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EXPLORING EFFECTIVENESS OF SPEECH GENERATING DEVICES FOR INDIVIDUALS WITH AUTISM: SYSTEMATIC REVIEW

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ABSTRACT

Individuals with autism encounter communication difficulties that minimize their opportunities to interact with others. These problems can impact their performance in schools and academic skills, homes, and other environments. Speech generating devices have been used to promote communication skills for these populations. An increasing body of research discussed the variety uses of speech generating devices as well as examining their effectiveness. This study reviewed the effectiveness of speech generating devices in relation to individuals with autism. The method utilized in this review was searching databases for the last 10 years including Education Resources Information Center (ERIC), EBSCO, SAGE journals, and Washington State University's electronic library. Studies reviewed indicated positive outcomes for the use of speech generating devices with autism individuals.

Keywords: Speech generating devices (SGD) for autism, Voice Output Communications Aids for autism, Augmentative and alternative communication for autism.

1.0 INTRODUCTION

Exploring Effectiveness of Speech Generating Devices For Individuals with Autism: Systematic Review.

It is estimated that one child of fifty-nine children is diagnosed with ASD (Gilroy, Leader & McCleery, 2018), and within that range, approximately 50% have limited or no functional communicative speech (Boesch, Wendt, Subramanian & Hsu, 2013). Individuals with autism encounter significant social communication deficits (Rogers, 2000; Oliveras-Rentas, Kenworthy, Roberson, Martin, & Wallace, 2012); that usually persists into the school ages and influences academic and social success (Wilson, 2013). In fact, the lack ability of expressive communication is prevalent among children with autism spectrum disorder (Sturmey & Fitzerm, 2009). Van der Meer et al.5, (2013) point out that they have severe and complicated communication needs. Some individuals with autism are nonverbal and others display different sorts of communication disorders (Crissey 2011). A high percentage of individuals with autism fail to develop adequate and appropriate speech to meet their daily communication demands (McLay et al., 2017). According to National Research Council report (2001), 30% of individuals with autism display severe communication disorders that impact their everyday interactions.

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According to Lord and Jones (2012), about twenty-five to thirty-five percent of individuals diagnosed with autism have little or no functional speech.

The technological tools have not only influenced people without disabilities' daily lives, but they also have impacted the lives of many people with complicated communication needs, including individuals with disabilities (McNaughton & Light, 2013). Augmentative and alternative communication (AAC) approach has been employed in order to enable individuals with autism and severe communication deficits to communicate and interact effectively (McLay et al., 2017). AACs can help to increase the interaction with other people (Hourcade, Pilotte,

West, and Parette, 2004). "Augmentative and alternative communication (AAC) refers to an area of research and clinical specialization that spans several disciplines, including: (a) assistive technology, (b) psychology, (c) rehabilitation, (d) special education, and (e) speech-language pathology." (Sigafoos, O'Reilly, Lancioni, & Sutherland, 2014; p. 51). There are different types of AAC such as speech generating devices, picture exchange as well as manual signing (Mirenda & Beukelman, 2005).

According to Cafiero & Meyer, (2008), in many cases students with autism are considered more visual learners than being auditory learners. Alternative and augmentative communication usually uses visual styles and systems in order to facilitate and provide individuals with autism opportunities to learn how to communicate with others in mutable environments (Cafiero, 2001). Moreover, Fisher and Shogren (2012) articulate several positive impacts when using AACs in the classroom such as enhancing meaningful friendships, creating and building social relationships since these tools increase the ability to communicate with peers and others.

Recently, many researchers have been interested in examining the effectiveness of speech generating devices on students diagnosed with autism and communication disorders. Speech generating devices interventions can help increasing individuals' interactional communication skills, social participation in daily activities in schools with peers or outside with others (Sevcik, Barton-Hulsey, & Romski, 2008). Speech generating devices (SGD) (also known as Voice Output Communications Aids) are electronic augmentative and alternative communication systems that depend on the user's pressing of an image or words "depicting the desired item or activity on an electronic screen with enough force to evoke a digitized SGD message (Lancioni et al. 2007; p. 469)." The purpose of this paper is to review and discuss the literature regarding the effectiveness of speech generating devices interventions. Implications for practices and recommendations for future research are provided.

2.0 RESEARCH METHOD

For the research method used in this systematic review, it consisted of looking and searching databases, specifying studies and peer-reviewed articles, writing summaries, and classifying evidence and outcomes into categories. The method included inclusion criteria and exclusion criteria. For the inclusion criteria, articles identified in this review should be within the date range of the last 10 years including peer-reviewed articles and studies that implement interventions using the speech generating devices (voice-output communication) for students

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with autism. The exclusion criteria, studies before the last 10 years and discuss population other than those with autism are excluded.

This study focuses on scholarly peer reviewed empirical research articles on interventions implemented speech generating devices on individuals with autism. The databases the researcher used include educational research databases (full text) such as Education Resources Information Center (ERIC), Academic Search Complete (EBSCO), SAGE journals, and the electronic library of Washington State University. The following keywords are applied when looking the chosen databases: Speech generating devices (SGD) for autism, Voice Output Communications Aids for autism, Augmentative and alternative communication for autism, communication devices for autism, and autism AAC devices.

When searching using these keywords, it returned over 809 potential articles from different fields. From this list, the researcher determined 27 peer-reviewed articles that are directly connected with this research paper topic. These articles were carefully read and scanned and writing annotated summaries. From these 27 peer-reviewed articles, I concluded with 19 articles that seemed to be the highest quality articles. Figure 1 displays a visual representation of the procedural selection of publications. A template was designed to include these studies reviewed including authors, studies purposes and designs, and sample size of each study.

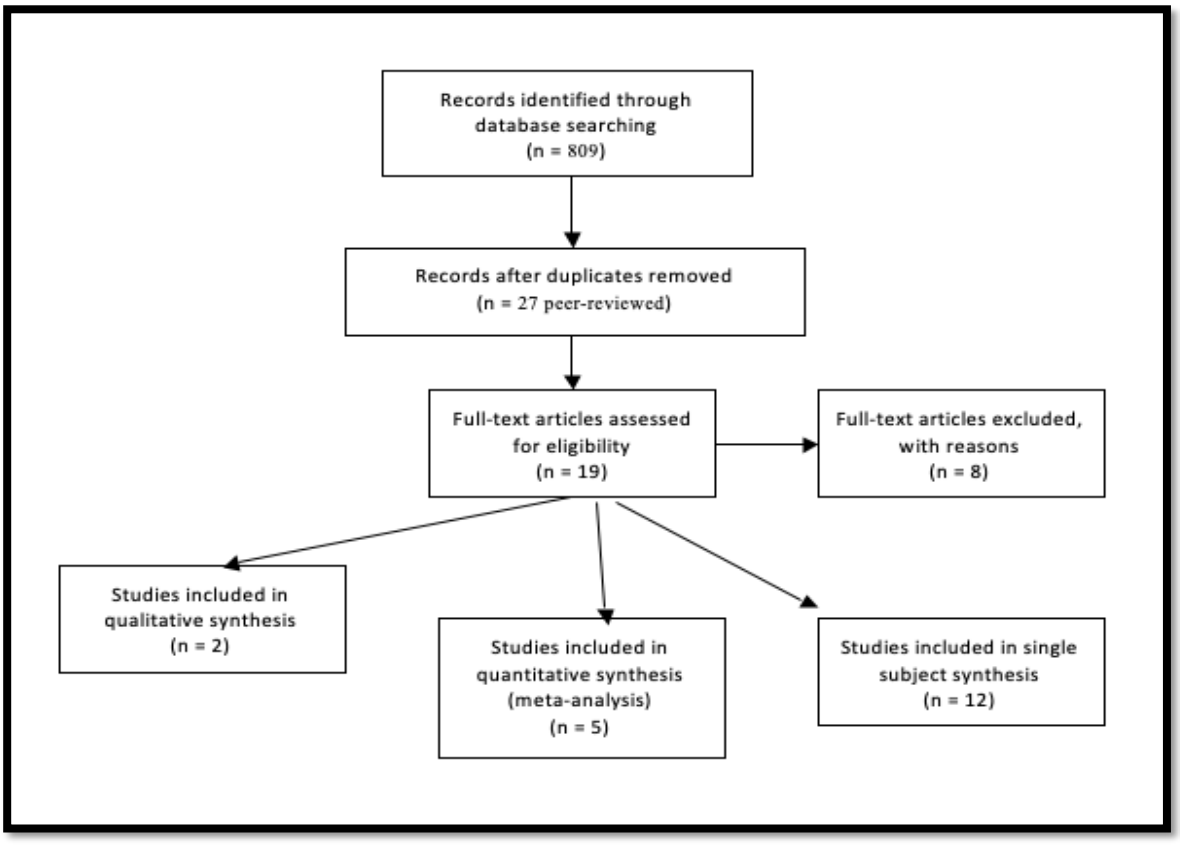

Figure 1. Summary of the Systematic Review Procedural Sele

3.0 DATA EXTRACTION

All the studies should discuss speech-generating devices in relation to students with autism. These studies must report data that evaluated the use SGDs. Articles that did not provide empirical data were not covered in this review. The article must have been published between the periods of 2010 to 2020. Studies that met the inclusion criteria were summarized in terms of:

(a) Participants (number and ages in years) (b) experimental design used studies, (c) target behaviors, (d) interventions' procedures, and (e) findings of studies. The screening process started after the deletion of duplicate studies identified in the initial search. The titles of articles and abstracts were independently screened for eligibility by the researcher. The researcher carried out a full-text review of eligible articles.

4.0 RESULTS

A total of 19 research articles met the criteria for inclusion in this review. The studies are summarized and documented in terms of their purposes, study designs, and the number of participants. Table 1 presented the reviewed articles that met the inclusion criteria. The review revealed three subsections of studies being reviewed. First, studies focused on expressive communication and speech-generating devices, Second, studies focused on vocalizations and speech generating devices. Third, studies focused on other skills using speech-generating devices.

Table 1. Studies included in the systematic review of SGD.

Table 1. Studies included in the systematic review of SGD.			
Authors	Purpose	Study type or design	Participants
Thiemann-Bourque, Feldmiller, Hoffman, and Johner, (2018).	This study examined the effects of incorporating a peer-mediated approach into a speech-generating device intervention on communication of 45 nonverbal and minimally verbal preschoolers with autism spectrum disorder (ASD) and 95 peers without disabilities. The SGD was an iPad 2 (Apple) with voice output app.	A multivariate randomized control trial design with repeated measures for 4 cohorts across baseline, intervention, generalization, and maintenance phases.	Participants included 45 children with ASD.

Neeley, Pulliam, Catt, & McDaniel (2015).	This case study examined the initial and renewed impact of speech generating devices on the expressive communication behaviors of a child with autism spectrum disorder. The specific expressive communication behaviors studied were communication acts (CAs) per obligatory context (OC) per minute, the percent of total communication acts, the number of different words naturally verbalized, and the different types of words naturally verbalized.	A retrospective design.	One male student with autism spectrum disorder.
McLay, Schäfer, van der Meer, Couper, McKenzie, O'Reilly,... & Sutherland, D. (2017).	Acquisition, preference and follow-up comparison across three AAC modalities taught to two children with autism spectrum disorder.	Alternating treatments design.	Two children with autism spectrum disorder
Lorah, E. R. (2018).	"Evaluated (a) the use of a discrimination training procedure and (b) the use of natural environment teaching (NET) in the acquisition of a mand repertoire for three preschool-aged children with autism using the iPad Mini® and application Proloquo2Go™ as an SGD (p.45).	A multiple baseline across participants' design.	Three preschool-aged participants with autism.
Waddington, H., van der Meer, Carnett, & Sigafoos (2017).	Examine the Use a SGD Across Settings: Clinic, School, and Home	A multiple baseline across settings design.	An 8-year-old male with autism.
Carnett, and Ingvarsson, (2016).	Examine how to answers to questions using a SGD.	A multiple baseline across stimulus sets	An 11-year-old male with autism.
Thiemann-Bourque, McGuff,, and Goldstein, (2017).	Examining the influences of peer-mediated on the use of a speech-generating device.	A multiple probe design across participants.	3 preschool participants with autism.

Chang, Shih, Landa, Kaiser and Kasari, (2018).	To examine functional and symbolic play skills in differential contexts.	Quantitative method (t-tests, Chi square tests, and Fisher test)	Fifty eight participants
Gevarter, O'Reilly, Kuhn, Mills, Ferguson, Watkins, and Lancioni, (2016).	Teaching to emit target vocalizations while using a SGD.	A multiple baseline design across participants	Four participants with autism.
Gevarter and Horan (2019).	Investigate a behavioral intervention package to enhance the use of target vocalizations using SGD mands.	A multiple baseline design across participants	Six participants with autism
Gevarter, O'Reilly, Sammarco, Ferguson, Watkins, Kuhn, and Sigafoos, (2018).	To examine the impacts of different speech-generating devices and vocabulary organizations on the acquisition of multi-step ordering responses for students with autism.	A multielement design.	Four children with autism
Xin, and Leonard, (2015).	Examining the impacts of using an iPad to help participants with autism in learning communication skills.	A multiple-baseline design with AB phases across settings	Three participants with autism.
Biggs, Carter, Bumble, Barnes, and Mazur (2018).	To examine the efficiency of a paraprofessional-facilitated peer network to improve peer interaction and to evaluate if embedding peer-implemented aided AAC modeling within the intervention can improve students' use of symbolic communication.	A multiple baseline across participants design with two intervention phases (A-B-BC).	Four participants with autism and intellectual disabilities.
Robillard, Roy-Charland, and Cazabon (2018).	Investigating the role of cognition on the navigational process of a speech-generating device.	A quantitative method.	20 participants with autism.
Boesch, Wendt, Subramanian, and Hsu (2013).	Examining the comparative efficacy of the Picture Exchange versus a speech-generating device (SGD) to improve requesting skills.	A multiple baseline design across participants	Three participants with autism.

Achmadi, Kagohara, van der Meer, O'Reilly, Lancioni, Sutherland, and Sigafoos (2012).	Teaching more advanced operations to request access to preferred stimuli using SGD.	A multi-probe multiple baseline across participants design	Two adolescents with autism.
Van der Meer, Sutherland, O'Reilly, Lancioni, and Sigafoos (2012).	Examining the acquisition and preference among manual signing, picture exchange, and speech-generating devices.	An alternating treatments design.	Four participants with autism.
Kagohara, Van Der Meer, Achmadi, Green, O'Reilly, Lancioni, G. E., ... and Sigafoos, J. (2012).	Examining the ability to name pictures using SGD.	A multiple-probe across participants design.	Two adolescents with autism.
Wu, Mirenda, Wang, & Chen (2010).	Addressing stereotypic behavior throughout the use of functional analysis and functional communication training that employed SGD.	Case study	One male student.

4.1 Studies Focus on Expressive Communication and The Use of Speech Generating Devices

Expressive language is important to classroom learning since it is the method to deliver instruction and exchange knowledge and information (Kathard & Pillay, 2015). According to Raghavendra, Olsson, Sampson, Mcinerney, and Connell, (2012), students who have speech problems or unable to meet their needs of communication encounter risks regarding the classroom's activities and participation. Studies examined the effectiveness of speech generating device on expressive communication in different contexts and different cases for students with autism (Kagohara et., 2012; Alzrayer and Banda, 2017; Neeley, Pulliam, Catt, and McDaniel, 2015).

For instance, Neeley, Pulliam, Catt, and McDaniel (2015) conducted a lengthy case study for six years in order to examine the expressive communication behaviors of a male student diagnosed with severe autism on speech generating devices. The study's outcomes clarified the use of the speech generating devices enhanced the participant's capacity to expressively communicate by increasing his verbalization of vocabulary and words. The study also indicated that the ongoing training of speech generating device use could positively influence the student's ability to expressively communicate.

According to Albert, Carbone, Murray, Hagerty and Sweeney-Kerwin (2012), mand is "a verbal operant in which the response is reinforced by a characteristic consequence and is therefore under the functional control of relevant conditions of deprivation or aversive stimulation" (p. 65). Recently, a single subject study (a multiple baseline across participants)

examined the "use of a discrimination training procedure and the use of natural environment teaching in the acquisition of a mand repertoire" using speech-generating device (Lorah, 2018, p.94). The participants of the study were three preschool-aged children diagnosed with autism. The result indicated that all three participants achieved the mastery level criterion of 80% or higher.

Waddington, van der Meer, Carnett, and Sigafoos (2017) conducted a case study to help an 8-year-old male with autism to approach communication partners to request wanted items across settings (e.g., clinic, school, and home) using an iPad®-based speech-generating device. The study's results pointed out that the participant's performance increased across all settings and show positive outcomes. The student reached 100% correct responses at the clinic and at school. Chang, Shih, Landa, Kaiser, and Kasari (2018) examined the functional and symbolic play skills in differential contexts of developmental behavioral intervention (Joint Attention, Symbolic Play, Engagement & Regulation). The participants of the study included 59 students between the ages of 5–8 diagnosed with autism. Participants were randomized into two groups to receive a speech-generating device and other group did not. The result indicated that both groups enhanced their play skills.

4.2 Studies Focus on Vocalizations and Speech Generating Devices,

Some researchers have also discussed vocalizations in the context of speech generating devices for students with autism (Gevarter et al., 2016; Wu, Mirenda, Wang, & Chen, 2010; Gevarter and Horan, 2019). Gevarter et al., (2016) examined whether students with autism and limited vocal speech skills can learn to independently emit target vocalizations (full words or vocal approximations) while using speech-generating devices. The study used multiple baseline design across participants for four students with autism. The four participants have shown increases and high vocalization rates when they were prompted using voice output communications aids (iPads). In addition, Gevarter and Horan (2019) have examined if speech generating devices "responding maintained during intervention, and whether vocalization responses generalized to contexts where the SGD was absent (p. 144)." The study included six participants (five males and one female) with autism and related disabilities. Researchers employed a multiple baseline design across participants. The results indicated that students 5 students showed increases in the use of their vocalizations.

In a case study, Wu, Mirenda, Wang, & Chen (2010) discussed the stereotypic behavior throughout the use of functional analysis and functional communication training that employed speech generating devices. One male participant was integrated in this study. The results suggested that the communication training was helpful in increasing the independent requesting in many settings and minimizing the frequency of vocalizations. Moreover, researchers reported that the vocalizations had served escape and tangible functions, and the student was able to make orders for a preferred item. Behaviors that are positively tangible reinforced can lead to access to dished items or activities (Ahearn, Clark, Gardener, Chung, & Dube, 2003). See table 2 below for studies included in this review.

4.3 Studies Focused on Other Skills Using Speech Generating Devices

There were other studies that have focused on different skills. For example, Carnett, and Ingvarsson (2016) examined the use a speech generating devices across settings: clinic,

school, and home with a child with autism to mand for answers to questions. Researchers employed a multiple baseline across stimulus sets. The result indicated in acquisition of both the mand for information and intra-verbal responses; however, it reported limited generalization of the mand for information. A study examined the impacts of different speech-generating devices and vocabulary organizations on the acquisition of multi-step ordering responses for students with autism (Gevarter, O'Reilly, Sammarco, Ferguson, Watkins, Kuhn, and Sigafoos, 2018). Four children with autism participated in the study implemented a multielement design. The result indicated that 3 participants have acquired requests with the schematic display but did not meet criterion requesting with the taxonomic display.

Robillard, Roy-Charland, and Cazabon (2018) conducted an intervention to investigate the role of cognition on the navigational process of a speech-generating device. Twenty participants with autism included in the study. Researchers reported there were correlations between the cognitive factors and the ability to navigate and speech-generating device were revealed. Boesch, Wendt, Subramanian, and Hsu (2013) examined the comparative efficacy of the picture exchange versus a speech-generating device (SGD) to improve requesting skills.

Researchers used a multiple baseline design across participants with three participants with autism. Results showed increases in requesting behavior for all three participants with both systems; however, difficulties were observed with picture discrimination.

5.0 DISCUSSION

Individuals with autism encounter significant social communication deficits that often persist into the school ages and impacts academic and successfully social interaction. The lack ability of expressive communication is prevalent among children with autism spectrum disorder as they display different kinds of communication disorders and issues. They always fail to develop adequate and appropriate speech to meet their daily communication demands.

Augmentative and alternative communication (AAC) approach has been implemented to enable individuals with autism and those who have severe communication deficits to communicate and interact effectively. This study focused on reviewing and discussing the literature regarding the effectiveness of speech generating devices interventions. The method utilized in this review was searching databases for the last 10 years including Education Resources Information Center (ERIC), Academic Search Complete (EBSCO), SAGE journals, and Washington State University's electronic library. Studies reviewed indicated positive outcomes for the use of speech generating devices with individuals with autism.

A speech-generating device is an electronic communication device that provides digital speech upon activation by persons with little to no communication (Lloyd et al., 1997). They are available in different features, expenses, and designs. Studies in this review of speech-generating devices for individuals with autism have focused on making requests and orders (Waddington, H., van der Meer, Carnett, & Sigafoos, 2017; Carnett, & Amarie, 2016; Xin, & Leonard, 2015), and SDG comparison with other approaches (Boesch, Wendt, Subramanian, & Hsu, 2013; van der Meer, Sutherland, O'Reilly, Lancioni, & Sigafoos, 2012; Gevarter, O'Reilly, Sammarco, Ferguson, Watkins, Kuhn, & Sigafoos, 2018; McLay et al., 2017).

Studies also included peer- mediated approaches applied SDGs (Thiemann-Bourque, Feldmiller, Hoffman, & Johner, 2018;

Thiemann-Bourque, McGuff, & Goldstein, 2017; Biggs, Carter, Bumble, Barnes, & Mazur, 2018; Waddington, Van der Meer, Carnett, & Sigafoos, 2017), and communication acts and behaviors (Neeley, Pulliam, Catt, & McDaniel, 2015; Chang, Shih, Landa, Kaiser & Kasari, 2018; Gevarter and Horan, 2019; Robillard, Roy-Charland, & Cazabon, 2018).

These studies reported positive outcomes regarding the effectiveness of using speech-generating devices. The results of this review suggest the potential value of incorporating speech generating devices into educational and rehabilitation settings for individuals with autism; however, it is important to consider several aspects of the existing literature base. The published studies had included a relatively small number of participants (<50) with a broad age-range between 4 and 27 years considering that these studies extensively discussed preschoolers and young children. While there should be value in evaluating and assessing whether older individuals could be taught to use this technology for accessing preferred stimuli and supporting communication and daily life activities.

The future research should consider examining speech-generating devices for middle schools; high schools and post-secondary programs for individuals with autism who have communication problems. For example, future studies should discuss how to enhance peer-mediated interactions in classrooms for individuals who use speech-generating devices for communication. In addition, the effects on requesting skills and increasing vocalizations for adolescents with autism.

6.0 DECLARATION OF CONFLICTING INTERESTS

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