they are portable electronic devices that are able to produce either synthetic or digitized speech with the push of a button (Strasberger & Ferreri, 2014).

This review aims to determine if there is evidence in the literature to support the use of SGDs for improving communication for children diagnosed with nonverbal ASD.

Objectives

The primary objective of this paper is to critically evaluate the existing relevant literature regarding whether or not SGDs are able to improve communication skills in children with nonverbal ASD.

Methods

Search Strategy

Computerized databases including the Western Libraries database and Google Scholar were searched with the following keywords: (aac OR augmentative and alternative communication) AND (autism OR asd) AND (children OR child) AND (communication) AND (sgd OR speech generating device).

Selection Criteria

The articles included in this review were required to include (a) a child with an ASD diagnosis, (b) the use of a SGD for communication, and (c) children that were under the age of 18 years.

Data Collection

Results of this literature search yielded seven articles including: six multiple baseline across participants designs and one ABCACB multiple-treatment reversal design.

Results

ABCACB Multiple-Treatment Reversal Design

This study design involves the participant being tested in a baseline condition, a treatment condition, and again in a return to a baseline condition. Reversal designs allow for more than one treatment type to be evaluated. After participants have moved from a baseline to intervention phase, they are returned to baseline before treatments are reintroduced. This reversed design is therefore able to better control for carryover effects. The following study by Chen et al., (2016) used this design in order to explore two interface designs in treatment.

Chen C., Wang C., Lee I., & Su C. (2016) used an ABCACB multiple-treatment reversal design to explore the use of SGDs by nonverbal adolescents with ASD. Three 12- to 13-year old individuals with nonverbal ASD participated in this study. The participants took part in a single three-hour session each week for six months. The content of the SGDs were based on the following three basic social needs: greetings, requests, and responses. Two different SGD interfaces were compared; the Hierarchical Relating Menu (HRM) and the Pie Abbreviation-Expansion Menu (PAEM). The HRM allowed the participants to have a home page where they were able to connect to a desired second page based on the content that was relevant to them in that moment (such as greet, problem, introduce, participate, etc). The PAEM, on the other hand, displayed all content on the same home page.

Significant differences were noted at baseline (A1), intervention (B1), and intervention (C1) for all three participants which demonstrated the effectiveness of both interfaces for each of the three participants. Significant differences were also noted at baseline (A2), intervention (B2), and intervention (C2) for all three participants which indicated that the three participants were all able to respond to questions using both of the two interfaces. During observation, the level of independent completion was higher on the HRM than the PAEM which meant the participants needed less support to use the SGD with the HRM multiple-page interface. Results showed that when all three participants used the HRM and PAEM interfaces, they were able to communicate with others and have simple conversations using phrases such as "how are you", "good morning", and "please help me". These results were consistent with other research findings that show that SGDs can help individuals with ASD to communicate. The authors noted that prompt interfaces and training programs should be designed for best results with these SGDs.

The authors discussed potential limitations to their study such as the idea that personal preference between the two interfaces may have been associated with some of the results. One participant was thought to have learned to use the interface more quickly, which also had an impact on the results. Both interfaces could have been further explained in the article to increase the reliability by making the study more replicable. The participants in this study were not organized into IQ-level groups as the authors did not believe that it would be statistically meaningful to do so. IQs may have affected the results, as indicated by one participant possibly learning the interface faster due to a higher IQ. Overall, this study provides suggestive evidence that SGDs can improve communication skills in nonverbal children with ASD.

Multiple Baseline, Across Participants Design

In this study design, a baseline is established for each of the participants in the study. After the baseline is established, the treatment is introduced to each participant at different points in time. The following studies all used a multiple baseline design to determine whether treatment was having an effect, or if other factors were contributing to the gains. This design also allowed researchers to account for individual needs and differences throughout their studies.

Strasberger, S. K. & Ferreri, S. J. (2013) used a single subject, multiple baseline design to examine the efficacy of using Peer Assisted Communication Application (PACA) training to teach children with ASD how to use an iPod-based SGD to increase communicative behaviours and socialization. Four males with ASD ranging from 5;8 to 12;11 years old participated in this study. Five typically developing peers also participated in the study and had been selected based on both their willingness and availability to participate.

This study began with a preference assessment in order to determine which item the child (primary participant) would prefer. During baseline, the primary participants were not instructed on how to use the SGD to complete two-step mand (request or demand) sentence sequences. During the intervention, neurotypical peers taught the primary participants how to use the device to communicate. Each session consisted of 10 opportunities to communicate and there was always at least a five-minute break between sessions. No more than three sessions were conducted each day with any of the primary participants. The authors used both follow-up and maintenance sessions as well as generalization of

learned behaviours in the classroom. All four children were able to use the iPod-based SGD for some communicative purposes by the end of the study. Two of the four children were able to generalize and maintain their communication skills in new settings. The authors indicated that the results of this study showed that children with ASD and cognitive impairment (CI) can learn to effectively communicate with an iPod-based SGD.

This study was able to demonstrate procedural integrity above 90% for each participant. In addition to that, each of the peer participants were required to complete an evaluation with 100% accuracy to proceed in the study. The primary investigator did not interact with the primary participants unless there were problematic behaviours to ensure the study maintained the construct validity of the PACA training. The primary investigators were able to minimize fatigue effects by limiting the amount of sessions each child was able to participate in each day and ensuring breaks were present. Overall, this study provides highly suggestive evidence that SGDs are able to improve communication skills in nonverbal children with ASD.

Lorah, E. R., Karnes, A., Miller, J., & Welch-Beardsley, J. (2019) used a multiple baseline across participants design to assess whether or not an interrupted chain procedure was an effective strategy for eliciting peer mands when the targeted individual was using an iPad-based SGD. The interrupted chain procedure creates deprivation by disrupting behaviours that had previously had reinforcing consequences, therefore creating a manding opportunity. Three preschool aged children who had all been previously diagnosed with ASD participated in this study. The participants in this study had previously learned how to mand and differentiate between more than 10 symbols on the iPad SGD screen. Along with the three children with ASD, three neurotypical peers with a mean age of three years, six months participated in the study.

During all sessions of the study, the iPad was positioned directly in front of or next to the participant. Three icons were presented on the iPad screen; two icons for manding targets and one distractor icon. The voice output on the SGD was set to "male child" to match the age and sex of the participants. The sessions were conducted in the "puzzle center" of the classroom where the puzzle had one, two, or three missing pieces that were placed in the possession of the peer. The participant was then expected to demonstrate prelinguistic communication, such as reaching for the puzzle piece. If the participant was able to mand for the missing puzzle piece either by using vocal speech or the SGD, within a five-second time delay the participant was granted access to the item. After a five-second time delay if no mand had occurred, a physical prompt was used to elicit a correct response. The results of this study indicate that the interrupted chain procedure with the five-second delay and physical prompting was effective in establishing peer manding in preschool-aged children with ASD when using an iPad-based SGD. Each of the participants were able to reach the mastery criterion of independent and accurate manding in approximately four sessions. The authors of this study indicated that these results can demonstrate ways to establish social communication for both children with ASD as well as other children who rely on SGDs for communication.

The authors continued peer training until they were able to 100% accurately and independently demonstrate the ability to respond to peer mands. Inter-observer agreement was noted to be 100% for the dependent measure and fidelity probes that were in place to ensure the procedures were followed were 100% for all of the trials. The lack of a generalization phase in this study did not allow for the analysis of whether or not generalization would have occurred. Overall, this study provides highly suggestive evidence that SGDs are able to improve communication skills in nonverbal children with ASD.

Waddington et al. (2014) used a multiple baseline across participants design to determine whether SGDs were able to aid with sequencing multi-step communication exchanges, specifically two requests and a social communication response. Three children with ASD and severe communication impairments participated in the study.

During all sessions of the study, the iPad was placed within easy reach of the child and was turned on and opened to the correct screen. Systematic instruction was used during intervention and consisted of a least-to-most sequence of prompting along with a time delay and error correction. Each session began with three practice trials where the interventionist asked the question "would you like anything" and immediately moved the child's hand to the correct icon while instructing them to press the button. Following the practice trials, the child completed 10 trials in which they were to press the button within 10 seconds or prompting began. Correct responses, prompted or not, were required to move to the next step in the sequence. The previous procedure was repeated for steps two and three. All three participants increased their percentages of correctly completed sequences by the end of the study. Two of the participants were reassessed following intervention. Results indicated that their gains had been maintained and were able to generalize to new communication partners.

Inter-observer agreement and procedural integrity were noted to be over 90% for each of the participants. It

should be recognized that this data should be interpreted with some caution as a small sample size was used. On top of the small sample size, only two of the three participants were reassessed to determine whether skills were maintained and generalized. To establish external validity, further research with a larger sample size would be suggested. Overall, this study provides suggestive evidence that SGDs are able to improve communication skills in nonverbal children with ASD.

Sigafoos et al. (2013) used a multiple baseline across participants design to determine whether children with ASD and little to no speech would be able to successfully learn to use SGDs to participate in communication exchanges. Two brothers, ages four and five with diagnoses of ASD participated in the study. One boy used reaching behaviours as a form of communication and the other used both reaching and hitting.

This study created requesting opportunities in baseline, intervention, maintenance, and generalization phases to allow the participants to request continuation of play with a toy they had been playing with for at least 30 seconds. In the baseline phase, the least amount of physical prompting necessary was used for the participant to activate the speech output using the symbol on the iPad. During the subsequent phases, no prompts were used. If the child did not respond with a request within 10 seconds, the toy was not given. After a lapse of 30 seconds, the trainer would initiate a new requesting opportunity. Both participants learned to use the SGD to make requests to continue playing with a preferred toy quite rapidly. During a maintenance phase, both children demonstrated their learning as correct request responses occurred during every opportunity. Both participants were able to eliminate their reaching and hitting behaviours by replacing them with a form of functional communication using the SGDs. Both participants were able to demonstrate generalization to other preferred stimuli.

Inter-observer agreement and procedural integrity were consistently 100% for each participant over the course of the study. The study methodology was well-scripted, which would allow for replication. This data should be interpreted with caution due to the small sample size. Overall, this study provides suggestive evidence that SGDs are able to improve communication skills in nonverbal children with ASD.

King et al. (2014) used a multiple baseline across participants design to determine whether children could acquire requesting skills via a SGD and whether the skills gained from using the SGD could lead to increased vocal requests. Three children diagnosed with ASD with limited or no vocal output participated in the study.

Participants were seated at a table facing the communication partner, with a trainer sitting behind them. The communication partner held the preferred stimulus and waited silently. If the participant began to reach for the stimulus, the trainer would physically prompt them to touch the picture of the preferred item on the iPad SGD. When the SGD produced the item name, the item was given to the participant. In a second phase, the participant was required to stand up, pick up the iPad, and bring the iPad to the communication partner to gain the partner's attention before touching the icon on the screen. In the third phase, the participant was required to discriminate between preferred and non-preferred stimuli on the iPad screen and to touch the icon of the preferred stimuli before they were granted access to the item by the communication partner. All participants reached mastery criteria of phases one through three. For all participants, vocal requests emerged and increased throughout the study, which supported SGDs aiding in creating requesting repertoires for children with ASD, as well as supporting the idea that speech may emerge as vocal requests when using a SGD.

Inter-observer agreement was calculated for all of the sessions and participants by both the communication partner and trainer. In each phase, the mean inter-observer agreement was 97%. This study was conducted in a school hallway with barriers in place surrounding the area in which the study was taking place to minimize distractions. Although barriers were in place, it can be assumed that distractions were likely still present. This study was able to promote generalization by having the communication partner and trainer alternate roles each session to increase the participant's ability to use their communicative skills with different communication partners. Overall, this study provides suggestive evidence that SGDs are able to improve communication skills in nonverbal children with ASD.

Gerverter et al. (2016) used a multiple baseline across participants design to determine whether children with ASD and limited vocal imitation skills could learn to independently produce target vocalizations through the use of a SGD. Four male children with diagnoses of ASD and previous experience using a SGD to make requests participated in the study.

During all phases, the child's preferred stimulus was placed in front of the participant, but not within reach, so the interventionist would have the ability to block reaching attempts for the item. The session was only started if the participant showed interest toward the target item. The interventionist placed the iPad-based SGD between the participant and the preferred stimulus and waited for a response for five seconds. The stimulus was immediately delivered to the participant if they vocally

emitted the target word, with or without the SGD, during the five seconds. In three of the four participants, independent vocalizations increased throughout the duration of the study. Generalizations were noted to occur when the participants began to vocalize in environments where the preferred stimuli were present, but the SGD was not.

Mean integrity scores ranged from 98-99% for each of the participants. Generalization probes were included throughout baseline, intervention, and post-intervention for all participants. Future research should explore conditions that allow requests made for one item to generalize so that requests for different items or activities may be made. Overall, this study provides suggestive evidence that SGDs are able to improve communication skills in nonverbal children with ASD.

Discussion

Based on the studies in this critical analysis, there is suggestive evidence to show that SGDs are able to improve communication skills in nonverbal children with ASD. Overall, the evidence was highly consistent across the studies.

Small sample size proved to be a limitation in all of the studies in this critical review, which makes the results of each of the studies less generalizable. Lack of long-term follow up sessions limited these studies as it is difficult to know how much success the children had with their AAC devices long-term, and therefore how the AAC device was able to improve their overall communication. There was no reporting of parental involvement in any of the studies reviewed. Since children spend the majority of their time with their parents, parents would play a large role in whether or not the children were able to use and benefit from their SGD long-term. Lastly, the studies in this review did not account for IQ and therefore could not account for potential differences in cognition levels when teaching the participants to use SGDs.

Additional research is suggested to address the limitations and improve the evidence in this area of research. The following recommendations should be considered:

I. Utilize larger sample sizes to enhance overall validity and generalizability.
II. Follow participants long term to assess whether SGDs are practical for this population and whether skills have generalized and been maintained following the intervention period.
III. Include parental involvement as an independent variable to evaluate how SGDs impact communication with varying amounts of parental participation.
IV. Include measures of IQ in studies to increase information on cognitive impacts when learning to use SGDs.

Clinical Implications

The available evidence suggests that speech-language pathologists should recommend AAC devices for children with nonverbal ASD. While this information should guide practice, caution should be applied as AAC devices must be suited to the needs of the particular child, as a SGD may not be the best fit for every child with nonverbal ASD. Careful objective measurements of the individual the device is for must be taken.

Parents of children with nonverbal ASD often fear that when an AAC device, such as a SGD, is introduced that the device may hinder or prevent vocal speech from developing (Gevarter, et al., 2016). However, the research completed by Gervarter et al. (2016) and King et al. (2014) demonstrate that SGDs may actually supplement and encourage the development of vocal speech through the use of an AAC system.

Based on this research, speech-language pathologists may have an evidence-based starting point for which AAC device may benefit this population; however, due to the suggestive nature of this critical review, it is important that clinicians continue to test out a variety of AAC systems to determine which form of AAC works best for their client.

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