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SPEECH GENERATING DEVICES AND AUTISM: A COMPARISON OF DIGITIZED AND SYNTHETIC SPEECH OUTPUT

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Dedication

I would like to dedicate this doctoral dissertation to my parents, Mr. Ramdoss and Mrs. Bhavani Ramdoss. I am especially thankful to my mother; she is the one who sewed in me seeds of love, honesty, and integrity. My father modeled a strong determination to embrace all that makes life worth living even in the face of overwhelming odds. Without their knowledge, wisdom, and guidance, I would not have the goals I have to strive and be the best to reach my dreams!

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SPEECH GENERATING DEVICES AND AUTISM: A COMPARISON OF DIGITIZED AND SYNTHETIC SPEECH OUTPUT

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Children with autism often experience substantial impairments in the domain of language and communication. Speech generating device (SGD) is one of the widely used augmentative communication systems with this population. The most prevalent speech output systems currently in use with SGDs are digitized and synthetic speech outputs. Advantages and disadvantages of each speech output system exist, and large individual differences in-terms of preference and performance have been speculated in both modalities. There is currently no published research that compares digitized and synthetic speech outputs.

The primary goal of this study is to examine the effects of SGD training using digitized vs. synthetic speech outputs on the acquisition of requesting skills of 4 non-verbal children diagnosed with autism. The study addressed the following research questions. First, are there differences in acquisition rates for requests taught using digitized vs. synthetic speech outputs? Second, do children show a preference for one speech output over other?

Finally, Are there any differences in perceived social validity of digitized vs. synthetic speech outputs?

The primary findings of this study were: (1) Differences in the performance were found between two of the participants within each speech output; (2) two of the participants appeared to prefer one speech output over other and one participant could not indicate his preference due to positioning bias; (3) social validity measures indicated favorable ratings for SGD training but no clear indications in-terms of acceptability and usability of speech outputs across different settings. The overall results obtained from this study suggest that speech output can play a significant role, and it is one of the important components that can contribute to the success of the intervention. Additionally, overall outcome suggests that non-verbal children with autism can successfully learn to use the SGDs at their own pace with the support of proper prompting strategies and instructional procedures.

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CHAPTER I: INTRODUCTION

Autism Spectrum Disorders (ASD) are a group of biologically based neuro-developmental spectrum of disorders that encompasses autistic disorders, Asperger syndrome, and Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS) (American Psychiatric Association, 2000). There are three distinctive behaviors that characterize autism. Children diagnosed with autism experience difficulties with verbal and non-verbal communication, problems with social interaction and repetitive behaviors or obsessional interests (APA, 2000). The severity of the individuals diagnosed within the spectrum can widely vary but major portion of the individuals diagnosed with ASD function in the severe range (APA, 2000). In the recent decades, the prevalence of ASD is thought to be much higher than it was initially described by Kanner in 1943. For instance, when it was explicitly described by Kanner in 1943, autism was considered as a rare disorder with an estimated prevalence of 2 to 5 per 10,000 children. Recently, Centers for Disease Control and Prevention has reported an overall average prevalence of 9.0 per 1000 population for the 2006 surveillance year (CDC, 2007). The astonishing increase in the prevalence rate can be an actual reflection of real increase in the prevalence rate or due to increased awareness and or screening tools such as Checklist for Autism in Toddlers (CHAT; Baron-Cohen, Allen & Gillberg, 1992). Due to steady decrease in the average age of diagnosis and unexpected increase in the prevalence rate, treatment providers are presented with high percentage of very young children with ASD who have no functional communication.

One of the prime characteristics of children diagnosed with ASD is their inability to develop functional communication skills. For instance, approximately 14% to 20% of children diagnosed with autism who receive early intervention are functionally non-verbal (Lord, Risi, & Pickles, 2004). Even children who do develop speech demonstrate speech irregularities such as echolalia (Charlop-Christy &Kelso, 1997) and or significant speech delays (American Psychiatric Association, 1994). Communication is one of the vital aspects of development. Deficits in early communication can affect children's growth in the areas of cognitive, academic, and social performance (Carson, Klee, Perry, Donaghy & Muskina, 1997). In the absence of functional speech, many children with autism develop pre-linguistic communicative behaviors such as reaching, pointing and other hand gestures (Keen, Sigafoos, & Woodyatt, 2001). Due to the idiosyncratic and subtle nature of pre-linguistic communicative behaviors (Drasgo, Halle, Ostrosky, & Harbers, 1996), the communicative intent of the pre-linguistic behaviors is hard to interpret (Keen et al., 2001). Therefore, it is more essential to develop alternative forms of communication to substitute or replace existing forms of pre-linguistic communicative behaviors (Caar & Durand, 1985).

American Speech Language Hearing Association defines Augmentative and Alternative Communication (AAC) as an area of clinical practice that attempts to compensate either temporarily or permanently for the impairment and disability patterns of individuals with severe expressive communication disorders (ASHA, 1991). AAC system is primarily designed to replacing existing pre-linguistic forms of communication with more symbolic forms of communication (Sigafoos & Mirenda, 2002). Generally, AAC systems can be classified into two main categories namely aided and unaided. Unaided system involves symbols such as manual signs and pantomime gestures. Aided communication involves symbols such as line drawings, photographs and letters. We can also incorporate external devices such as communication books and speech-generating devices in Aided systems (Mirenda, 2003). The two most popular AAC systems employed with non-verbal children with developmental disabilities in the past were sign language training and Picture Exchange Communication System (PECS) (Adkins & Axelrod, 2001).

Teaching sign language involves making request for preferred items and or activities by producing the sign that corresponds to preferred item (Tincani, 2004). Based on the level of mastery, stimulus control is gradually faded from physically prompting the learner to make signs in the presence of preferred items to make the signs independent of prompts (Sundburg & Partington, 1998). On the other hand, teaching PECS involves making requests for preferred items by using picture symbols and it progresses through six phases. In the first phase, a learner learns to physically exchange the picture for corresponding item. In the second phase, individual learns to exchange the picture icon to a communicative partner with a certain amount of physical distance. In the third phase, individual learns to discriminate between pictures and in the fourth phase, sentence structure is introduced. In the fifth phase, individual is taught to respond to the question, "What do you want?" And in the sixth phase, commenting on items or activities in the environment is introduced (Frost & Bondy, 2002).

There is substantial body of literature documenting the potential advantages and disadvantages of both manual signs (e.g., Bonvillian & Blackburn, 1991; Remington & Clarke, 1983; Yoder & Layton, 1988) and PECS (e.g., Anderson, 2001; Peterson, Bondy, Vincent & Finnegan, 1995; Schwartz, Garfinkle & Bauer, 1998) for individuals with autism.

Speech-generating device (SGDs) and Voice Output Communication Aid (VOCAs) is one of the most significant advances in enhancing the communicative abilities of individuals with severe language and communicative impairments. SGD or VOCA is a term used to describe variety of voice output devices that are designed to provide an effective means for verbal communication for individuals with severe communicative impairments (Mirenda, 2001). SGDs may range from single message generating devices with the storing time of few minutes to a complex computer like systems capable of storing and generating infinite number of messages. Some SGDs use recorded human natural speech (digitized) and some other devices use computer generated speech (synthetic) outputs to enable communication.

A retrospective analysis on the use of assistive technology by individuals with autism and severe intellectual impairments indicates that nearly 63.6% of individuals with severe intellectual impairments are using SGDs to augment their communication (Mirenda, Wilk, and Carson, 2000). Another study estimates that 25 to 61 percent of children diagnosed with autism are functionally non-verbal and require voice output devices to support their communication Weitz, (Dexter & Moore, 1997). Compare to other non-electronic communication modalities such as communication boards, speech-generating and voice output communication devices have been identified to have several advantages due to the additional availability of speech output (Schlosser, Sigafoos, Luiseli, Angermeier, Harasymowyz, Schooley et al., 2007). For instance, speech-generating option of communication devices can provide a more natural and understandable form of communication output to listeners (Schepis, Reid, and Behrman, 1996). In addition, speech output generated by these devices can serve as antecedent auditory stimuli (i.e., augmented input) and consequent auditory stimuli (i.e., feedback) (Romski & Sevcik, 1988; Romski & Sevcik, 1993).

At present, there are two types of speech output generated by SGDs namely, digitized and synthesized speech. Synthesized speech refers to mechanical conversion of written language in to an auditory form using the rules of correspondence between written words and sounds (Cowley & Jones, 1992). In contrast, digitized speech refers to recorded human natural speech, which is stored electronically usually in a compressed form (Cowley & Jones, 1992). There are several advantages and disadvantages in using both digitized and synthetic speech in speech-generating devices. For instance, prosody is one of inherent qualities of digitized speech and it is highly beneficial in conveying the essential meaning of the message to the listener. On the other hand, synthetic speech is less prosodic in terms of quality in comparison to digitized speech and it may some time lead to misinterpretation of the intended meaning of the conveyed message (Cowley & Jones, 1992). For more information with relevant to the advantages and disadvantages of incorporating digitized and or synthetic speech in speech-generating devices (See, Mirenda & Iacono, 2009, p. 144).

In order to better comprehend the speech signals, one must be able to segment the speech signals in to meaningful word units. Prizant (1983) has suggested that children with autism who are non-speaking or echolalic may not be able to use the stress cues present in natural speech to segment incoming speech in to meaningful word units. Several pioneers in the areas of AAC suggested that synthetic speech may be helpful for children with autism because of the auditory processing issues with auditory recognition and segmenting of words (Parsons & La Sorte, 1993; Romski & Sevcik, 1996). Some other vital components of synthetic speech such as lack of variability and inherent consistency may provide particular advantage for learners with autism and facilitate the comprehension of speech signals (Romski& Sevcik, 1993; Romski & Sevcik, 1996). Few other pioneers in the field of AAC also putting forth an argument completely in support of synthetic speech by stating that the lack of variation in the intonation that signals emotion of the speaker might facilitate better comprehension of the speech signals and it will afford the learner to rely more readily on auditory information in symbol referent relation (Schlosser, Sigafoos, Luiseli, Angermeier, Harasymowyz, Schooley et al., 2007). On the contrary, few authors argued that the poor acoustic nature of synthetic speech signals may increase the challenges of individuals with severe intellectual disabilities (i.e., ASD) in processing synthetic speech because children with intellectual disabilities often demonstrate characteristics that may not helpful in facilitating the comprehension of synthetic speech signals such as working memory deficits (Hutt & Gitty, 1979), slower processing time (Kail, 1992) and limited attention span with increased distractibility (Haring, McCormic & Haring, 1994).

Chapter Summary

In summary, augmentative communication is essential for major portion of children diagnosed with in the autism spectrum. Speech-generating devices are one of the most popular augmentative systems and it has several advantages due to additional availability of speech output. Digitized and synthetic speech outputs are widely used in speech-generating devices and both speech outputs have several inherent advantages and disadvantages. Based on the language and communicative characteristics of children with autism, several pioneers surmise that synthetic speech output is more appropriate for children with autism. On the contrary, few pioneers speculate that synthetic speech output is not appropriate for children with autism due to their cognitive characteristics.

Next chapter is designed to substantially analyze the literature on the use of SGDs with individuals with ASD and to address the identified gap in the literature with appropriate research questions.

CHAPTER II: REVIEW OF LITERATURE ON THE USE OF SPEECH-GENERATING DEVICES IN COMMUNICATION INTERVENTIONS FOR INDIVIDUALS WITH AUTISM SPECTRUM DISORDERS

Objectives

In order to understand the learner's specific preference for speech output and the effectiveness of speech output on learning and acquisition of children diagnosed with ASD, it is essential to systematically review the literature on the use of SGDs in communication intervention for individuals with ASD. This chapter is primarily aimed at reviewing the literature on the use of Speech-generating Devices (SGDs) in communication interventions for individuals with Autism Spectrum Disorders (ASD). Specifically, literature will be comprehensively analyzed from three different aspects.

(1) First of all, a comprehensive review will be conducted to analyze the corpus of studies conducted using SGDs with individuals with ASD to teach basic level communicative requests (e.g., request for food items, play items) in natural setting (e.g., classroom, playground).

(2) Secondly, a comprehensive review of studies on the use of SGDs will be conducted to understand the potential effectiveness of speech output on the rate of learning and acquisition in individuals with ASD.

(3) Thirdly, a comprehensive analysis of literature will be conducted to understand, whether individuals diagnosed within the autism spectrum can be trained to select their preferred AAC system that involved a SGD. In addition published studies in the areas

of speech systems will be reviewed to understand the listening preferences for speech output (i.e., natural, digitized, synthetic) of children diagnosed within the autism spectrum.

Methods

SEARCH PROCEDURE AND SELECTION CRITERIA

Systematic computerized searches were conducted using four electronic databases (i.e., CINAHL, ERIC, MEDLINE and PsycINFO). Crosschecks were conducted to find relevant published book chapters. Crosschecks were also conducted with published reviews in the areas of speech output (Schlosser, 2003; Schlosser & Bilschak, 2001), voice output communication aids (Lancioni et al., 2007) and speech-generating devices (Mirenda & Iacono, 2009; VanDerMeer & Rispoli, 2010; Wendt, 2006). Systematic searches were conducted using the following boolean operators. (autis*) or (asperger*) or (developmental disab*) or (intellectual disab*) and (speech-generating*) or (voice output*) and (augmentative*) and (alternative*) or (communication*). The database search occurred during October and the November of 2009.

Selected studies for this review must have been published during 1979-2009 in a peer-reviewed journal, and must have utilized either a digitized speech or synthetic speech device as a part of an augmentative and alternative communication intervention package. Studies must have demonstrated the use of speech output by at least one participant diagnosed with autism with little or no functional speech (e.g., Brady, 2007). If a study included both participants diagnosed with autism and other intellectual and developmental disabilities (e.g., Sigafoos, Didden, & O'Reilly, 2003), only results obtained from the participants diagnosed with autism were taken into consideration. Studies were included only when they demonstrated the use of speech output on learners. Studies were included if they demonstrated the effectiveness of intervention through a case study, single subject experimental design, or group study methods.

Studies that demonstrated the effectiveness of speech output on individuals diagnosed with other intellectual and developmental disabilities (e.g., cerebral palsy (Raghavendra & Oaten, 2007), Rett syndrome (Van Acker & Grant, 1995)) were excluded. Studies that demonstrated the effectiveness of speech devices on individuals with autistic like behavior, but not diagnosed with autism (e.g., Sigafoos & Drasgow, 2001) were excluded. Qualitative studies, anecdotal reports, opinion papers were also excluded.

Results

Eighty-four studies described the use of speech output in individuals with different disabilities. Out of those studies, nearly 80% of studies discussed the use of speech output with learners with other intellectual disabilities (e.g., cerebral palsy (Raghavendra & Oaten, 2007) and developmental delays (DiCarlo & Banajee, 2000)). Very few studies involved participants diagnosed with autism.

OVERVIEW OF SELECTED STUDIES

Eighteen intervention studies met all the six above-mentioned criteria. Forty-one individuals participated in these studies and sixteen children (40%) were below or at the age of six. Out of forty-one, all but two of these students were able to succeed to various degrees. Success of the participants involved using SGDs for gaining access to preferred food items (Sigafoos, O'Reilly, Seely-york & Edrisinha, 2004). Few studies also taught children to use digitized speech output devices to request for play items such as glue (Brady, 2000), cars (Olive et al., 2006) and respond to questions and make social comments (Schepis, Reid, Behrmann, & Sutton, 1998).

To facilitate the discussion, based on the content and the components, the selected studies were categorized in to three categories (i.e., use of SGDs to teach communicative requests using an intervention package, use of SGDs and other AAC systems to understand the learner's preference, and use of SGDs to understand the effectiveness of speech output on learning and acquisition.

Use of SGDs in Communication Interventions: An Overview

Nine studies primarily aimed at demonstrating the use of SGDs in teaching basic level communicative requests for children with ASD in different settings.

Table 1: Use of SGDs in communication interventions for individuals with ASD

Study	N	Ages	Communication Characteristics	Settings	Variables	Outcomes
Brady (2007)	1*	5	Non-speech vocalizations, spoken word approximations	CR	Comprehension of object names	Improved for target objects
Durand (1999)	2*	9.5,11.5	No functional vocabulary	CR	Requests for assistance and attention	Both learned to make requests; skills transferred to bookshop and library

Table 1 (continued)

Franco et al. (2009)	1	7.6	Manual sign approximations, no functional speech	PG & Gym	Requests for tangibles and break	Learned to request escape and tangibles; inappropriate vocalizations decreased
Olive et al. (2007)	1	4	Echolalia, pronoun reversals & perseveration	Home	Requests for attention	Learned to make requests; challenging behavior decreased
Olive et al. (2006)	3	3.9-5.6	No functional speech, vocalization, verbal imitation	CR	Communicative interactions	3 learned and increased making requests; 1 began vocalizing
Schepis et al. (1998)	4	3-5	No functional speech, frequent vocalization, gestural communication, pre-symbolic communication	CR	Communicative interaction	4 improved in CR routines; 2 improved additional routines
Sigafoos et al. (2004)	1*	20	Pre-linguistic communication, bilateral hearing loss	OR	Request and repair communicative breakdown	Learned to request and repair communicative breakdown
Sigafoos et al. (2004).	2*	12, 20	Pre-linguistic communication	OR & CR	Locate VOCA to request preferred food	2 learned to locate VOCA and make requests
Sigafoos et al. (2004)	1	12	No functional speech	CS	Request preferred food	Learned to make requests; skill transferred to home

Abbreviations: N = number of participants; CR = classroom; PG = play ground; OR = office room; CS = clinical setting.

* = number of participants diagnosed with autism. For example, in Brady (2000) two individuals participated and one student (1*) was diagnosed with autism.

Three studies have demonstrated the use of digitized speech in a naturalistic communication intervention (Brady, 2000; Olive et al, 2006; Schepis et al, 1998). For example, Schepis et al., (1998) worked with four children of 3-5 years of age who were diagnosed with autism. Intervention consisted of using naturalistic teaching strategies to provide opportunities for using VOCA that involved digitized speech in the context of regularly occurring classroom routines. Intervention was implemented during play and snack routines. All children demonstrated increase in their communicative interaction using VOCA In the naturally occurring classroom routines. Further, the participants expressed interest in using digitized speech based VOCA to request items, respond to questions and make social comments. The contextual appropriateness of VOCA use was supported by the social validity study conducted with teachers and persons unfamiliar with children.

In another example, Olive and others (2006) examined the use of enhanced milieu teaching combined with a digitized speech output device on the requesting skills of 3 children diagnosed with autism. In this study, interventions were conducted during 5-minute play sessions, 4-days per week. Intervention effects were measured in terms of children's independent use of VOCA, gestures and vocalizations/verbalizations during play. All three children demonstrated increase in the independent use of VOCA. In addition all three children showed an increase in gestural and verbal communication but only one participant began vocalizing during this study.

Three studies incorporated digitized speech output devices for functional communication training (Durand, 1999; Franco et al., 2009; Olive, Lang, & Davis, 2007). For example, a study conducted by Durand (1999) examined the effectiveness of functional communication training by incorporating a digitized speech output device. Two students diagnosed with autism with mental retardation who exhibited a variety of problem behavior participated in this study. In the first phase, functional analyses and the Motivational Assessment Scale were conducted to identify the variables that maintained the problem behavior. In the second phase, teachers trained the students to use their communication device in the classroom in order to request the variables (i.e., attention that presumably maintained the problem behavior). After students learned to use their communication device, in the third phase, teachers introduced the same sessions in community settings (i.e., library). Overall outcome of this study indicated that both participants learned to request the variables that maintained the challenging behavior by using digitized speech devices. In addition, these students also generalized this skill to community setting.

In another study, Franco and her colleagues (2009) examined the effectiveness of a digitized speech output device programmed multiple messages on challenging behavior maintained by multiple functions. Based on the results obtained from analogue functional analysis, a 7-year old child diagnosed with autism was taught to use a multi-message speech-generating device in a controlled setting. The child was taught to use the device by discriminating the multiple message options and then to choose appropriate message option in the general settings (i.e., playground). Study outcomes indicated that the availability of the speech-generating device significantly reduced inappropriate vocalizations across all settings and increased the level of engagement and interaction.

Three studies incorporated digitized speech devices in their intervention to promote the functional capacities that are relevant to the use of augmentative and alternative communication (Sigafoos et al., 2004; Sigafoos, O'Reilly, Seely-York, & Edrisinha, 2004; Sigafoos et al., 2004). For example, a study conducted by Sigafoos, O'Reilly, Seely-York & Edrisinha (2004) attempted to teach to locate communication devices for two non-verbal children diagnosed with autism. Prior to the initiation of the study, participants were trained to independently use Tech/Talk, a digitized speech output device for requesting. Following the acquisition of the target request, baseline data were collected to assess the children's ability to make requests in two conditions, namely when the device was within reach, and when the device was placed out of reach. During the intervention, children were taught to locate the device when it was out of reach by using a least-to-most prompting procedure. VOCA location skills of the children were evaluated using delayed multiple baselines across subjects. The results indicated the intervention was effective in teaching children to teach locating speech device when they were in need.

Effects of Speech Output on Learning and Acquisition: An Overview

Five studies attempted to understand the effectiveness of speech output on children with ASD. Some of the targeted skills involved spontaneous utterances, learning spelling, making basic level communicative requests, and natural speech production.

Study	N	Ages	Communication Characteristics	Settings	Variables	Outcomes
Parsons & LaSorte (1993)	6	4.8-13.1	Produced intelligible speech	ER	Spontaneous utterances (SU)	Frequency of SU increased in synthetic speech condition for all subjects
Schlosser et al. (1998)	1	10	Word approximations and finger spelling	Lib & CR	Word Spelling	Synthetic speech alone condition resulted in more efficient spelling
Schlosser et al. (2004)	4	8-12	Little or no functional speech	CR	Word spelling	For 3 children, print condition resulted in more efficient spelling; for 1 child speech/ print condition resulted in more efficient spelling
Schlosser et al. (2007)	5	8-10	Pre-linguistic communication, no functional speech	CR	Requesting, natural speech production	2 students requested effectively in speech condition, one student in without speech condition, and no difference for remaining two.
Sigafoos et al., (2003)	2*	4, 13	Frequent vocalizations, no intelligible words	CR	Vocalizations	2 increased requests and vocalization. 1 began to produce single words

Table 2: Effectiveness of Speech Output on Learning and Acquisition

Abbreviations: N = number of participants; CR = classroom; PG = play ground; OR = office room; CS = clinical setting; Com Characteristics = communication characteristics.

* = number of participants diagnosed with autism. For example, in Brady (2000) two individuals participated and one student (1*) was diagnosed with autism.

Four studies examined the effectiveness of synthetic speech (i.e., Parsons & La Sorte, 1993; Schlosser, Blischak, Belfiore, Bartley, & Barnet, 1998; Schlosser & Blischak, 2004; Schlosser et al., 2007) and only one study examined the effectiveness of digitized speech (Sigafoos, Didden & O'Reilly, 2003) in individuals with autism. Eighteen individuals diagnosed with autism participated and 4 children who participated in these studies are at or below 6-years old. All the individuals participated in these studies were able to succeed to various degrees. Success of the participants involved using speech system to produce spontaneous utterances (Parsons & La Sorte, 1993), learning spelling (Schlosser, Blischak, Belfiore, Bartley, & Barnet, 1998; Schlosser & Blischak, 2004) and making requests and natural speech production (Schlosser et al., 2007; Sigafoos, Didden & O'Reilly, 2003). The study conducted by Sigafoos, Didden and O'Reilly (2003) evaluated the role of digitized speech output on maintenance of requesting and frequency of vocalization on two students diagnosed with autism with ages 4 and 13. Intervention was aimed at teaching students to request preferred food items using a speech-generating device. The number of requests and frequency of vocalizations were calculated and compared across two conditions, namely speech-on and speech-off conditions. Results indicated there were no major differences across conditions for both participants, and one participant began to produce single word utterances during the final part of the study.

Parsons and La Sorte (1993) attempted to measure the effectiveness of synthetic speech on the frequency of spontaneous utterances in two conditions namely with and without speech. Six children diagnosed with autism, ages 4.6 to 6.8, participated in the study. In order to examine the component of synthetic speech and compare between treatment and within treatment effects, authors used interactional single subject design. Results indicated computer-assisted intervention without speech condition did not produce any changes in the frequency of spontaneous utterances. When synthesized speech was added, the frequency of spontaneous utterances increased.

In an attempt to understand the effectiveness of synthetic speech and print feedback on word spelling, Schlosser and his colleagues (1998; 2004) carried out two studies. In the first study, a ten year old student with autism was taught to spell word under three different feedback conditions namely, speech, print and speech plus print. An adapted alternating treatment design was used to understand the effects of three feedback conditions. Results indicated that the participant reached criterion and maintained performance in all the conditions. However, the more efficient spelling resulted in the speech condition followed by speech plus print feedback and print condition. This same study was replicated with four participants diagnosed with autism, ages 8 to 12, in 2004. Similar to the previous outcome, all four children reached criterion in all the three conditions. However, three children first reached criterion in print or print plus speech feedback conditions, and one child first reached criterion in print plus speech followed by speech condition. Based on the differences in the study outcomes, authors proposed two distinct feedback efficiency profiles. Children who exemplified visual profiles spelled more effectively when the feedback condition involved print, and children who exemplified auditory profiles spelled effectively when the feedback involved speech.

Learners' preference for SGDs and other AAC systems: An Overview

Few intervention studies attempted to promote self-determination in individuals with developmental disabilities by enabling them to participate in selecting their own communication device (e.g., Dyches, Davis, Lucido & Young, 2002; Soto, Belfiore, Schlosser & Haynes, 1993).   . Over the past three decades (i.e., 1979 to 2009), only four studies attempted to understand the learner's preference for communication modalities by comparing speech-generating devices and other AAC systems in individuals with autism.

Study	N	Ages	Communication Characteristics	Settings	Variables	Outcomes
Beck et al. (2008)	2*	M-	No functional speech	CR	Correct response	Neither learned to make correct response using VOCA; No predictable preferences
Sigafoos et al. (2009)	1	15	No speech	CR	Correct request and device preference	Learned to request using both PE and SGD; Showed a slight preference for using PE
Sigafoos et al. (2005)	1*	12	No speech, but able to vocalize	CR	Selection of device to make request	Almost always preferred mini message mate to make requests
Son et al. (2006)	3	3-5.5	No functional speech	Home	Request preferred food	1 preferred VOCA to make requests

Table 3: Learner's Preference for AAC Systems and Speech-generating Devices

Abbreviations: N = number of participants; M- = information was missing; CR = classroom; PG = play ground; OR = office room; CS = clinical setting.

* = number of participants diagnosed with autism. For example, in Brady (2000) two individuals participated and one student (1*) was diagnosed with autism.

Three studies attempted to understand the learners' preference between Picture Exchange Communication System (PECS) and a voice output communication device with digitized speech output (Beck, Stoner, & Bock, 2008; Sigafoos et al., 2009; Son, Sigafoos, O'Reilly & Lancioni, 2006) and one study attempted to understand the learner's preference among three different speech-generating device with digitized speech output (Sigafoos, O'Reilly, Ganz, Lancioni & Schlosser, 2005). For example, the study conducted by Beck and others (2005) compared use of picture exchange system and voice output aid to understand the preference for each system and the number of verbalization of the participants. Two pre-school children diagnosed with autism (twins) participated in this study. An adapted alternating design was used to measure learner's preferences and verbalization. The study outcome indicated a slight variation across these twin participants. Both participants appeared to have reached criterion for the second phase of PECS with slight difference in acquisition rate. Neither of these participants learned to make accurate response using voice output device. The total number of utterances increased only for one participant for both conditions. Gain in the number of spoken utterances appeared greater in PECS than VOCA.

In another example, the study conducted by Sigafoos et al. (2005) demonstrated a useful choice making methodology that might enable non-speaking students with developmental disabilities to participate in communication device selection. A 12-year old student diagnosed with autism participated in this study. Implementation of intervention was demonstrated in two controlled conditions using a multiple baseline design. In the first condition, three speech-generating devices were selected and acquisition instructions were introduced. Following the acquisition instruction, the choice assessment phase was introduced. The student showed a clear and consistent preference for a particular speech-generating device. In a following demonstration, students were provided with a choice to select between their preferred communication device and a communication board. Students expressed a preference for communication device over communication board.

LISTENING PREFERENCES OF CHILDREN WITH ASD

Listening preferences of very young children diagnosed within the autism spectrum has been sparsely documented in several clinical (e.g., Clancy & McBride, 1969; Kanner, 1943), anecdotal (e.g., Rowlands, 1972) and retrospective (Ornitz, Guthrie, & Farley, 1977) reports. All the studies cited above suggest that children diagnosed with autism have shown noticeable auditory indifference to the sounds of natural speech (Klin, 1991). An observed Obliviousness demonstrated by children diagnosed with autism towards natural speech may be one among the factors that contributing to deficits in the realm of communication (Osterling & Dawson, 1994) and social responsiveness (Bates, Benigni, Camaioni, Bretherton, & Volterra, 1979). Study conducted by Klin (1991) examined the listening preferential patterns of four young children diagnosed with developmental disabilities that include two children diagnosed with autism, one child with developmental disability other than autism and one child with a language disorder (LD). Diagnosis of all the participants was confirmed after the completion of this study. Children's' listening preferential patterns of speech were obtained in a free choice naturalistic setting (i.e., spontaneous play at home) using a two choice audio feedback device. In the experimental tasks of this study, children were allowed to make choice between a track that presented child directed speech (e.g., participant' mother's speech talking to him or her) and the track that presented the noise of super-imposed voices recorded in a busy canteen (e.g., Babel). The super-imposed voices recorded in a busy canteen are devoid of any central characteristics of speech such as intonation, stress etc. Rather, it was sounded like a continuous and monotonous buzzing noise. The final outcome obtained from the experimental task indicated that both, child diagnosed with a developmental disability other than autism and the child diagnosed with language disorders showed a strong listening preference for their mother's speech. Child diagnosed with a developmental disability other than autism spent 79% of the total listening time and the child diagnosed with LD spent 77% of the total listening time in child-directed speech. In contrast, both children diagnosed with autism showed a strong preference for babel by listening child-directed speech only for 29% and 31% of their total listening time. Another study conducted by Paul and others (2007) examined the listening preferences in toddlers with ASD and matched group of (a) typical age mates, (b) age mates with developmental disabilities other than autism and (c) younger children matched for language age. This study examined the auditory preferences of participants using Head Turn Preference Procedure (HPP). Selected children were allowed to choose between child-directed natural CD speech and the electronically manipulated version of same natural speech. The final outcome indicated that children diagnosed with autism have shown a reduced preference for natural speech compared with typical age mates and other group of participants.

Limitations Of Existing Research

Though, there were few studies conducted to understand the listening preferences of natural and synthetic speech for very young children with autism (e.g., Klin, 1991; Paul et al., 2007), at present, there is no published research study that compares digitized and synthetic speech output to understand the preferences of children with autism and its effectiveness in teaching early communicative requests.

Statement Of Problem

Many children with autism lack speech and experience limitations in functional communication. Consequently, the absence of functional communication in children with autism will have tremendous impact on the level of participation in various day-to-day life activities at home, school community and perhaps more importantly, the social interaction (Prizant & Wetherby, 1987). Therefore, one of the critical goals of intervention for young children with autism is to provide training to support their basic level communication skills (APA, 2000). Theories of neural plasticity have emphasized the need for individualizing the early treatment for children with autism in order to optimize the outcomes of early intervention (Chugani, Phelps & Mazziotta, 1987). Principles of self-determination emphasize the value of enabling individuals with intellectual disabilities to participate in decisions that are affecting their education and therapy. Additionally, failure to identify and prescribe a SGD that meets the user needs and preferences often leads to technology abandonment. For instance, A study conducted with speech language pathologists at the crippled children association of South Australia identified some important factors that are associated with return and abandonment of SGDs (e.g., poor quality of speech, unsuitable voices, inadequate control over the speech generated by SGDs) (Guidera & Olsson, 2004). The present study is well grounded on the theoretical notions surrounding the use of natural and synthetic speech for children with autism. This study will help us to reevaluate the outcomes obtained in the studies that measured the listening preferences of children diagnosed with autism. Finally, this study will throw some light on the relationship that exists between listening preference and rate of acquisition.

Towards this end, The goal of the current study is to train four young non-verbal children with autism in using speech-generating devices with digitized and synthetic speech output to make communicative requests in two natural settings i.e., snack time and play. The specific purpose of this study is to investigate:

(a) Are there any differences in acquisition rate for requests trained using speech-generating devices with digitized vs. synthetic speech output?

(b) Do children show preference to one mode of speech over other by frequently using a device with specific speech output to make communicative requests during choice assessment probe condition?

(c) Are there differences in perceived social validity of speech-generating devices with digitized speech vs. synthetic speech output?

Chapter Summary

Comprehensive review of literature on the use of SGDs in communication interventions for individuals with ASD is clearly indicating that SGDs can successfully be utilized to teach basic level communicative requests for individuals with ASD. Majority of the studies that examined the effectiveness of speech output have reported that speech output is appearing potentially effective in determining the rate of learning and acquisition in individuals with autism. The studies that attempted to promote self-determination revealed that children with autism can be trained in selecting their preferred AAC systems. Few research outcomes that have been reported in the literatures indicating that young children with autism are showing reduced preference to natural speech compared with children with other developmental disabilities and typical counterparts. At present, there is no published study that compares the digitized and synthetic speech outputs in SGDs to understand the preference of children with autism and its effectiveness in teaching early communicative requests. Based on this identified gap in the literature, next chapter is designed to propose a method of enquiry to understand the learner preference for two different speech outputs (i.e., digitized, synthetic) and the effectiveness of speech output on learning acquisition of basic level communicative requests in children with ASD.

CHAPTER III: METHOD

The purpose of the chapter is to describe this study's methodology. In the first section, the participant selection criteria, the locations in which the study was implemented, and the various materials that were used to conduct this study are described. Second section details the preference assessment procedures that were conducted to identify the preferred items for two activities namely, snack and play. In the third section, the experimental design, the independent variables, and the procedural overview of baseline, treatment and post-acquisition or choice assessment probe conditions are given. Finally, fourth section details the dependent variables and data collection procedures, inter-observer agreement formula, treatment fidelity, social validity measures and methods of data analysis and interpretation.

Participants

SELECTION CRITERIA AND PROCEDURES

In this study, four children diagnosed with autism participated and all of them were boys. Participants were selected based on the following criteria. Selected children were in the ages ranging from 3 to 8 years. Young children were particularly selected to cover children who are less likely to have received SGD intervention. All the four selected participants had the diagnosis of autism as per the report from school district or local agency and the parents. All the selected participants had the expressive vocabulary of less than 10 spoken words and did not have any physical or sensory abnormalities that may preclude them from using voice output devices.

Three participants were recruited from the private autism training/ therapy centers that serving Austin and Round Rock area in Texas. First, the investigator directly contacted the directors of these training centers and expressed interest in conducting this study in their centers. Parents of the potential participants were directly contacted by the directors of these centers and helped the principal investigator to obtain consent from the parent / guardians of the potential participants and to videotape all the sessions for the educational and research purposes.

Fourth participant was recruited through the voluntary participation. Parents of this participant received a letter from the investigator inviting their child to take part in the study voluntarily. This letter provided a brief description of the study, and explained the participant selection criteria, purpose of the study, potential risks and benefits, timeline of the study, and the contact information of the investigator. The investigator personally met with the parents of this participant and obtained parental consent for the child to participate and to be videotaped for educational and research purposes.

The recruitment and the experimental procedures were approved by the University of Texas at Austin's Institution Review Board.

PARTICIPANT DESCRIPTION

Participant 1 was a seven-year and two-month old Caucasian-Hispanic boy with the diagnosis of autism. He was functionally non-verbal and trained to use sign language for the purpose of communication. He had one mastered sign for candy. He had less than 10 expressive vocabulary (e.g., swing, yogurt, turtle, nose, mouth) and he can receptively identify some objects and body-parts (e.g., ears, elbow, eyes, foot, hair, tummy and chin). He had severe level of disruptive and challenging behaviors such as flopping, screaming, yelling, hitting himself, biting himself, hit others, bite others etc. He was frequently drawn to cords and wires. At the time of this intervention, he was attending a public school.

Participant 2 was a four-year and six month old Caucasian-Hispanic boy with a diagnosis of autism and speech impairment. He was non-verbal and trained to use sign language for the purpose of communication. He had one mastered sign for swing. He enjoys physical activities such as tickles, spinning and throwing but does not request for these activities. He did not imitate sounds, point to body parts, or use name to identify familiar people and objects. He engages in whining, crying, flopping, and elopement behaviors that function as escape. Some other disruptive behaviors include climbing, jumping off items/ furniture and he is drawn towards sharp items. Just two months prior to the onset of this study, he started attending preschool program for children with disabilities (PPCD).

Participant 3 was a four-year and one-month old Hispanic boy with the diagnosis of autism. He was non-verbal and spoke no words at the start of this study. Previously, he was introduced to picture exchange communication system (PECS) but did not master the target skill due to fine-motor limitation. He had attended preschool program for children with disabilities (PPCD), and had also received support from early childhood intervention services (ECI) prior to the onset of this study. Participant 3 had moderate levels of stereotypic behaviors such as rocking back and forth, lifting arms and reaching for therapists, mouthing (e.g., thumb and objects), and whining. He did not imitate sounds, point to body parts, or use name to identify familiar people and objects. He was diagnosed with autism when he was two-years old and some of the tools that were used to diagnose autism were Adaptive Behavior Assessment System-II (ABAS), and Developmental Assessment of Young Children (DAYC).

Participant 4 was a three-years and six-month old African American boy with a diagnosis of autism. He is functionally non-verbal and neither he can speak any words nor he can imitate sounds. Previously, he had not been introduced to any forms of augmentative and alternative communication. He did not respond to his name, point to body parts, and use names to identify with familiar people and objects. Participant 4 had moderate-levels of challenging behaviors such as crying, screaming and repetitive behaviors such as body rocking, slapping flat surfaces with both hands, and object mouthing.

Settings

The setting for each participant was chosen based on teacher and parent preference and the availability of space within the clinic or home. All settings were places where the participants were usually allowed or expected to engage in learning and play activities (e.g., classrooms, play ground, living room). For the first three participants, the study was conducted in clinical setting (e.g., classrooms, and playground) and for the fourth participant the study was conducted in home setting (e.g., living room).

Training occurred in the context of two activities. The first activity involved snack time where children taught to use a speech-generating device with either digitized or synthetic speech output to request preferred snack items. The other activity involved play time where children learned to make requests for preferred toy items or play activities (e.g., spin-chair) using SGD.

The study involved 25 to 50-minutes of intervention per day, depending on the number of sessions the children received. Within each session, the trainer provided maximum of 10 opportunities for participants to access the preferred item. The sessions were conducted in a one-to-one situation with the trainer. The participant and the trainer sat at a table in the room. For participants 1, 2, and 3, sessions were conducted either in a separate room or playground in the clinic. For participant 4, sessions were conducted in a small corner of the living room where the couch, television and other household items were placed and the legal guardian was present. During all phases of the study, trained behavior therapists administered the instruction under the direct observation of the investigator.

Materials

A paired-choice preference assessment (see procedures) was conducted for each child to identify the preferred items to be used in the training. The items identified in the preference assessment were ranked from most-to-least and assigned to use in each condition. Each participant had a maximum of three to four items and the same items were used for training with speech-generating devices with both conditions namely, speech-generating device with digitized and speech-generating device with synthetic speech output.

The materials included snacks (e.g., gummy, chips, strawberries, yogurt), the play items included (e.g., swing, movie, spin-chair, toy-bus, turtle) and a neutral item (e.g., napkin) that were used for each of the routines and the actual pictures corresponding to each item. Considering the discriminative ability, neutral item was used only with participants 1 and 2. Color pictures of the preferred stimuli items were obtained using a Sony® digital video camera. Using the color picture of the actual items, overlays were constructed for SGD called Tech/Talk® and Big Mack® single-switch communication device. Tech/Talk® devices were used to provide instructions for participant 1, 2, and 3 and Big-Mack single switch devices were used to provide instructions for participant 4.

No	Participant	Settings	Preferred Snack Items (Most-to-least)	Preferred Play Items (Most-to-Least)
1	B.L.	Clinical; Assessment room, and play ground	Gummy, Yogurt, and Chips	Swing, Turtle, and Puzzle
2	D.L.	Clinical; Assessment room, and play ground	Gummy, Skittles, and Cheetos	Swing, iPads Movie, and Toy-bus
3	H.Z.	Clinical; Assessment room and play ground	Gluten-free chips, Gluten-free brownies, and juice	Movie, spin-chair, and swing
4	C.W.	Home; Living room	Sugar-free Gummy, raisins, and strawberries	Ring, Slinky, and Koosh-ball

Table 4: Implementation Settings and Preferred Items

Independent And Dependent Variables

This study was primarily aimed at understanding the effectiveness and preference for a specific speech output in children with autism. In order to measure the preference for specific speech output, two Tech/ Talk® from Advance Multimedia Devices Inc (AMDI) and two Big-Mack® single-switch communication devices were programmed to generate communicative requests in either digitized or synthetic speech output. Tech/Talk device is designed to deliver eight different messages. The water resistant membrane front panel can be activated with light-touch and square pictures size of 2.75in can be used. External speakers along with record jacks are providing increased flexibility to program messages in either digitized or synthetic format. Similarly, big-Mack devices can be programmed to generate communicative requests in both digitized and synthetic speech outputs. Communicative requests were programmed in a sentence format (e.g., May I have preferred item, please?) to give ample time for participants to understand the underlying differences between digitized and synthetic speech in terms of intonation, prosody and the quality of speech. Further, communicative statements with punctuations (e.g.,?) were selected to give them opportunities to differentiate speech outputs in terms of intonations and prosody. Speech-generating device that generates synthetic speech was programmed by using Microsoft speech synthesis engine®. The voice output responses were played at the rate of 115 words per minute (WPM), and with a constant pitch rate of 15. Microsoft speech synthesis engine with the default female voice was particularly chosen because of its robotic quality and to facilitate speech discrimination in selected participants. In order to program synthetic speech output in the TechTalk and Big-

Mack speech-generating devices, first, the communicative request statements of the preferred items (e.g., May I have Gummy, please?) were created in textual format using a software called Kurzweil-1000®. Later the created texts were converted in to speech using Microsoft® speech synthesis engine and saved in MP3 files. The MP3 files were played using Windows media player® and directly and manually recorded into the selected devices. Device that generated digitized speech output was programmed with human voice at a constant intensity level with normal speech rate (SPR). Female therapists who provided instruction on a given day programmed the selected device with their voice. If male therapists were selected to provide instruction then, one of the female therapists working in the clinic were allowed to program the device with their voice. This step was taken to ensure that both of the devices were programmed to provide speech outputs in female voice.

Three dependent measures were collected in-order to understand the preference for a device with specific speech output and the difference in the rate of acquisition across two types of speech output. (a) Percentage of correct responses, (b) number of trials taken to reach mastery criterion, and (c) percent of time a device with specific speech output selected.

Collecting data on percentage of correct responses helped in understanding whether participants had previous training in using SGDs. In addition, collecting this data was helpful in demonstrating the effectiveness of intervention in teaching basic-level communicative requests. Data on percentage of correct responses were collected in all the sessions across all the phases.

To calculate the percentage of correct responses, four types of responses were recorded. Independent response, verbal and or gestural prompt, physical prompt, and no response. An independent response was recorded when the participant requested an item by pressing the correct panel on the Tech/Talk® or by pressing the Big-Mack communication device within 10 seconds after the presentation of the item without any prompt. A verbally prompted or gesture modeled responses were recorded when the child requested an item within 10 seconds after the delivery of the verbal prompts such as pointing to the picture on a Tech/Talk or Big-Mack device and or verbally prompting the child to touch the right panel (e.g., touch gummy). A physically prompted response was recorded when the child requested an item after the delivery of physical prompt by the trainer such as touching some parts of the child's elbow, wrist, or hand to guide the response of pressing the right location on a given device. A no response was recorded when the child did not respond within the 10 seconds after delivery of prompts.

For each participant, data was collected on number of sessions, trials taken to reach the criterion to compare the acquisition rates using device with each speech output. Finally, for participants, data was collected on percentage of the times device with specific speech outputs were selected for use at the beginning during the choice assessment probe sessions.

Observational Measures

When an opportunity for requesting was initiated by the trainer during the session, the investigator recorded the child's type of response (i.e., independent response, prompted, and no response). Real-time data was collected for all the sessions using a data-sheet and this data-sheet included columns in which investigator recorded whether the response was independent, what kind of prompting were provided to initiate request, and the types of behavior child enacted. In addition, data on the type of speech output selected by the child was recorded during baseline, and choice assessment probe sessions. The responses were recorded on data-sheets as independent, prompted (i.e., verbal, gestural, full physical, partial physical), and no response so as to calculate percentage of correct responses (see appendix). Percentage of correct responses was calculated for each session and it involves maximum of block of 10 trials. Percent of correct requesting was calculated by summing up the total number of independent responses divided by the total number of trials in that session, and multiplying the calculated number by 100. The obtained data was graphically plotted for each participant. The number of trials required for each participant to reach the mastery criterion (e.g., 60% of trials performed correctly for three consecutive 10 trial sessions) was calculated to compare the speed of acquisition for each speech output condition. Only independent responses were taken into consideration to calculate percent of correct responses towards mastery criterion.

Experimental Design

A single subject, alternating treatment design was used to conduct this study. Aiming at understanding the individual differences in child's performance, Single subject design (Harsens & Barlow, 1976) was chosen. Further, single subject design is most appropriate when a study involves intensive treatment with limited number of participants.

This study involves exposing participants to two different treatment conditions namely digitized and synthetic speech and understanding the individual differences in terms of preference and acquisition. In an alternating treatments design, each participant serves as his own control and can be exposed to two or more treatment conditions in an alternating fashion. In this study, investigator was interested in understanding the relative effectiveness of two speech outputs in a short period of time. Specifically, investigator was interested in determine whether the children would show different rates of acquisition behavior using two speech outputs, and to see whether they would show preference for one type of speech output over another. The order of treatment schedule within sessions was alternated in an AB AB design to get the treatment sequences equal in number. Interventions were introduced only after the baseline and the choice assessment probe sessions were introduced only after the mastery criterion was met. Once a child reached the mastery criterion, the study continued to identify child's preference for a specific speech output. In-order to control the order effects; the order of the introduction of an item was varied for each session and for each day of the instruction. Further, positioning bias was controlled by systematically varying the position (left-hand side or right-hand side) positioning of a device with specific speech output.

Procedural Outlook

PREFERENCE ASSESSMENT

The selected children were trained to use speech-generating devices in two sets of activities namely snack time and play time. In-order to identify the training items for snack time, first participants' parents and therapists were requested to identify minimum of 6 preferred snack items. Once possible snack items were identified, participants were allowed to choose the snack items they prefer. In-order to evaluate the participants' preference for a snack item, paired-choice preference assessment (Fisher, Piazza, Bowman, Hagopian, Owens & Slovin, 1992) was conducted. Based on this preference assessment protocol, two snack items were presented to participant at given time and the selected item was recorded. A Combination of two snack items was presented in a randomized sequence. Possibilities for position bias were controlled by systematically varying the side (e.g., left or right) in which the item was presented. The selection of a snack item was indicated by which item the participant touched first. If the participant touched and selects a particular snack item, the other item was removed and the participant was given access to the small portion of the snack item. If the participant did not touch either of the items within five seconds of presentation, both of the items were removed and the next pair of snack items was presented. If the participant touched both of the items, both items were removed and were presented again after 10 seconds. The snack items that were selected by the participant were added in total to determine the over-all preference. Snack items identified in the preference assessment were ranked from most to least preferred and the first three highly-ranked preferred items were used for instruction. Similarly, a second paired-choice assessment was conducted to identify the preferred play items using the same protocol. Initially parents and therapists were requested to come-up with a list of 6 preferred play items for each participant. Using the same paired choice preference assessment protocol (Fisher et al., 1992), the preferred play items were determined and ranked from most to least and the highly-ranked first three preferred play items were used for instruction. In the play item preference assessment, if the participant selects a particular play item, then he/she was provided access to the play item for 30 seconds.

BASELINE

During the baseline session, the child was seated in front of a desk across from the therapist. The therapist initiated communication by saying that it was time to have snack or play and provided an opportunity for a communicative request by showing / pointing towards the most preferred item. Each session typically involved 10 requesting opportunities (i.e., trials) and lasted approximately 15 minutes; although the length of the session and the number of trials varied depending on the participants' level of challenging behaviors (e.g., elopement) and factors such as individualized therapeutic goals and other requirements. Typically, two sessions (i.e., both devices with play and snack sessions) were conducted per day. Depending on a given session (i.e., play / snack), the preferred item was placed within the view of the participants but out of reach. Devices with both digitized and synthetic speech outputs were placed within the reach of the participants in each condition. The therapist allowed 10 seconds for the child to see whether he can initiate request by pressing the right panel on either one of the devices. Children were given access to the item on requests by using pre-linguistic forms of communicative repertoires such as reaching, pointing or other behavioral indications (Drasgow, Halle, Ostrosky, & Harbers, 1996). No prompts or model behaviors were given during baseline phase.

SGD TRAINING

The Children were provided with a SGD with the targeted speech output during the routine. At the beginning of each session, child participants were allowed to freely explore the device (e.g., pressing the panel, and listening to messages) approximately for two-minutes. The participants were taught to use SGD during 15-minute training sessions, and two to four times per week. SGD training continued until the targeted participant reach mastery criterion (i.e., 60% or higher independent responses for three consecutive sessions). The children learned to press the right panel on a given device and the therapist subsequently provided access to preferred item as reinforcement. An appropriate requesting behavior (i.e., pressing the right panel) resulted in access to the targeted item. If no attempt to request the object was made or attempting to make requests using inappropriate behaviors (e.g., banging on the device, touching wrong panel) resulted in therapist prompting the child to use the SGD. SGD use was taught using most-to-least prompting hierarchy (MTL). This prompting hierarchy included four prompting levels: Full physical (i.e., hand-overhand), partial physical (i.e., hand on the participant's upper-arm or light-touch and or shadow by the elbow), verbal and or gestural prompt (i.e., pointing the right panel, or ask the participant to touch the picture of the preferred item), and no response. The criterion for reducing the prompt level was two consecutive correct responses at designated prompt level. Two consecutive errors resulted in increasing the intrusiveness of the prompt level.

SPEECH OUTPUT CHOICE ASSESSMENT PROBE

Following the SGD training, post acquisition session was conducted to assess the children's preference for speech outputs. No teaching procedures were implemented during the post-acquisition session. Participants were presented with repeated opportunities to request an item when given two identical SGDs with two different speech outputs to request the snack or play item. The number of times the device with a specific speech output selected was recorded at each session. The speech output selected more frequently was presumed to be more preferred over the less frequently selected speech output.

Inter-Observer Agreement

Two graduate students served as independent observers and coded reliability data of 40% from videotapes of all the sessions. Prior to data-recording, operational definitions of the dependent variables that need to be scored and observation procedures were provided to the observers. Observers provided with opportunities to practice recording procedures by watching videotapes with the investigator. During the reliability sessions, both observers recorded the type of responses (i.e., independent, prompted, no response) for all the participants on a trial-by-trial basis. The data collected by the observers were compared with those real-time data collected by the investigator. An agreement was calculated when the two observers agreed on occurrence or non-occurrence of a response. Any discrepancy in scoring between the observers resulted in disagreements. For instance, in-order to achieve agreements during training sessions, observers had to agree on percent of independent responses, levels of prompts provided and the type of the speech output selected. A percentage of agreement was calculated at the end of each observational session using a formula: agreements / agreements + disagreements * 100. Inter-observer agreement (IOA) across each condition of the study for participants 1, 2, 3, and 4 is summarized in table 5.

Description	P1 (B.L.)	P2 (D.L.)	P3 (H.Z.)	P4 (C.W.)
Total No of Snack Sessions	6	7	18	8
Total No of Snack Trials	51	43	180	75
Total No of Play Sessions	8	6	22	10
Total No of Play Trials	69	38	220	91
No of Trials IOA Data Collected With %	36 (30%)	40 (50%)	110 (28%)	90 (54%)
% of IOA- Average	100%	100%	97%	98%
Range	--	--	80-100%	90-100%

Table 5: Inter-observer Agreement

P=Participant

Treatment Integrity

Two trained graduate student observers collected treatment fidelity data for 40% of sessions for each participant. Prior documenting the treatment fidelity, observers were provided with instructions on procedural steps for baseline, treatment and choice assessment conditions. After receiving the instruction, observers recorded therapist behaviors including: (1) initiation of requesting opportunities, (2) amount of time provided for the participant to respond, (3) whether the therapist provided designated amount of prompt, and (4) whether the reinforcement was contingently delivered (See appendix). Observers provided their responses by stating “Yes”, “No”, or “N/A” (Not applicable). By calculating the percent of “Yes” responses agreements obtained and calculation of “No” responses resulted in disagreements. Treatment fidelity data were collected for 40% of sessions for each participant. The column labeled for each participant display the percentage of “Yes” responses for participant 1 to 4 and averaged across each condition of the study (see Table 6).

Phase	P1	P2	P3	P4
Baseline	100%	100%	100%	100%
Treatment	N/O	N/O	91%	98%
Choice assessment probe	100%	99%	N/O	100%
Average	100%	99.5%	95.5%	99%

Table 6: Treatment Integrity

N/O= not obtained; P=participant

Social Validity

One of the purposes of this study is to understand whether the intervention was effective enough to implement in future, and whether there was any difference in the perceived social validity across two types of speech output. In-order to measure the effectiveness of intervention and the acceptability of techniques, parents and teachers of the selected participants were asked to complete a questionnaire. This questionnaire primarily covered areas such as parents and teachers impression about participants' communicative ability after the intervention, and their impression with regard to acceptability of speech outputs across different setting. Investigator convened a 15-minute face-to-face meeting with parents and teachers to obtain social validity measures. During this meeting, parents and teachers were introduced to the definitions of digitized and synthetic speech. Parents and teachers of the participants were allowed to watch speech output samples from external resources in order to help them to understand the underlying differences between digitized and synthetic speech in terms of intelligibility, prosody and intonation. After allowing them to watch speech samples, parents and teachers of each participant were allowed to watch performance of the child from a randomly selected two videotaped baseline sessions and two videotaped choice assessment probe sessions. After introducing parents and teachers to speech samples and individual videotape sessions, social validity questionnaire was distributed to them. If parents and or teachers preferred to complete at their convenience, social validity questionnaires along with other materials (speech samples, videotaped sessions of their children) were provided in electronic format.

Data Analysis

This study primarily used visual analysis to compare the performance of each participant during baseline, treatment, and choice assessment probe involving digitized and synthetic speech output. Visual analysis of graph figures that contained the percentage of correct responses across sessions was used to compare the effectiveness of digitized and synthetic speech output. Average percentage was calculated for each speech output and total number of training trials taken to reach the mastery criterion was calculated for each participant to find the effectiveness of specific speech output. The percent of speech output chosen during the choice assessment probe was calculated to find preference for speech output. Finally, social validity measures on acceptability, generalizability, and effectiveness were evaluated by qualitatively analyzing the responses obtained from the therapists and the parents.

CHAPTER IV: RESULTS

The purpose of the study was to compare the effects of digitized and synthetic speech outputs for teaching basic level communicative requests to four young children diagnosed with autism. The following sections describe the results of the study in-terms of the effects of intervention by individual results. Data was collected from four young non-verbal children diagnosed with autism on the acquisition of the requesting skills. In-order to reach the mastery criterion for skill acquisition, selected participants required to use the device with a given speech output independently over 60% of the time for three consecutive sessions during the treatment condition. In addition, the preference for one speech output over other was determined by comparing the two speech outputs (i.e., digitized and synthetic) in-terms of percent of time a device with specific speech output selected. After the completion of the study, social validity measures were collected from a group of four therapists associated with the selected participants.

Individual Results

Individual results for each participant are graphically presented in figures 1 through 9. In the provided figures, the circle represents the data obtained from digitized speech and triangle represents the data obtained from synthetic speech conditions.

PARTICIPANT 1

Figure 1 illustrates independent requesting responses emitted by participant 1 across baseline and speech choice assessment probe conditions. Participant 1 participated in a total of 14 sessions (8 play sessions and 6 snack sessions) and 120 trials (69 trials in play sessions and 51 trials in snack sessions). In the first few trials of the first session, participant 1 did not emit any correct response. However, he quickly learned to associate the picture of the preferred item with the actual item and started making independent requesting responses without any training. In the baseline condition itself, participant 1's independent requesting responses increased from 66.5% to 100%. During the choice assessment sessions 4 through 14, he maintained the full level of mastery in using SGD.

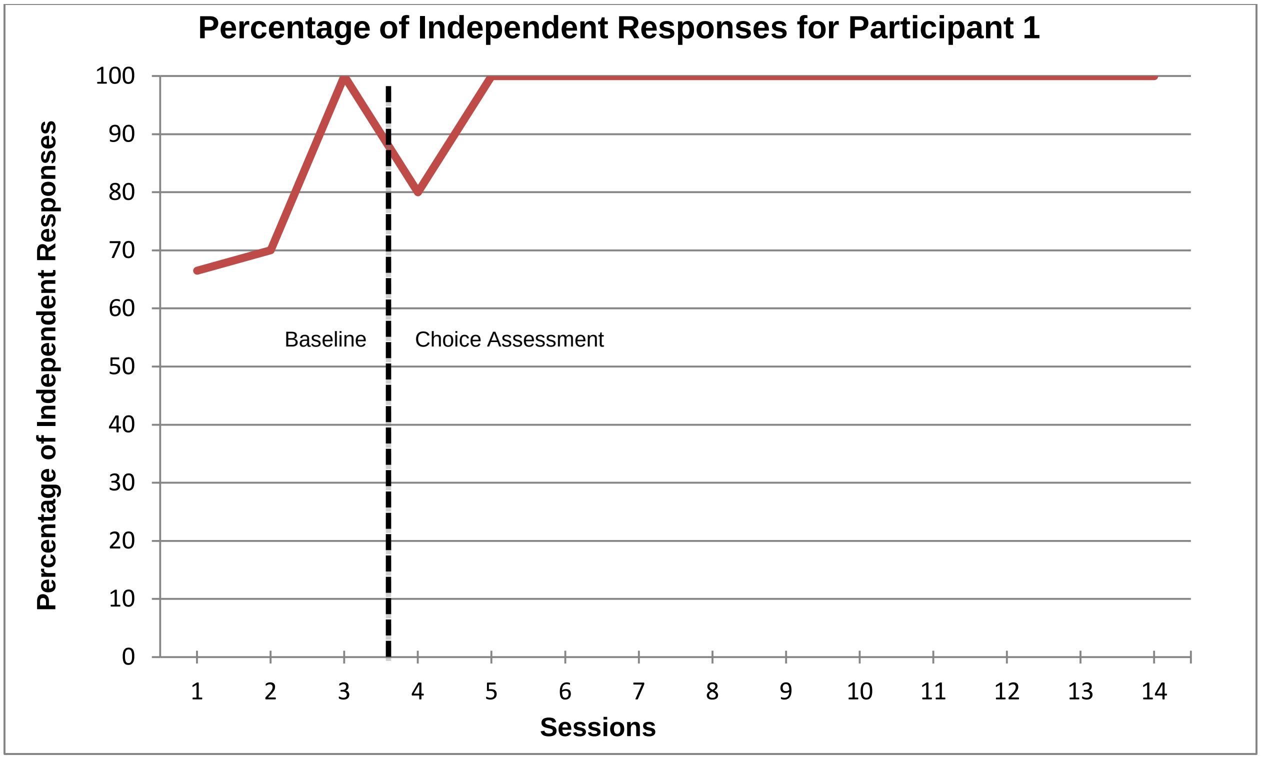

Figure 1: Percentage of Independent Responses for Participant 1

Speech output choice made by the participant 1 was graphed for sessions 4 through 14 (i.e., 11 sessions in total). Figures 2 and 3 illustrate the percentage of correct responses for each speech output and percent of speech selected during the sessions, respectively. In figure 2, Visual inspection of the data-path from sessions 1 through 11 revealed that participant 1 was showing a preference for synthetic speech output in majority of the sessions to make basic level communicative requests. Out of 11 sessions, 7 sessions (64.0%) have shown that participant 1 is making higher percent of independent responses using synthetic speech output. In 2 sessions (18.0%), he showed preferences for digitized speech output over synthetic speech output and in the remaining 2 sessions, he selected each speech outputs for comparable number of times. Totally, speech preference assessed for 91 trials and he preferred to use synthetic speech output for 64 trials (70%) and digitized speech output for 27 trials (30%).

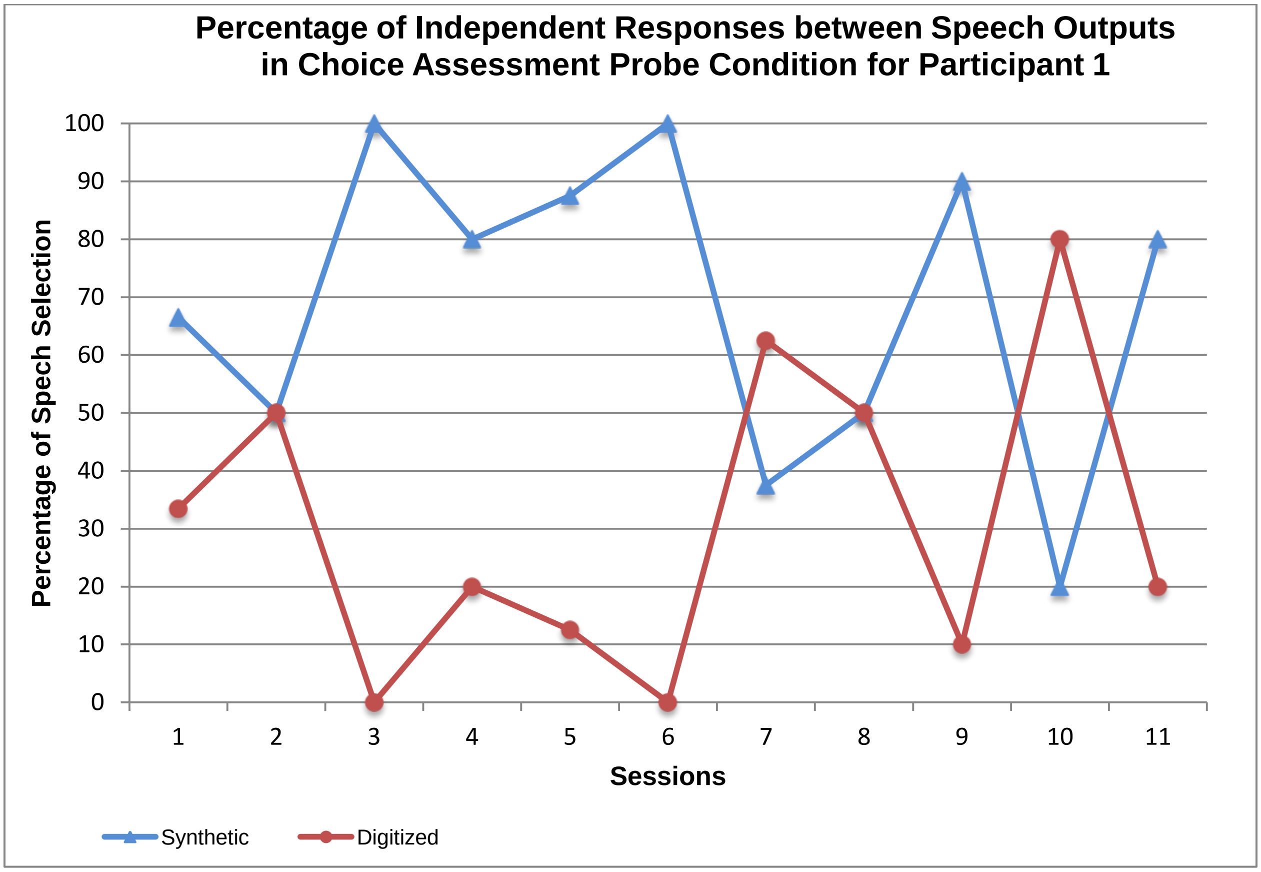

Figure 2: Percentage of Independent Responses between Speech Outputs in Choice Assessment Probe Condition for Participant 1

In-order to understand whether there is any positioning bias for participant 1, the presentation of the devices with a specific speech output was systematically controlled. In figure 3, visual inspection of the bar diagram from sessions 1 through 11 revealed that participant 1 was indicating a clear preference for synthetic speech output to make his communicative requests. Out of 11 sessions, digitized-speech output device was placed on the right side of the participant for 6 sessions (i.e., 53 trials) and synthetic speech output device was placed on the right side of the participant for 5 sessions (i.e., 38 trials). When digitized speech output device was placed on the right side, he chose to select synthetic speech output device for 43 trials (81%). When the synthetic speech output device was placed on the right side, he chose to select synthetic speech output device for 21 trials (55%).

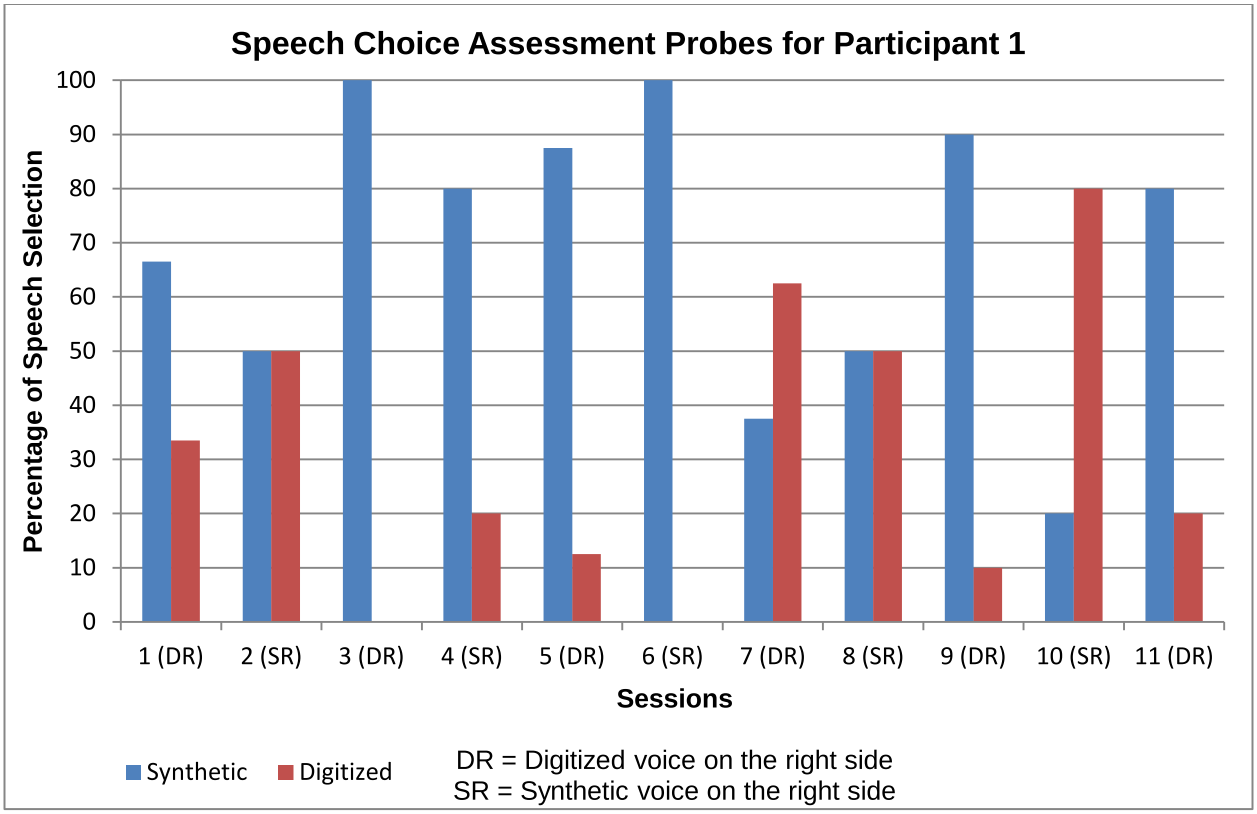

Figure 3: Speech Choice Assessment Probes for Participant 1

PARTICIPANT 2

Figure 4 illustrates independent requesting responses emitted by participant 2 across baseline and speech choice assessment probe conditions. Participant 2 participated in a total of 13 sessions (6 play sessions and 7 snack sessions) and 81 trials (38 trials in play sessions and 43 trials in snack sessions). Similar to participant 1, in the first few trials of the first session, participant 2 did not emit any correct response. However, he quickly learned to associate the picture of the preferred item with the actual item and started making independent requesting responses without any training. In the baseline condition itself, participant 2's independent requesting responses increased from 60% to 90%. During the choice assessment sessions 4 through 13, participant 2's percent of independent responses were slightly fluctuating due to severe behavioral challenges (e.g., elopement, and poor motivation). However, he maintained his level of mastery of making more than 60% of independent responses for almost all the sessions except session 11.

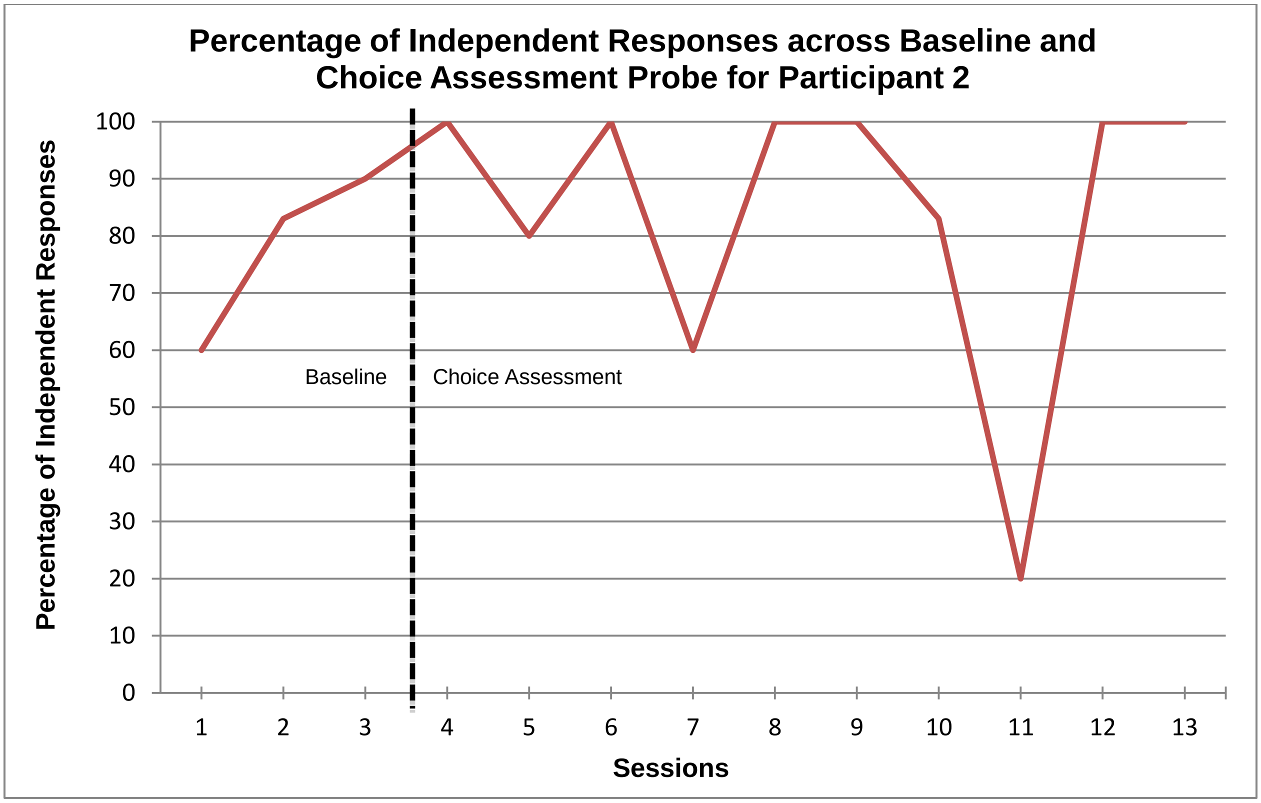

Figure 4: Percentage of Independent Responses across Baseline and Choice Assessment Probe for Participant 2

Speech output choice made by the participant 2 was graphed for sessions 4 through 13 (i.e., 10 sessions in total). Figures 5 and 6 illustrate the percentage of correct responses for each speech output and percent of speech selected during the sessions, respectively. In figure

5, Visual inspection of the data-path from sessions 1 through 10 revealed that participant 2 was showing a preference for digitized speech output over synthetic speech output in majority of the sessions to make basic level communicative requests. Out of 10 sessions, 6 sessions (60%) have shown that participant 2 is making higher percent of independent responses using digitized speech output. In 2 sessions (20%), he showed preferences for synthetic speech output over digitized speech output and in the remaining 2 sessions, he selected each speech outputs for comparable number of times. Totally, speech preference assessed for 62 trials and he preferred to use synthetic speech output for 20 trials (32.5%) and digitized speech output for 42 trials (67.5%).

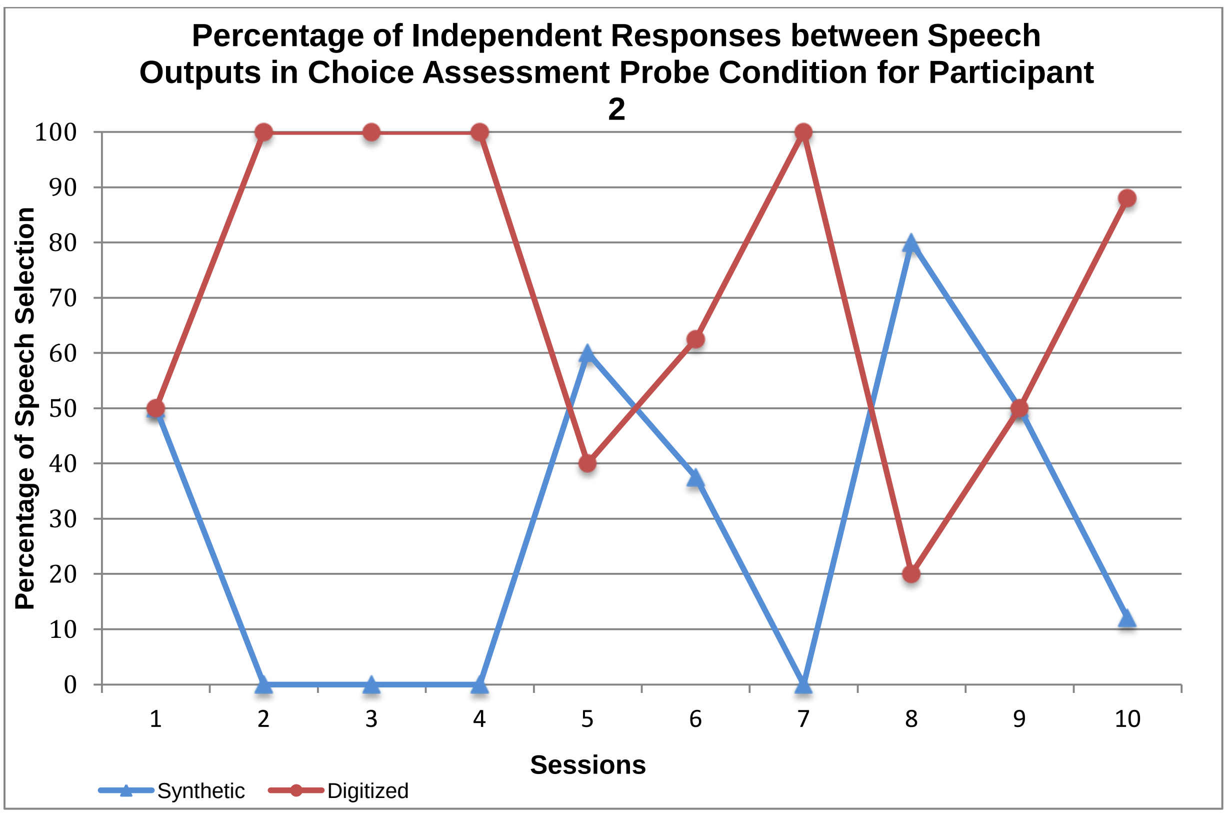

Figure 5: Percentage of Independent Responses between Speech Outputs in Choice Assessment Probe Condition for Participant 2

In-order to understand whether there is any positioning bias for participant 2, the presentation of the devices with a specific speech output was systematically controlled. In figure 6, visual inspection of the bar diagram from sessions 1 through 10 revealed that participant 2 was indicating a better preference for digitized speech output to make his communicative requests. Out of 10 sessions, digitized-speech output device was placed on the right side of the participant for 5 sessions (i.e., 31 trials) and synthetic speech output device was placed on the right side of the participant for 5 sessions (i.e., 31 trials). When digitized speech output device was placed on the right side, he chose to select digitized speech output device for 19 trials (61%). When the synthetic speech output device was placed on the right side, he chose to select digitized speech output device for 23 trials (74%). Participant 2's choice assessment sessions were cut short because the parents decided to terminate the therapeutic services that they were receiving from the clinic and opted home-based therapy.

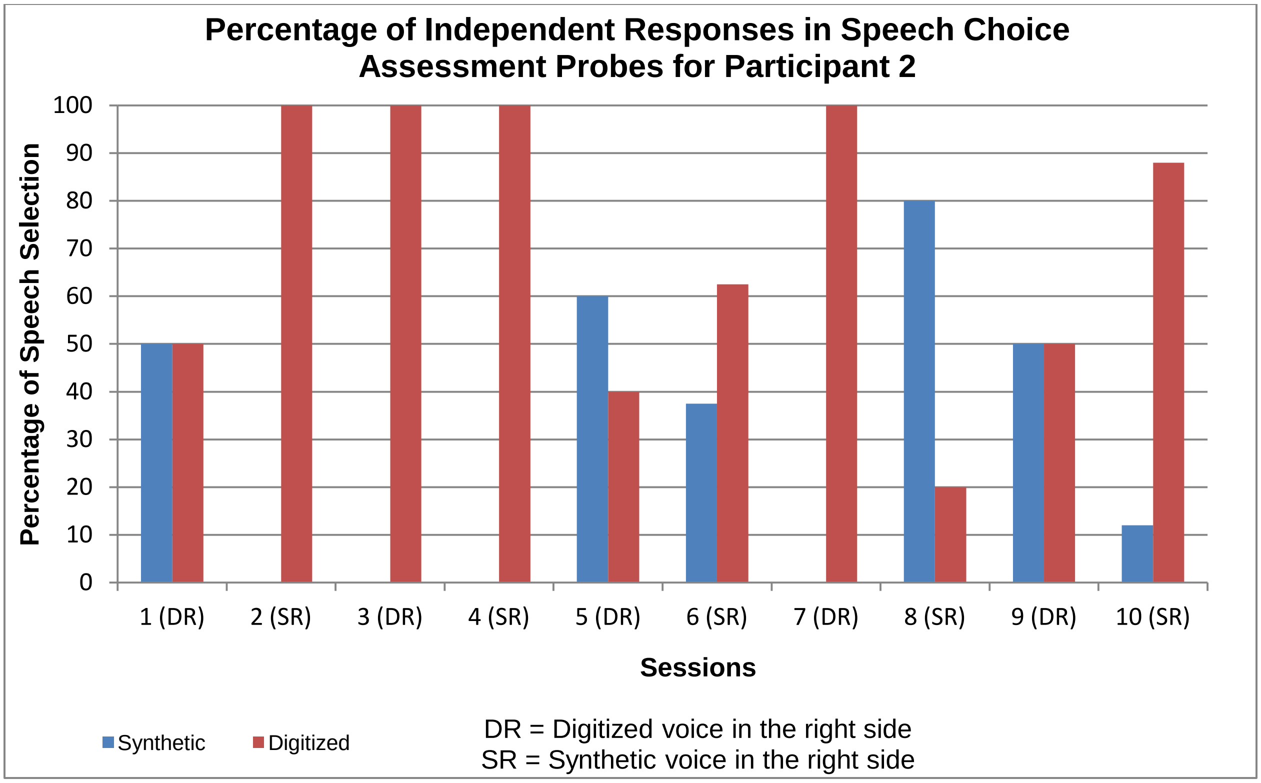

Figure 6: Percentage of Independent Responses in Speech Choice Assessment Probes for Participant 2

PARTICIPANT 3

Figure 7 illustrates participant 3's acquisition rates across baseline and treatment condition. Participant 3 participated in a total of 40 sessions (22 play sessions and 18 snack sessions). He participated in a total of 400 trials (220 trials in play sessions and 180 trials in snack sessions). Figure 7 shows a graphical representation of independent requesting responses emitted by participant 3. During baseline, he emitted no correct responses, even though he engaged in certain pre-linguistic forms of communicative behavior such as reaching for preferred items, grabbing, and or engaging in severe bruxism. In alternating acquisition-training sessions 5 through 40, participant 3’s independent requesting responses were slowly increasing but it was highly fluctuating. In SGD training sessions 5 through 40, participant 3’s independent requesting responses were increased from 0% to 50% in training sessions with the device with digitized speech output and 0% to 10% in training sessions with the device with synthetic speech output. Visual inspection of the data from session 5 through 40 revealed differences of digitized and synthetic speech output data paths, with digitized speech output training producing higher percentage of independent requesting responses. Using the original mastery criteria of manding at 60% or higher percent of independent responses for three consecutive sessions, it was determined that participant 3 had not fully mastered the skill to make basic level communicative request by using the speech-generating device. Considering factors such as failure in surpassing the mastery criteria, failure in maintaining the acquired skill repertoire, and some health-related reasons, choice assessment probes with participant 3 had not been conducted.

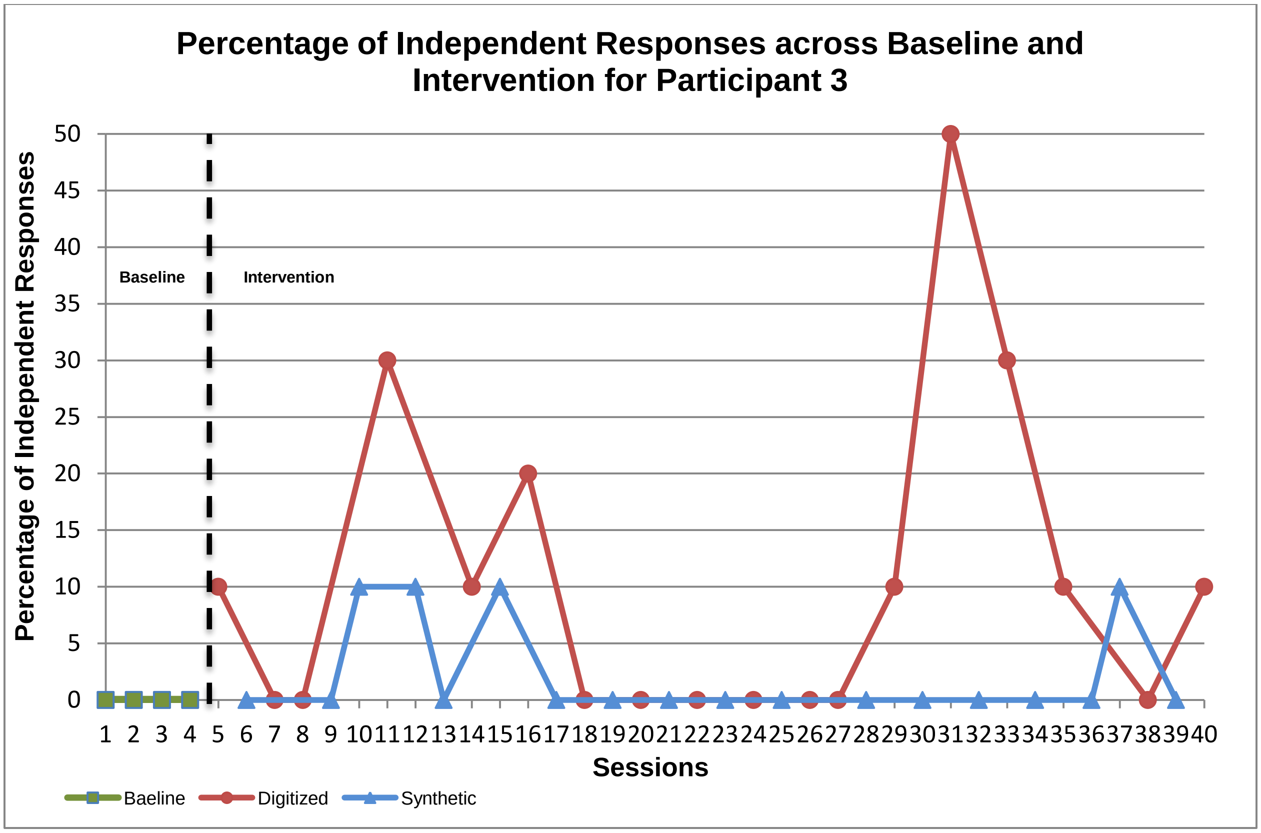

Figure 7: Percentage of Independent Responses across Baseline and Intervention for Participant 3

PARTICIPANT 4

Figure 8 illustrates participant 4's acquisition rates across all the three contexts i.e., baseline, intervention and speech output choice assessment probe. He participated in a total of 18 sessions (10 play sessions and 8 snack sessions), and in a total of 166 trials (75 snack trials and 91 play trials). Figure 8 shows a graphical representation of independent requesting responses emitted by participant 4. During baseline, he accidentally emitted 1 correct response (10%) on one session, and he emitted no correct responses in other baseline sessions. However, he engaged in pre-linguistic forms of communicative behavior to gain access to the preferred items. In alternating acquisition training sessions 5 through 14, participant 4's skill acquisition was really rapid and it increased from 10% to 100%. Visual inspection of data in sessions 5 through 14 revealed a slight difference of digitized and synthetic speech output training data-paths, with digitized speech output producing higher percentage of independent requesting responses. Using the original mastery criteria of manding at 60% or higher percent of independent responses for three consecutive sessions, it was determined that participant 4 was fully mastered the skill to make basic level communicative request by using the voice output device. Considering the rapid skill acquisition and maintenance, choice assessment probes were conducted with participant 4, in-order to understand his preference for a specific speech output.

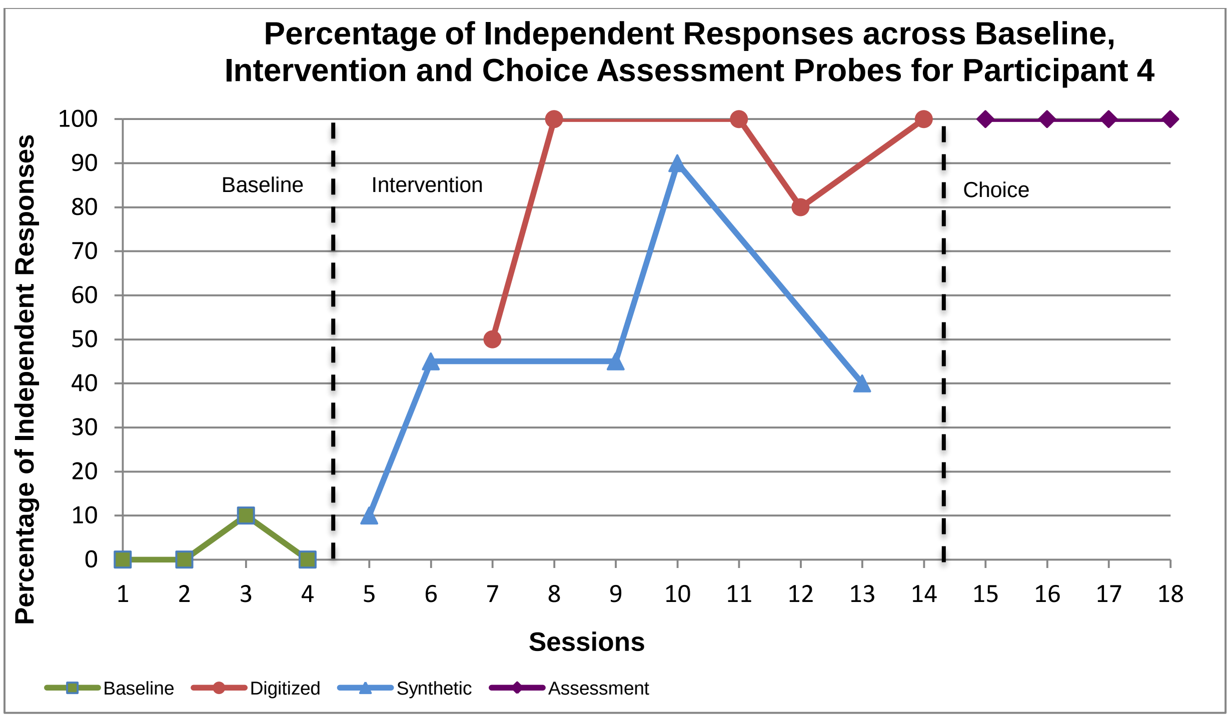

Figure 8: Percentage of Independent Responses across Baseline, Intervention and Choice Assessment Probes for Participant 4

In-order to understand whether there is any positioning bias for participant 4, the presentation of the devices with a specific speech output was systematically controlled. In figure 9, visual inspection of the bar diagram from sessions 1 through 4 revealed that participant 4 was not indicating a clear preference for either digitized or synthetic speech outputs to make his communicative requests. Out of 4 sessions, digitized-speech output device was placed on the right side of the participant for 2 sessions (i.e., 20 trials) and synthetic speech output device was placed on the right side of the participant for 2 sessions (i.e., 20 trials). When digitized speech output device was placed on the right side, he chose to select digitized speech output device for 100% of times. When the synthetic speech output device was placed on the right side, he chose to select synthetic speech output device for 100% of times. Participant 4 clearly indicated a bias for devices positioned on his right side. Several efforts were made to assure that there were no problems in device positioning and the intervention delivery. For instance, participant 4 was allowed to walk and or stand and press either one of the devices to make his communicative requests. Intervention delivery positions of the therapist were also altered to see whether it was contributing towards his positioning bias.

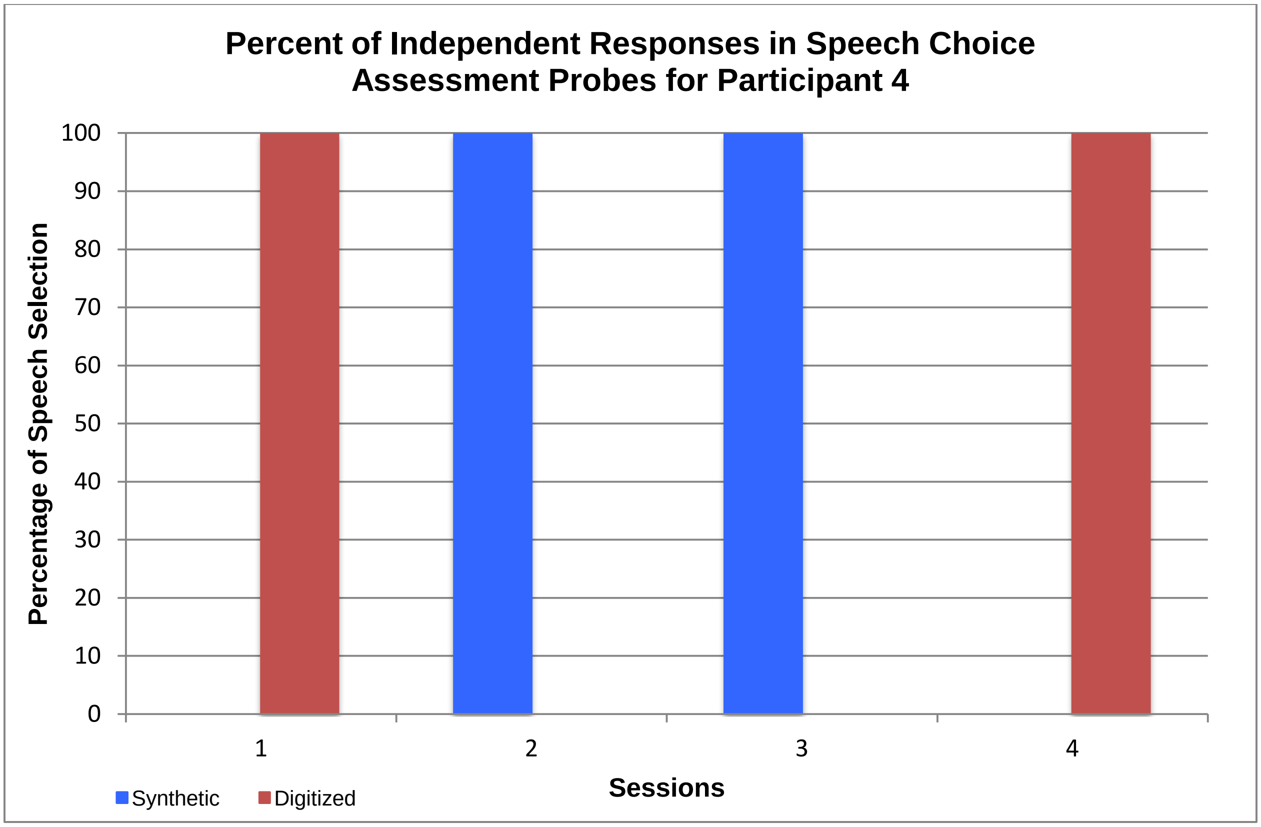

Figure 9: Percent of Independent Responses in Speech Choice Assessment Probes for Participant 4

Research Questions And Findings

RESEARCH QUESTION #1

Are there differential effects of SGD training using digitized and synthetic speech output on the acquisition of requesting skills?

The first research question was examined whether or not, there are differences in the acquisition of communicative requesting skills existed between SGD training using digitized and synthetic speech outputs. The measure of acquisition of the requesting skills was determined by the average percentage of correct and the number of trials taken by the participants to meet the mastery criterion. In-order to accomplish the mastery criterion; the selected participants must perform at the 60% accuracy level for three consecutive sessions. The average percentage correct and the number of trials required to reach the mastery criterion were compared between two SGD training conditions (i.e., digitized and synthetic speech output conditions). Based on the data available, it is not possible to predict the differences in the acquisition of communicative requesting skills between SGD training using digitized and synthetic speech outputs for participants 1 and 2. Each speech output showed differences in the rates of acquisition between participants 3 and 4, and both participants 3 and 4 showed differences in rates of acquisition between digitized and synthetic speech outputs. Participants 3 and 4 produced more independent requesting responses during the training with digitized speech output. Even though participant 3 produced more independent requesting responses during the training sessions with digitized speech output, his failure in reaching the required level of accuracy prevented the investigator in determining the range of number of trials to reach the mastery within digitized speech output condition. Participant 4's skill acquisition in the digitized speech output condition was really rapid and he took 40 trials to reach the full mastery criterion. A follow-up and a generalization probes were conducted a week after the choice assessment probes and he performed at the accuracy level of 100 percent with untrained preferred snack and play items and with untrained persons as well.

RESEARCH QUESTION #2

Do children show a preference for one speech output over other?

Speech choice assessment probes were conducted immediately after participants reached the mastery criterion. For participant 1, speech preference assessed for 91 trials and he preferred to use synthetic speech output for 63 trials (69%) and digitized speech output for 28 trials (31%). For participant 2, speech preference assessed for 62 trials and he preferred to use synthetic speech output for 20 trials (32.5%) and digitized speech output for 42 trials (67.5%). Participant 3's failure in reaching the required level of accuracy prevented the investigator from conducting speech output choice assessment probes with him. For participant 4, speech preference assessed for 40 trials and he preferred to use synthetic speech output for 20 trials (50%) and digitized speech output for 20 trials (50%). Participant4's positioning bias prevented the investigator from deriving a clear preference for a specific speech output. Based on the available information, it is not possible to predict a pattern between the skill acquisition and the speech output choice.

RESEARCH QUESTION #3

Are there any differences in perceived social validity of digitized vs. synthetic speech outputs?

One of the purposes of this study is to understand whether the intervention was effective enough to implement, and whether there is any difference in the perceived social validity across two types of speech output. In-order to measure the effectiveness of intervention and the acceptability of speech outputs, parents and teachers of the selected participants were requested to complete a questionnaire. Four therapists and a legal guardian associated with the selected participants expressed their consent to complete the social validity questionnaire. Only Four therapists completed the questionnaire, and due to some extenuating medical reasons, the legal guardian did not participate in the study. This social validity questionnaire was descriptive in nature, and it primarily covered areas such as parents and teachers impression about participants' communicative ability after the intervention, and their impression with regard to acceptability of speech outputs across different setting.

Considering the nonverbal characteristics of the selected participants and the difficulties experienced by the participants in acquiring and maintaining the sign and PECS in the past, all the four therapist participants agreed that using SGD is an appropriate strategy to improve their student's communicative repertoires. All the four therapists observed that this SGD intervention improved their student's ability to make independent requests, and one therapist in particular observed that this intervention increased his student's ability to make eye-contacts with his communication partner.

All four therapists agreed that it is very vital to have proper training and guidance prior teaching a child to use speech-generating devices. One therapist in particular, emphasized the need for having SGD training to understand the exact topographies accepted as an independent mand, and to learn the proper use of prompt fading techniques and errorless learning strategies.

There was no consensus regarding the role of speech outputs in teaching basic level communicative requests, and the acceptability of speech outputs in different settings. One therapist participant underscored the need for selecting the speech outputs and act in the best interest of students. Another therapist maintained that speech output is not an important component in the device selection. All the four therapists did not indicate a preference for any speech outputs. Three therapist participants indicated personal preference for iPads® to teach basic level communicative requests, and these favored responses for iPads were based on social acceptability, generalizability and sophistication. Possible explanations for these results will be discussed in the discussion section.

CHAPTER V: DISCUSSION AND CONCLUDING COMMENTS

The primary purpose of this chapter is to discuss the findings of this study. The primary goal of this study is to examine the effects of SGD training using digitized vs. synthetic speech outputs on the acquisition of requesting skills of 4 non-verbal children diagnosed with autism. The investigator addressed the following research questions. First, are there differences in acquisition rates for requests taught using digitized vs. synthetic speech outputs? Second, do children show a preference for one speech output over other? Finally, Are there any differences in perceived social validity of digitized vs. synthetic speech outputs? Given the differences in the acoustic nature of these speech outputs (e.g., prosody, intonation), differences in the rates of acquisition and differences in-terms of individual preference have been expected.

This chapter will first address the results of this study with respect to each of the three research questions. Second, this chapter will elaborate limitations, and practical implications of the study. Third, this chapter will offer some recommendations for future research and clinical practice. Finally, this chapter will end with some concluding remarks.

The primary goal behind the first research question is to understand whether there is any difference in the rate of acquisition in the requesting responses between two types of speech outputs. For the purpose of understanding differences in the rate of acquisition across individual participants, two relevant dependent measures were collected and analyzed. First, percentage of correct responses were collected and visually analyzed to understand selected participant's progress in the intervention. Second, trials taken to reach the mastery criterion were also analyzed to predict the differences in the rapidity of skill acquisition across two speech output conditions.

Dependent measures with respect to the rate of skill acquisition were not obtained from participants 1 and 2 because of the percent of correct responses they made, and the level of mastery that they demonstrated during the baseline condition. A visual analysis of data (i.e., number of trials to mastery and average percent correct responses) obtained from participants 3 and 4 displayed a better rate of acquisition in training using SGD with digitized speech output. Additionally, the rapidity of skill acquisition differed across participants 3 and 4. However, it is really hard to draw a conclusion that one type of speech output produced better results with these two participants because participant 3 did not reach the mastery criterion and participant 4’s performance appeared slightly better in digitized speech output but the differences in the performances between speech outputs were not significant enough to claim that one speech output is better than the other. So these results need to be replicated with more children with similar characteristics, in-order to draw a firm conclusion.

Previous research has emphasized the role of speech outputs in facilitating the skill acquisition in individuals with autism. For instance, studies have been conducted to understand the effectiveness of synthetic speech output (e.g., Parsons & La Sorte, 1993; Schlosser, Blischak, Belfiore, Bartley, & Barnet, 1998; Schlosser & Blischak, 2004), and digitized speech output (Sigafoos, Didden & O’Reilly, 2003) For teaching skills such as basic level communicative requests, and spelling to individuals with ASD. The present study extended this literature by directly comparing digitized vs. synthetic speech outputs. This study is the first direct comparison between digitized vs. synthetic speech output for teaching basic level communicative requests to non-verbal children with autism.

The primary goal behind the second research question is to understand whether the selected participants can indicate their preference for a specific speech output. For the purpose of understanding the preference of individual participants, a dependent measure i.e., percent of time with respect to the selection of the device with a specific speech output was calculated for each session and analyzed.

When we closely scrutinize the data obtained from choice assessment, mixed outcomes are clearly evident. Participant 1 exhibited a clear preference for synthetic speech output and participant 2 exhibited a clear preference for digitized speech output. Choice assessment probe has not been conducted with participant 3 because he did not demonstrate the required level of mastery in using the SGD within the stipulated period of the intervention. Even though participant 4 exhibited rapid skill acquisition in digitized speech condition, he could not express his preference because of the positioning bias and he chose both speech outputs relatively equal number of times.

An important component of this study was the speech output preference-assessment phase. In this phase, the children who acquired the requesting skills were given a choice between devices with digitized and synthetic speech outputs prior each trial, and positioning of the devices were systematically controlled for each session. Previously, studies have been conducted to enable individuals with developmental disabilities to participate in their intervention plan by helping them to select their own communication device (e.g., Dyches, Davis, Lucido & Young, 2002; Soto, Belfiore, Schlosser & Haynes, 1993). Similarly, studies have been conducted with individuals with autism to understand learner's preference for specific AAC system by giving them opportunities to choose either PECS or SGDs (Beck, Stoner, & Bock, 2008; Sigafoos et al., 2009; Son, Sigafoos, O'Reilly & Lancioni, 2006) and one study conducted to examine the learner's preference among three different speech-generating devices with digitized speech output (Sigafoos, O'Reilly, Ganz, Lancioni & Schlosser, 2005).

It has been widely argued that choice making is a very vital response that children with autism should be allowed to engage in, so that it can improve their overall learning and outcome (Koegel, Koegel, Harrower & Carter, 1999). Further-more, by enabling students to participate in decisions that Affecting their education and therapy, we can promote their self determination and in the long run, it will lead to improved educational and therapeutic outcomes (e.g., Baer, 1998; Wehmeyer, Agran, Hughes, Martin, Mithaug, & Palmer, 2007).

The third research question in this study examined whether there exist a difference between the raters impression on acceptability of digitized and synthetic speech outputs across different settings, and raters impression about the participant's communicative ability after the intervention. Social validity measures were obtained from four therapists working with the selected participants. Social validity measures obtained in this study suggests that the raters did not reveal a preference for a specific speech outputs and identify its efficacy in improving communicative outcome. In-fact, it appeared that it was very difficult for them to ascertain the acceptability of two different speech outputs across different settings and the possible role of speech outputs in learning and acquisition. The poor understanding about the role of speech output in learning and acquisition might be due to the widely held belief that individuals with autism spectrum disorders are primarily visual learners and they tend to process visual stimuli more readily than auditory stimuli (Schlosser, Sigafoos & Koul, 2009). Social validity data suggests that use of iPads® appeared to be favored and rated as more acceptable, appropriate and personally preferred by three out of 4 raters. All the therapists clearly indicated that SGD intervention helped to improve their student's communicative abilities and they preferred to use SGDs in future. Social validity measures could have been obtained from the parents to have their perceptions and preferences on the use of two different speech outputs in SGD devices across diverse settings.

Study Limitations

This study has several limitations in-terms of research methods and overall outcome. First limitation was the short duration of the study. Due to this limitation, investigator could not obtain maintenance and generalization data with all the participants having necessary skills to make basic-level communicative requests using SGD. Longer periods with follow-up and generalization phases have to be conducted in-order to understand children's ability to use the learned skills with different people and or different setting. It is also necessary to understand social perception about the acceptability of digitized and synthetic speech outputs across diverse setting. For instance, specially designed augmentative and alternative communication (AAC) programs for the devices like iPads® and Google android tablets® are primarily using synthetic speech outputs, and findings to date indicate that synthetic speech in general is less intelligible than recorded natural speech (e.g., Miranda & Beukelman, 1990).

This study is highly limited in-terms of its adaptability to larger population because of the total number of participants participated (N=4) and there were no female participants. Therefore, the selected sample is not representative of all young non-verbal children with autism.

A third limitation is associated with the differences in the quality of digitized speech outputs generated by the devices. For instance, all the selected participants were provided with a synthesized speech output in their device and it was programmed to play at constant rate of 115 words per minutes (WPM) with a constant pitch rate of 15. The synthesized speech outputs were produced using Microsoft speech synthesize engine®. However, digitized speech outputs were produced and programmed in the devices with the help of the available therapists and it was very challenging to exercise control over the qualitative differences of the speech samples in terms of prosody, intonation, pitch rates, and speech rates. Future studies can address this issue by creating digitized speech samples prior to the intervention and program the devices to generate digitized speech outputs at constant rates.

A fourth limitation of this study is the lack of data on collateral behaviors. The investigator should have prepared a list of operationally defined maladaptive behaviors to be observed and the occurrence of behavior should have been measured using systematic recording procedures such as event recording and interval recording (Alberto & Troutman, 1999). Future studies can consider collecting data on collateral behaviors such as vocalizations, speech development, and changes in the occurrences of pre-linguistic forms of communicative behaviors.

Implications For Research And Practice

Practically, the implications for this study are far-reaching. By individualizing the SGD training based on certain specific components, (i.e., preferred speech output), we can maximize motivation and success and minimize frustrations and challenging behaviors.

For behavior therapists and educational professionals, the study outcome emphasizes the need for introducing an appropriate antecedent intervention to reduce problem behavior and increase on-task behavior. For instance, one of the participant participated in this study did not show considerable progress in the intervention due to some maladaptive behaviors (e.g., diurnal bruxism, sensitivity to itchy clothing). It has been suggested that by introducing appropriate antecedent interventions, we can reduce the problem behaviors exhibited by individuals with autism and increase on-task behaviors (Duker & Rasing, 1989). Therapists and educational professionals can enhance the overall outcome of intervention by properly identifying and modifying the environmental factors that precipitating and maintaining problem behaviors (Mittenberger, 1998).

Drawing on the overall outcome, this study emphasizes the need for providing interventions without interruption. One of the participants participated in the study experienced frequent interruptions in the intervention due to some unavoidable circumstances (e.g., issues with insurance benefits), and at one occasion intervention was interrupted almost for a month. It has been argued that interruptions in the intervention services will lead to acquisition of response patterns that are detrimental to future opportunities, and accelerate behavioral challenges that are expensive not only in terms of dollars but also in terms of the quality of the life of people with autism and their families (McClannahan, MacDuff & Krantz, 2002).

For parents and educational professionals, this study provides new information about a specific component of an augmentative system that will help them to choose appropriate speech outputs based on their children's learning styles and cognitive characteristics in future.

One of the participants participated in this study was trained in his home setting. This participant demonstrated the rapid acquisition and maintenance of requesting skills. This result may therefore have practical implications for Parents-assisted SGD training at home setting.

Suggestions For Future Research

Future research studies should investigate child characteristics associated with performance, speech processing and preference. Specifically, studies can give more attention to performance related characteristics (e.g., joint attention, vocal imitation) and try to establish its role in learning and acquisition of skills relevant to the use of SGDs. Further, researchers can also investigate individual characteristics that are necessary to process and indicate preference for specific speech outputs. For instance, studies can investigate individual cognitive characteristics (e.g., memory, matching repertoires, auditory and visual discrimination) and establish its role in supporting individuals with ASD to process and indicate their preferred speech output.

One of the main goals of this study is to understand child preference for a specific speech output. The preliminary outcome obtained from this study has shown that young children with autism do show a behavioral preference for one speech output over the other. Similarly, studies conducted by Klin (1991) and Paul and his colleagues (2007) have documented that young non-verbal children with autism can indicate their preference for a specific speech output. It would be highly preferable, if future researchers could develop an assessment tool to predict Response and preference patterns of young children with autism and or children at-risk. This is highly beneficial for children less than 4-years of age, when neural-plasticity is high (Chuganni, Phelps & Mazziotta, 1987).

Previously, study conducted by Groen, Van-Orsouw, Zwiers, Swinkels, Van-der Gaag, and Buitelaar (2008) demonstrated that perception of voice gender is not impaired in high functioning autism (HFA). Future studies can extend this literature by understanding perception of and preference for voice gender in young non-verbal children diagnosed with autism. The current study used female voices (i.e., digitized and synthetic speech outputs) for all the selected male participants to understand their preference for a specific speech output.

Previously, studies have been conducted to examine the effectiveness of speech output on speech production (Parsons & La Sorte, 1993; Schlosser et al., 2007), spelling (Schlosser et al., 1998; Schlosser & Blischak, 2004), requesting (Schlosser et al., 2007; Sigafoos et al., 2003). Nonetheless, there are still many areas that require attention of future researchers. For instance, researchers can investigate the role of speech outputs in teaching communication skills other than requesting such as rejecting, commenting, greeting others etc. As computer-based instructions are becoming more prevalent (e.g., Ramdoss, Machalicek, Rispoli, Mulloy, Lang et al., 2012; Ramdoss, Mulloy, Lang, O'Reilly, Sigafoos et al., 2011), future researchers can compare the effectiveness of speech outputs in teaching academic and social communicative skills to individuals with high functioning autism (HFA) and Asperger's Syndrome (AS).

Summary

The purpose of the study was to compare the effects of two different speech output based SGD training on four children's requesting abilities. The primary findings of this study were: (1) Differences in the performance were found between two of the participants within each speech output; (2) two of the participants appeared to prefer one speech output over other and one participant could not indicate his preference due to positioning bias; (3) social validity measures indicated favorable ratings for SGD training but no clear indications in-terms of acceptability and usability of speech outputs across different settings. Despite individual differences, the overall results obtained from this study suggests that non-verbal children with autism can successfully learn to use the SGDs at their own pace with the support of proper prompting strategies and instructional procedures.

Successful implementation of the steps involved in SGD is key to successful outcome. Choosing any type of augmentative system in general and SGDs in particular should be based on children's learning styles and abilities, along with their physical and cognitive characteristics at any given point. Generally, teachers / practitioners select an appropriate SGD based on symbol displays, durability and the portability of the device, available training and technical assistance, and funding resources. From the preliminary outcome obtained from this study, it should be clear that speech output can play a significant role, and it is one of the important components that can contribute to the success of the intervention. Special educators and speech pathologists who consider prescribing SGDs for children with autism should take speech outputs into their consideration when making this important and potentially costly decision. However, it should be clear that decision making related to selection of a specific speech output is a complex and challenging endeavor and require careful assessment and individualization. Although there exist passionate theoretical arguments for both and against digitized and synthetic speech outputs, the fact of the matter is that there are no comparative research studies currently available to inform clinical practice in this area. Future studies should develop guidelines and protocols for decision making that are based on sound research.

APPENDIX A: Data Collection Sheet

Date: Name of the observer:
Pseudonym of the Participant:
Phase: ( ) Baseline ( ) Treatment ( ) Choice Assessment Probe
Condition: ( ) Digitized Speech output ( ) Synthetic Speech Output
Settings: ( ) Snack Time ( ) Play time

Session Number	Trial Number	Type of Response	Observer's Comments
1	1 2 3 4 5 6 7 8 9 10		
2	1 2 3 4 5 6 7 8 9 10		
3	1 2 3 4 5 6 7 8 9 10		

NOTE: IR= Independent Response; VP= Verbal Prompt; GM= Gesture Modeled; PP= Physical Prompt; NR= No Response

APPENDIX B: Treatment Integrity Checklist

Date: Name of the observer:
Pseudonym of the Participant:
Phase: ( ) Baseline ( ) Treatment
Condition: ( ) Digitized Speech output ( ) Synthetic Speech Output
Settings: ( ) Snack Time ( ) Play time

NOTE: Please provide your response by highlighting the appropriate boxes provided below.
A= Agreement D=Disagreement NA= Not Applicable

Integrity Measures	Trial No										Total "A"
	1	2	3	4	5	6	7	8	9	10	
(a) Trainer appropriately places the device and preferred items in front of the participant:											
(b) Trainer waits 10 seconds to receive a response from the participant (Only during baseline):											
(c) If the participant did respond, trainer provided access to preferred item (small portion of snack or 10 sec for play) and delivered verbal reinforcement (e.g., good job) (only during baseline)											
(d) If the participant did not respond within 2 sec, trainer uses errorless teaching with appropriate time delay (i.e., full physical, partial physical, gestural, and verbal)											
(e) Teacher re-states discriminative stimulus (SD) with 0 seconds time delay after an error											
Teacher uses transfer trials after two errors (Prompted response)											
Teacher returns to target after few trials Later											

APPENDIX C: Social Validity Questionnaire

Dear Parent / Teacher,

This questionnaire is designed to understand your personal opinion on the effectiveness of the implemented intervention in improving child's ability to make basic level communicative requests. This questionnaire is also designed to understand your impression about the differences in acceptability and effectiveness of speech outputs indifferent natural and social settings. The personal information that you provided here, will not be disclosed without your written permission. Participation in this survey is voluntary and no compensations will be provided for taking part in this survey. Thanking you for your cooperation.

Date:
Name of the Parent / Teacher

Do you think that using speech-generating devices to teach basic level communicative requests was an appropriate instructional strategy with this child? If yes, can you please briefly explain? And if not, can you please briefly explain?

Did you notice any changes in the communicative behavior on the part of this child? If so, can you please briefly explain?

Do you think that it is important to receive training before teaching a child to use speech-generating devices? If yes, can you please briefly explain? If not, why do you think so?

Do you think that one type of speech output is more effective than other one in making basic level communicative requests? If so, can you please tell which type of speech output? Can you list some reasons to justify your point?

Do you think that one type of speech output is more acceptable in general classroom setting than other one? If so, which speech type of speech output? Can you please give some reasons for your selection of that specific speech output?

Do you think that one type of speech output is more acceptable than other one in home setting? If so, which type of speech output? Do you have specific reason to justify your point? Can you please briefly explain?

Do you think that one type of speech output is more acceptable than the other one in a general social setting (e.g., restaurant)? If so, which type of speech output? Can you please explain?

Do you continue to use speech output devices for this child in future? If you decide to continue, can you please specify few reasons? If you do not wish to continue, can you please explain, why you do not want to continue?

References

Alberto, P. A., & Troutman, A. C. (1999). *Applied behavior analysis for teachers* (5th Ed.). Englewood Cliffs, NJ: Merrill.

Adkins, T. & Axelrod, S. (2001). Topography-versus selection-based responding: Comparison of mind acquisitions in each modality. *The Behavior Analyst Today, 2,* 259-266.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders: DSM-IV* (4th Ed.). Washington, DC: American Psychiatric Association.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders DSM-IV* (4th Ed., text revision). Washington, DC: American Psychiatric Association.

American Speech-Language-Hearing Association. (1991). Report: Augmentative and alternative communication. *ASHA, 33,* 9-12.

Anderson, A. (2001). *Augmentative communication and autism: A comparison of sign language and the picture exchange communication system.* Doctoral dissertation, University of California, San Diego.

Baer, D. M. (1998). Commentary: Problems in imposing self-determination. *The Journal of the Association for Persons with Severe Handicaps, 23,* 50-52.

Baron-Cohen, S., Allen, J., & Gillberg. C. (1992). Can autism be detected at 18 months ? The needle, the haystack and the CHAT. *British Journal of Psychiatry, 161,* 839-843.

Beck, A. R., Stoner, J. B., & Bock, S. J. (2008). Comparison of PECS and the use of a VOCA: A replication. *Education and Training in Developmental Disabilities, 43*(2), 198-216.

Bedrosian, J., Hoag, L., Calculator, S. & Molineu, B. (1992). Variables influencing perceptions of the communicative competence of an adult augmentative and alternative communication system user. *Journal of Speech and Hearing Research, 35,* 1105-1113.

Bonvillian, J., & Blackburn, D. (1991). Manual communication and autism: Factors relating to sign language acquisition. *Manual Communication and Autism,* 255-300.

Bourret, J. C., Iwata, B. A., Harper, J. M., & North, S. T. (2012). Elimination of position-biased responding in individuals with autism and intellectual disabilities. *Journal of Applied Behavior Analysis, 45,* 241-250.

Brady, N.C. (2000). Improved comprehension of object names following voice output communication aid use: Two case studies. *Augmentative and Alternative Communication, 16,* 197-204.

Carr, E. G., & Durand, V. M. (1985). Reducing behavior problems through functional communication training. *Journal of Applied Behavior Analysis, 18,* 111-126.

Carson, D., Klee, T., Perry, C, Donaghy, T.. & Muskina, G. (1997). Measures of language proficiency as predictors of behavioral difficulties, social and cognitive development in 2-year old children. *Perceptual and Motor Skills, 8,* 923-930.

Charlop-Christy, M. H., Carpenter, M., Le, L., LeBlanc, L. A., & Kellet, K. (2002). Using the picture exchange communication system (PECS) with children with autism: Assessment of PECS acquisition, speech, social- communicative behavior, and problem behavior. *Journal of Applied Behavior Analysis, 35,* 213-231.

Chugani, H., Phelps, M., & Mazziotta, J. (1987). Positron Emission Tomography study of human brain functional development. *Annals of Neurology, 22,* 487-497.

Cowley, C. K., & Jones, D. M. (1992). Synthesized or digitized? A guide to the use of computer speech. *Applied Ergonomics, 23*(3), 172-176.

DiCarlo, C. F., & Banajee, M. (2000). Using voice output device to increase initiations of young children with disabilities. *Journal of Early Intervention, 23*(3), 191-199.

Drager, K. D. R., Clark-Serpentine, E. A., Johnson, K. E., & Roeser, J. L. (2006). Accuracy of repetition of digitized and synthesized speech for young children in background noise. *American Journal of Speech-Language Pathology, 15,* 155–164.

Drager, K. D. R., & Reichle, J. E., (2001). Effects of discourse context on the intelligibility of synthesized speech for young adult and older adult listeners: Application for AAC. *Journal of Speech, Language, and Hearing Research, 44,* 1052-1057.

Drasgow, E., Halle, J. W., Ostrosky, M. M., & Harbers, H. M. (1996). Using behavioral indication and functional communication training to establish an initial sign repertoire with a young child with severe disabilities. *Topics in Early Childhood and Special Education, 16,* 500-521.

Duker, P. C., Didden, R., & Sigafoos, J. (2004). *One-to-one training: Instructional procedure for learners with developmental disabilities.* Austin, TX: Pro- Ed.

Duker, P. C., & Rasing, E. (1989). Effects of redesigning the physical environment on self-stimulation and on-task behavior in three autistic-type developmentally disabled individuals. *Journal of Autism and Developmental Disorders, 19,* 449–460.

Durand, V. M. (1999). Functional communication training using assistive devices: Recruiting natural communities of reinforcement. *Journal of Applied Behavior Analysis, 32,* 247-267.

Fisher, W., Piazza, C. C, Bowman, L. G., Hagopian, L. P., Owens, J.C. & Slevin, I. (1992). A comparison of two approaches for identifying reinforcers for persons with severe and profound disabilities. *Journal of Applied Behavior Analysis, 25,* 491-498.

Franco, J. H., Lang, R. S., O'Reilly, M. F., Chan, J. F., Sigafoos, J.,& Rispoli, M. (2009). Functional analysis and treatment of inappropriate vocalizations using a speech-generating device for a child with autism. *Focus on Autism and Other Developmental Disabilities, 24*(3), 146-155.

Frankel, R., Leary, M., & Kilman, B. (1987). Building social skills through pragmatic analysis: Assessment and treatment implications for children with autism. In D. Cohen, A. Donnellan, & R. Paul (Eds.). *Handbook of Autism and Pervasive Developmental Disorders*. New York: Wiley.

Galloway, C. (1967). Modification of a response bias through differential amount of reinforcement. *Journal of the Experimental Analysis of Behavior, 10,* 375-382.

Ganz, J. B, & Simpson, R. L. (2004). Effects on communicative requesting and speech development of the picture exchange communication system in children with characteristics of autism. *Journal of Autism and Developmental Disorders, 34,* 395-409.

Groen, W., Van-Orsouw, L., Zwiers, M., Swinkels, S., Van-Der Gaag, R. & Buitelaar, J. (2008). Gender in voice perception in autism. *Journal of Autism and Developmental Disorders, 38*(10), 1819-1826.

Haring, N. G., McCormick, L., & Haring, T. G. (1994). *Exceptional children and youth*. New York: Merril.

Hedbring, C. (1985). Computers and autistic learners: An evolving technology. Australian *Journal of Human Communication Disorders, 13,* 169-188.

Hersen, M, & Barlow, D. (1976). *Single case experimental designs: Strategies for studying behavior change.* New York: Pergamon Press.

Hoag, L., Bedrosian, J., Johnson, D. & Molineux, B. (1994). Variables affecting perceptions of social aspects of the communicative competence of an adult AAC user. *Augmentative and Alternative Communication, 10,* 129-137.

Hutt, M. L., & Gibby, R. G. (1979). *The mentally retarded child: Development training & education.* Boston: Allyn & Bacon.

Kagohara, D., van der Meer, L., Achmadi, D., Green, V. A., O'Reilly, M., Mulloy, A., Sigafoos, J. (2010). Behavioral intervention promotes successful use of an iPod-based communication device by an adolescent with autism. *Clinical Case Studies, 9,* 328-338.

Kail, R. (1992). General slowing of information processing by persons with mental retardation. *American Journal on Mental Retardation, 97,* 333-341.

Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous Child, 2,* 217-250.

Keen, D., Sigafoos, J., Woodyatt, G. (2001). Replacing prelinguistic behaviors with functional communication. *Journal of Autism and Developmental Disorders, 31,* 385-398.

Kintch, W., & Van-Dijk, T. A. (1978). Towards a model for text comprehension and production. *Psychological Review, 83,* 363-394.

Klin, A. (1991). Young autistic children's listening preferences in regard to speech: A possible characterization of the symptom of social withdrawal. *Journal of Autism and Developmental Disorders, 21,* 29-42.

Koegel, L. K., Koegel, R. L., Harrower, J. K., & Carter, C. M. (1999). Pivotal response intervention I: Overview of approach. *Journal of Association for Persons with Severe Handicaps, 24,* 174-185.

Koul, R., & Hanners, J. (1997). Word identification and sentence verification of two synthetic speech systems by individuals with intellectual disabilities. *Augmentative and Alternative Communication, 13,* 99-107.

McClannahan, L. E., MacDuff, G. S., & Krantz, P. J. (2002). Behavior analysis and intervention for adults with autism. *Behavior Modification, 26*(1), 9-26.

Mirenda, P. (2003). Toward functional augmentative alternative communication for students with autism: Manual signs, graphic symbols, and voice output communication aids. *Language, Speech, and Hearing Services in Schools, 34,* 203-216.

Mirenda, P., & Iacono, T. (1988). Strategies for promoting augmentative and alternative communication in natural contexts for children with autism. *Focus on Autistic Behavior, 3*, 1-15.

Mirenda, P., & Iacono, T. (2009). *Autism Spectrum Disorders and AAC*. Baltimore: Paul H Brookes.

Mirenda, P., & Schuler, A. L. (1988). Augmenting communication for persons with autism: Issues and strategies. *Topics in Language Disorders, 9*, 24-43.

Mirenda, P., Wilk, D., & Carson, P. (2000). A retrospective analysis of technology use patterns of students with autism over a five-year period. *Journal of Special Education Technology*, *15,* 5-16.

Mittenberger, R. G. (1998). Methods for assessing antecedent influences on challenging behaviors. In J. K. Luiselli & M. J. Cameron (Eds.), *Antecedent control procedures for the behavioral support of persons with developmental disabilities* (pp. 47–66). Baltimore: Paul H. Brookes.

National Research Council (2001). *Educating children with autism*. Washington DC: National Academy Press.

Neef, N. A., Mace, F. C., & Shade, D (1993). Impulsivity in students with serious emotional disturbance: The interactive effects of reinforcer rate, delay, and quality. *Journal of Applied Behavior Analysis, 26,* 37-52.

Olive, M. L., LaCruz, B., Davis, T. N., Chan, J. F., Lang, R., O'Reilly, M. et al., (2007). The effects of enhanced milieu teaching and a voice output communication aid on the requesting of three children with autism. *Journal of Autism and Developmental Disorders*, *37*(6), 1505-1513.

Olive, M. L., Lang, R. B., & Davis, T. N., (2008). An analysis of the effects of functional communication and a voice output communication aid for a child with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *2*(2), 223-236.

Oxman, J. C., Webster, C., & Konstantareas, M. (1978). The perception and processing of information by severely dysfunctional nonverbal children: A rationale for the use of gestural communication. *Sign Language Studies*, *21,* 289-316.

Parsons, C. L., & La Sorte, D. (1993). The effect of computers with synthesized speech and no speech on the spontaneous communication of children with autism. *Australian Journal of Human Communication Disorders, 21,* 12-31.

Paul, R., Chawarska, K., Fowler, C., Cicchetti, D., & Volkmar, F. (2007). “Listen my children and you shall hear”: Auditory preferences in toddlers with autism spectrum disorders. *Journal of Speech, Language, and Hearing Research, 50*(5), 1350-1364.

Peterson, S., Bondy, A., Vincent, Y., & Finnegan, C. (1995). Effects of altering communicative input for students with autism and no speech: Two case studies. *Augmentative and Alternative Communication, 11,* 93-100.

Prizant, B. M. (1983). Language acquisition and communicative behavior in autism: Toward an understanding of the "whole" of it. *Journal of Speech and Hearing Disorders, 46,* 241-249.

Quill, K. A. (1997). Instructional considerations for young children with autism: The rationale for visually cued instruction. *Journal of Autism and Developmental Disorders, 27,* 697-714.

Raghavendra, P. & Oaten, R. (2007). Effects of speech and print feedback on spelling performance of a child with cerebral palsy using a speech-generating device. Disability and Rehabilitation: *Assistive Technology, 2*(5), 299-308.

Ramdoss, S., Machalicek, W., Rispoli, M., Mulloy, A., Lang, R., & O’Reilly, M. (2012). Computer-based interventions to improve social and emotional skills in individuals with autism spectrum disorders: A systematic review. *Developmental Neurorehabilitation, 15,* 119-135.

Ramdoss, S., Mulloy, A., Lang, R., O’Reilly, M., Sigafoos, J., Lancioni, G., Didden, R., & El Zein, F. (2011). Use of computer-based interventions to improve literacy skills in students with autism spectrum disorders: A systematic review. *Research in Autism Spectrum Disorders, 5,* 1306-1318.

Remington, B., & Clarke, S. (1983). Acquisition of expressive signing by autistic children: An evaluation of the relative effects of simultaneous communication and sign-alone training. *Journal of Applied Behavior Analysis, 16,* 315-328.

Romski, M. A., & Sevcik, R. A. (1993). Language comprehension: Considerations for augmentative and alternative communication. *Augmentative and Alternative Communication, 9,* 281-285.

Romski, M. A., & Sevcik, R. A. (1996). *Breaking the speech barrier: Language development through augmented means.* Baltimore: Paul H Brookes.

Schepis, M. M., Reid, D. H., Behrmann, M. M., & Sutton, K. A. (1998). Increasing communicative interactions of young children with autism using a voice output communication aid and naturalistic teaching. *Journal of Applied Behavior Analysis, 31,* 561-578.

Schlosser, R. W. (2003). Roles of speech output in augmentative and alternative communication: Narrative review. *AAC: Augmentative & Alternative Communication, 19*(1), 5-27.

Schlosser, R. W., & Blischak, D. M. (2004). Effects of speech and print feedback on spelling by children with autism. *Journal of Speech, Language, and Hearing Research, 47,* 848-862.

Schlosser, R. W., Blischak, D. M., Belfiore, P. J., Bartley, C., & Barnett, N. (1998). Effects of synthetic speech output and orthographic feedback on spelling in a student with Autism: A preliminary study. *Journal of Autism and Developmental Disorders, 28,* 309-319.

Schlosser, R. W., Sigafoos, J., Luiselli, J., Angermeier, K., Schooley, K., Harasymowyz, U., & Belfiore, J. (2007). Effect of synthetic speech output on requesting and natural speech production in children with autism. *Research in Autism Spectrum Disorders, 1,* 139-163.

Schuler, A. L., & Baldwin, M. (1981). Non-speech communication and childhood autism. *Language, Speech, and Hearing Services in the Schools*, *12*, 246-257.

Schwartz, I., & Garfinkle, A. (1998). The picture exchange communication system: Communicative outcomes for young children with disabilities. *Topics in Early Childhood Special Education, 18,* 144-162.

Sigafoos, J., Didden, R., & O'Reilly, M. (2003). Effects of speech output on maintenance of requesting and frequency of vocalizations in three children with developmental disabilities. *Augmentative and Alternative Communication, 19*(1), 37-47.

Sigafoos, J., & Drasgow, E. (2001). Conditional use of aided and unaided AAC: A review and clinical case demonstration. *Focus on Autism and Other Developmental Disabilities, 16*(3), 152-163.

Sigafoos, J., Drasgow, E., Hall, J., O'Reilly, M., Seely-York, S., Edrisinha, C. et al.(2004). Using VOCA as a communicative repair strategy. *Journal of Autism and Developmental Disorders, 34*(4), 411-424.

Sigafoos, J., Green, V. A., Payne, D., Son, S., O'Reilly, M., & Lancioni, G. (2009). A comparison of picture exchange and speech-generating devices: Acquisition, preference and effects on social interaction. *Augmentative and Alternative Communication, 25*(2), 99-109.

Sigafoos, J., & Mirenda, P. (2002). Strengthening communicative behaviors for gaining access to desired items and activities. In J. Reichle, D. Beukelman & J. Light (Eds.), Exemplary practices for beginning communicators. *Implications for AAC* (pp. 123-156). Baltimore: Paul H. Brookes.

Sigafoos, J., O'Reilly, M., Ganz, J., Lancioni, G., & Schlosser, R (2005). Supporting self – determination in AAC interventions by assessing preference for communication devices. *Technology and Disabilities, 17,* 143-153.

Sigafoos, J., O'Reilly, M., Seely-York, S., & Edrisinha, C. (2004). Teaching students with developmental disabilities to locate their AAC device. *Research in Developmental Disabilities, 25*(4), 371-383.

Sigafoos, J., O'Reilly, M., Seely-York, S., Weru, J., Son, S. H., Green, V. A., et al. (2004). Transferring AAC intervention to the home. *Disability and Rehabilitation, 26*(21), 1330-1334.

Son, S. H., Sigafoos, J., O'Reilly, M., & Lancioni, G. E. (2006). Comparing two types of augmentative and alternative communication for children with autism. *Pediatric Rehabilitation, 9,* 389-395.

Sundberg, M. L., & Partington, J. M. (1998). *Teaching language to children with autism or other developmental disabilities.* Pleasant Hill, CA: Behavior Analysts, Inc.

Tincani, M. J. (2002). Effects of selection-based versus topography-based communication training on the acquisition of minds by children with autism and multiple disabilities. Doctoral dissertation, The Ohio State University.

Van Acker, R. & Grant, S. (1995). An effective computer-based requesting system for persons with Rett's syndrome. *Journal of Childhood Communication Disorders, 16,* 31-38.

Vander Meer, L., & Rispoli, M. (2010). Communication interventions involving speech-generating devices for children with autism: A review of the literature. *Developmental Neuro Rehabilitation, 13*(4), 294-306.

Wehmeyer, M., Agran, M., Hughes, C., Martin, J., Mithaug, D., & Palmer, S. (2007). *Promoting self-determination in students with developmental disabilities*. New York, NY US: Guilford Press.

Wendt, O. (2006). *The effectiveness of augmentative alternative communication for individuals with autism spectrum disorders: A systematic review and meta-analysis.* Unpublished Doctoral dissertation, Purdue University, West Lafayette.

Weitz, C., Dexter, M., & Moore, J (1997). AAC and children with developmental disabilities. In S. Glennen, & D. DeCoste (eds.), Handbook of augmentative and alternative communication (pp. 395-431). San Diego: Singular.

Willis, L., Koul, R., & Paschal, D. (2000). Discourse comprehension of synthetic speech by individuals with mental retardation. *Education and Training in Mental Retardation and Developmental Disabilities, 35*, 106-114.

Yoder, P., & Layton, T. (1988). Speech following sign language training in autistic children with minimal verbal language. *Journal of Autism and Developmental Disorders. 18,* 217-229.