Critical Review:

Do Speech-Generating Devices (SGDs) Increase Natural Speech Production in Children with Developmental Disabilities?

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As speech-generating devices (SGDs) become increasingly accessible and affordable with the advent of AAC applications compatible with popular electronic devices such as the iPad™, questions regarding the advantages and disadvantages of SGD use become increasingly relevant. This critical review explores whether SGDs promote natural speech in children with developmental disabilities. A literature search of electronic databases revealed 5 articles meeting the selection criteria. Study designs include 4 single-subject research designs and 1 systematic review. Research results indicate that SGD use does not increase natural speech production in children with developmental disabilities, with the exception of certain factors and conditions, which require further exploration. Recommendations for future research and clinical implications are also discussed.

Introduction

Children with severe communication disorders arising from conditions such as intellectual disability, cerebral palsy, autism, and a multitude of syndromes may require augmentative and alternative communication (AAC) to meet their communication needs (Beukelman & Mirenda, 2005). A subset of AAC includes speech-generating devices (SGDs). SGDs can be defined as any low or high-tech electronic or computer-based device with a visual display that can be programmed to produce synthetic speech or recorded digitized speech (Sigafoos et al., 2011). There are a number of social, communicative benefits to using SGDs, including greater naturalness for listeners, greater social acceptability among peers, and decreased misunderstandings among unfamiliar listeners due to the precision of the messages (Sigafoos et al., 2011). Some parents of children with developmental disabilities may ask whether use of an AAC device will hinder their natural speech production. While research has provided evidence that this is not the case (Schlosser & Wendt, 2008), the question of whether SGDs may have a beneficial affect on natural speech production has emerged. As SGDs are becoming increasingly accessible and affordable with the advent of AAC applications that are compatible with popular electronic devices such as the iPad, questions regarding the benefits and disadvantages of SGD use become increasingly relevant for parents, clinicians and researchers.

There are a number of hypotheses as to why SGDs may increase speech production. Theoretically, speech output could have implications for communication, motor and acoustic effects, which may support natural speech production (Blischak, Lombardino, & Tyson, 2003). Communication effects that could enhance natural speech production include gains in the number of conversational turns, communicative functions, and utterance length (Blischak et al., 2003). Blischak et al. (2003) have also proposed that motor effects such as reduced physical demands and reduction in pressure to speak may also have a positive effect on natural speech. Lastly, a number of acoustic effects, including the acoustic model provided by the device and the pairing of spoken with graphic symbols could theoretically enhance natural speech in children using SGDs (Blischak et al., 2003). However, the evidence regarding the relation between SGDs and natural speech production must be considered before setting expectations for improved speech and/or implementing such AAC devices as an intervention method to increase natural speech production.

Objectives

The primary objective of this paper is to critically evaluate existing literature regarding whether speech-generating devices increase speech production in children living with developmental disabilities.

Methods

Search Strategy

A number of online databases, including but not limited to PubMed, Scholars Portal, EBSCO*host*, Google Scholar, and ScienceDirect were searched using the following terms:

(Speech generating devices) OR (SGD) OR (speech output)
AND (children)
AND (developmental disabilities) OR (autism)
AND (natural speech production) OR (speech production)

Selection Criteria

Studies selected for inclusion in this critical review were required to include children (under age 18) with any developmental disability. Studies were also required to use AAC devices under speech and no-speech conditions, and include natural speech production (however defined) as a dependent variable. No limitations were placed on the research design or outcome measures.

Data Collection

The literature search yielded five papers that fit the aforementioned selection criteria: four single subject design studies, which investigated the effects of synthetic speech output on natural speech production, among other parameters such as frequency of requesting or naming and one systematic review on the effect of different AAC approaches, including SGDs, on speech production.

Results

Single-Subject Designs

Single-subject study designs are especially appropriate, considering the heterogeneous and diverse characteristics children with a variety of developmental disabilities. As well, the objective of the studies is to measure changes in the amount of speech production as compared to each participant's baseline measures. However, this type of design cannot provide population-based evidence that can be easily extrapolated beyond the individuals in the studies.

Using an alternating treatments single-subject design, Sigafoos, Didden, & O'Reilly (2003) investigated the effects of SGD use on frequency of vocalization in three children (3–13 years) with various developmental disorders. Each participant was trained on an SGD with a single pre-programmed message in speech output ON and speech output OFF conditions. More vocal requesting use was observed for the one participant who had recently stopped using words, in both output conditions. Sigafoos et al. (2003) concluded that speech output did not have an effect on the frequency of vocalizations. However, AAC use involving SGDs may increase vocalizations in cases of selective mutism.

A strength of Sigafoos et al.'s (2003) study is the inclusion of baseline measures of vocalization. However, the results from this study should be interpreted with caution as a number of nuisance variables could have affected the frequency of vocalizations in the participants. Improvements in the one participant's output could have been influenced by opportunities to imitate the trainer's speech, and positive reinforcement from the trainer. As well, the researchers did not control for the settings in which device acquisition was trained and post-acquisition use was assessed. The nature of the environments (i.e. noise in an outdoor recreation area during lunch time) could have been prohibitive to the production and interpretation of vocalizations. No inter-observer agreement values were reported for vocalizations. Additionally, the researchers did not conduct a statistical analysis of frequency of vocalizations to determine signifance or effect size. Considering the limitations outlined, this level I evidence according to Logan, Hickman, Harris, & Heriza (2008) is considered equivocal.

Schlosser et al. (2007) conducted a multiple-baseline single-subject ABA design investigating the effects of SGD use on requesting and natural speech production in five children (8-10 years) with autism. For the purposes of this review, findings regarding SGD effects on the natural speech production of the participants will be examined. Only participants who met an eight item criteria of inclusion were considered in the study. Each child was trained to use an SGD pre-programmed to include speech output for four reinforcing items and remain silent for the remaining items. An increase in vocal requesting in speech output ON and speech output OFF conditions was observed in the only participant with vocal imitation abilities. Schlosser et al. (2007) concluded from visual analysis that speech output did not have an effect on natural speech production. However, AAC use involving SGDs may increase natural speech production in children with vocal imitation abilities.

This study by Schlosser et al. (2007) demonstrated some strengths in experimental design. They performed a multiple baseline study controlled for setting, used a well-defined set of inclusion criteria, and clearly outlined their criteria for correct elicited vocalizations. The researchers also chose to investigate the added variable of imitation ability and obtained stable baseline measures for it. The intervention conditions were described in detail, allowing for replication of the procedure. The study also reported good inter-observer reliability (100%) across all participants, conditions and phases. The study also demonstrated some weaknesses in experimental design. Nuisance variables not considered in the study may have affected the participants' natural speech production. The researchers

in this study chose to investigate elicited vocalizations as an indicator of the effect of SGDs on speech production; however, the tester was required to give a model and elicit an imitation from the participant if the child did not name the item on the first try. Therefore, increases in natural speech production could have been influenced by opportunities to imitate the tester's speech. Additionally, the researchers did not apply any statistical tests on the results. Therefore, significance and effect size could not be determined. Considering strengths and weaknesses of study design, this level I evidence according to Logan et al. (2008) is suggestive that use of an AAC device under speech and no-speech conditions do not affect natural speech production.

A single-subject ABC study by Sigafoos et al. (2011) examined the effects on natural speech production of the use of speech generating devices, and reinforcement of augmented requests in one 14-year-old with Klinefelter Syndrome and limited spoken language abilities. The participant was trained to request for desired items using an Apple iPod Touch™ installed with Proloquo2Go™ software under three conditions: long-output, short-output, and no-output. In a second phase of study, Sigafoos et al. (2011) explored the role of extinguishing reinforcement during augmented requesting in the randomly selected long-output condition. The participant would request for a desired item using the iPod programmed to produce long speech output in the form of a phrase or sentence. The trainer would then eliminate reinforcement by failing to fulfill the participant's request by withholding the desired item. Appropriate non-parametric statistical analysis revealed no significant differences in natural speech production in a cross comparison between all three conditions: long output and no-output (z = -1.414; p = 0.157), short-output and long-output s (z = 0.000; p = 1), short-output and no-output (z = -0.530; p = 0.596). However, statistical analysis revealed that extinguishing reinforcement of augmented requesting in the long-output condition resulted in a significant increase in the number of spoken words, when compared against the reinforced long-output condition (z = -3.055; p = 0.001). Additionally, the participants used relevant words in a requesting context during the long-output condition where extinguished reinforcement was involved.

This study by Sigafoos et al. (2011) displays many strengths, including an ABC alternating treatment design, a clearly defined criteria for natural speech production, a clearly reported procedure, good inter-rater reliability and appropriate statistical analysis to determine significance. The validity of the study is good, as the researchers chose to examine only spontaneously produced speech under a restricted context, and avoided eliciting imitations of the trainer's models. However, the study also displayed some weaknesses in experimental design. The researchers randomly chose to extinguish reinforcement only on augmented requests made through the long-output condition. It is unknown whether the same effects would be observed from extinction of augmented requesting in the short-output and no-output conditions. Additionally, this study was performed on one participant with Klinefelter Syndrome. The results are likely not generalizable due to the small sample size ($n=1$) and the specific nature of the syndrome. This is an area to be investigated in future research. Considering the strengths and weaknesses outlined, this level I evidence according to Logan et al. (2008) is suggestive that different speech output conditions have no effect on natural speech production, but that extinguishing reinforcement of augmented requesting using an SGD may increase natural speech production.

Two multiple baseline single-subject design studies by Kagohara et al. (2012) investigated the effect of systematic instruction and speech-generating devices on naming performance and natural speech production in two adolescents (13-17 years) with autism spectrum disorders. Exclusively results regarding natural speech production will be considered. The participants were trained to use an Apple iPad™ installed with Proloquo2Go™ software under speech output ON and OFF conditions in a naming task. The amounts of intelligible spoken words produced during the naming tasks in the speech output ON and OFF conditions were recorded. Both participants used varying amounts of intelligible spoken words during the naming tasks in both speech output conditions. Visual analysis of the data determined no changes in the number or quality of spoken words were observed in comparison to baseline measures.

This study by Kagohara et al. (2012) displays some strengths in experimental design, including clearly specified participant eligibility criteria, a concurrent multiple baseline design, clearly outlined procedure and response definition for spoken words, and good inter-rater reliability. However, the results of this study must be interpreted with caution as a number of weaknesses can be identified. No stability of data was demonstrated prior to beginning the intervention phase due to one participant's short baseline phase (3 data points). Results may not be valid as spoken words cannot be directly attributed to SGD use. Spoken word performance may have been influenced by imitation of the tester's prompting (e.g. "touch *penguin*"). The outcome assessors were not blinded to the phase of the study, possibly biasing results. Additionally, no follow-up phase was included in the study due to the end of the

school year. No statistical tests were applied to the results; therefore significance and effect size could not be determined. Considering the weaknesses outlined, this level II evidence according to Logan et al. (2008) is considered equivocal.

Systematic Review

Schlosser & Wendt (2008) conducted a systematic review of the effects of a variety of AAC interventions on speech production in children with autism spectrum disorders. Nine single-subject design studies and two group studies were analyzed. Three of the studies focused on speech generating device and are relevant to this review. The review rated one study as preponderant, indicating minor flaws in experimental design resulted in the conclusion that speech outcomes were more than likely a result of the SGD use. The other two studies involving SGDs were appraised as suggestive, indicating that these studies had several minor flaws in design resulting in the conclusion that it was *plausible* that speech outcomes were related to AAC intervention. Only one speech output ON condition in one study was determined to be a fairly effective intervention strategy (mean PND 83.3) on the dependent speech outcome variable through a percentage of non-overlapping data (PND) analysis.

This systematic review by Schlosser & Wendt (2008) displays many strengths in study design. The researchers presented detailed information regarding the participants, interventions given, and outcomes considered in a chart format, allowing for comparison between the studies. They offered a detailed description of their methodology, including their selection criteria, data collection, and process of PND analysis. The decision not to combine the results is a strength in design, as the studies involved different dependent speech outcome measures. Schlosser & Wendt (2008) also noted that the data from PND analysis should be interpreted with caution. Although mean PND reflected an overall level of effectiveness, there was great variability in the performance of individual participants. Some weaknesses of the systematic review include a failure to search for unpublished and non-English language studies. This could have resulted in publication and language biases, although this is unlikely to influence the application of the findings to the local population. Another weakness is the imprecision of the results reported, as no statistical analyses of data giving measures of significance or effect size were conducted. Considering the strengths and weaknesses outlined, this paper offers a suggestive level of evidence.

Discussion

Although the data collected yielded different levels of evidence and validity, the commonalities in the findings are suggestive that speech-generating functions of AAC devices do not have an effect on the natural speech production in most children with developmental disorders. However, there is equivocal evidence to support that SGD use in general may be associated with increases in natural speech production in some special cases. Particularly, Sigafoos et al. (2003) and Schlosser et al.'s (2007) studies found that SGD use may increase natural speech production in children with selective mutism and vocal imitation abilities, respectively. Additionally, Sigafoos et al.'s (2011) study demonstrated that extinguishing reinforcement of augmented requesting may have a role in increasing natural speech production.

Most of the single subject studies reviewed used an alternating treatments design. This is especially appropriate, given that researchers' goals were to investigate and compare the immediate effects of two (or more) treatments in a single subject. In all of the studies, the treatments were related to the amount of speech output generated by the AAC device. However, this type of alternating treatments design does not allow the researchers to identify any effects that may require consistent, long-term use of the device under a single condition. It is also important to note that the increases in natural speech production described above were only observed in isolated cases in each study. The participant criteria of developmental disabilities or even autism spectrum disorder may be too broad to generate conclusive, clear-cut results across all participants. Had the researchers narrowed the criteria for inclusion and focused on one factor common to every participant in their study, they may have produced more conclusive results to determine causation. As well, there are concerns regarding the validity of the results in many of the studies, as imitation of trainer models could have contributed to the observed increase in natural speech production. Other concerns regarding experimental design include the lack of experimenter blinding in all the studies, possibly biasing the results. The presence and/or process of randomization of conditions across participants were not described in most of the studies. Additionally, all but one of the studies reviewed in this critical analysis employed visual or qualitative statistical analyses to determine conclusions. Therefore, significance and effect size indicating a trend towards clinical significance could not be determined from most of the data. In order to provide conclusive causal evidence, the internal validity should be considered, and appropriate quantitative statistical analyses should be applied to the data.

Although these limitations weaken the overall validity of the results, these studies have provided many considerations for future research. Alternating treatment single-subject designs that focus on participants with selective mutism or vocal imitation abilities may yield more clear-cut evidence regarding the association between SGD use and increase in natural speech production. A single-subject crossover treatment design study could be performed to identify if any effects of consistent, long-term use of an SGD under a specific speech condition exist.

Clinical Implications

Given the suggestive evidence that SGDs generally do not increase natural speech production in most children with developmental disabilities, clinicians should support parent and teacher expectations regarding improvement in oral language while using these devices. That being said, it is also important to inform family members and caregivers that using SGDs will not decrease speech production, and that in some special cases, may have a positive effect on their child's speech. A wait-and-see approach to prescribing the SGD would be unwarranted, as it will not have a negative impact on speech production. There is also seminal evidence that suggests manipulation of reinforcement may increase natural speech production. However, further research exploring these factors must be done before SGDs can be used as an intervention strategy for speech outcomes in a clinical setting.

Conclusion

There is suggestive evidence that speech-generating devices do not increase natural speech production in most children with developmental disabilities. Further research with good internal validity must be conducted before this evidence can be considered conclusive. This seminal research has raised questions regarding possible therapeutic uses of SGDs for increasing natural speech production in some contexts. Further research should explore and identify the unique factors identified associated with SGD use and an increase in natural speech production.

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