2018

Tuned In: An Investigation of the Use of Group Amplification Systems for Students, Including Those on the Autism Spectrum, in First Grade Mainstream Classrooms

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TUNED IN: AN INVESTIGATION OF THE USE OF GROUP AMPLIFICATION SYSTEMS FOR STUDENTS, INCLUDING THOSE ON THE AUTISM SPECTRUM, IN FIRST GRADE MAINSTREAM CLASSROOMS

by Emily Velichka

An Independent Study Thesis
Presented in Partial Fulfillment of the Course Requirements for
Senior Independent Study: The Department of Communication

February 28, 2018

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ABSTRACT

The purpose of this study was to determine the academic benefits and challenges, if any, of utilizing a group amplification system in first-grade mainstream classrooms. More specifically, this study measured the influence of a group amplification system throughout language-based tasks, such as spelling accuracy. A total of 33 first-grade students, including two students reportedly diagnosed with an Autism Spectrum Disorder (ASD), participated in the study, with 17 students in Classroom A and 16 students in Classroom B. This studyôs experimental procedures included a spelling pretest, two intervention activities, and a spelling posttest, administered over the course of four days. The spelling pretest was comprised of 10 grade-level words, and was administered to each classroom without the use of an amplification device. Intervention activities had students create tongue twisters, as well as play a ñSpelling Wordò Bingo game. The spelling posttest was comprised of the same 10 grade-level words. During the intervention and posttest procedures, the researcher made use of a group amplification system in Classroom A, while Classroom B did not as a control measure. Overall, students in Classroom A demonstrated significant increases in change scores from spelling pre- to posttest measures when compared to Classroom B. In addition, the use of a group amplification system appeared to positively impact students in Classroom A through improvement of the signal-to-noise ratio. Findings suggest the use of this hearing assistive technology was effective in the first-grade mainstream classroom.

Keywords: Group Amplification System, Autism Spectrum Disorders, Elementary School Classroom, Spelling Accuracy

ACKNOWLEDGEMENTS

First, I would like to thank my family. As a first-generation college student and the oldest sibling, I will be the first person to obtain my bachelorôs degree in our family. Your encouragement and positivity keep me going on days when nothing seems to be in my favor. Thank you for accepting my countless hours in the library whenever I needed to conquer a section of I.S., even when I was supposed to be relaxing, and all around being my biggest fans.

Secondly, I would like to thank my advisor, Dr. Donald Goldberg. I had no idea I would fall in love with the profession of audiology as much as I did, but your introductory course junior year opened my eyes to a career I cannot wait to begin. Your enthusiasm, drive, and commitment to my academics and Independent Study pushes me to be the very best student I can be. Thank you for all of your help throughout my experimental process, as well as keeping up with my fast-paced writing style. I know this Independent Study became an incredible piece of writing thanks to your expertise.

Next, thank you to Tessa in the Writing Center for helping to polish my Independent Study and tweak all of those ñawkwardò sections in my writing. You were not only a mentor to me throughout this process, but a friend as well. Thank you for listening to my endless complaining, and helping to improve my Independent Study into what it is today.

Finally, thank you to all of my friends at Wooster and back home in Wickliffe. I may have known you for years, or just a little while, but you have truly made an impact on my life. Thank you for spending time with me, laughing with me, and all around being the best support system. I love you all more than you know.

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CHAPTER I: INTRODUCTION

In recent years, the number of elementary school-aged students on the Autism Spectrum who are mainstreamed in general education classrooms has steadily increased. By 2016, 39.7% of these students were placed in general education classrooms for 80% or more of the school day (National Center for Education Statistics, 2016, p. 1). With the increased numbers of mainstreamed students diagnosed with Autism Spectrum Disorders (ASD), appropriate educational resources, including group amplification systems, have the potential to be critical tools for these students. This form of hearing assistive technology may prove to be of academic benefit to this sample population. In this chapter, the researcher will present the purpose of this study, provide scholarly and practical rationales for conducting the research, define important terms, review critical background information on the topic, and describe a brief summary of the studyôs method.

Purpose Statement

The purpose of this study was to examine the academic benefits and challenges, if any, of utilizing group amplification systems such as frequency-modulated (FM), infrared-receiver (IR), and remote-microphone (RM) devices in first grade classrooms. More specifically, this study measured the influence of these group amplification systems throughout academic, language-based tasks, such as spelling accuracy. This study focused on first-grade students, including some on the Autism Spectrum who are fully included in these mainstreamed classrooms.

Rationales

There are both scholarly and practical justifications for completing this important research study. Currently, there is a gap in the literature regarding the benefit of group amplification systems in the first-grade mainstream classroom. Researchers have examined

preschool (Nelson, Poole, Muñoz, Nippold, & Pratt, 2013, p. 239); kindergarten (Maag & Anderson, 2006, p. 380); second grade (Maag & Anderson, 2006, p. 380; Massie & Dillon, 2006, p. 80); and fourth grade (Larsen & Blair, 2008, p. 454; Maag & Anderson, 2006, p. 380) mainstream classrooms. Nelson and Nelson (1997) have additionally studied second through sixth grade combined mainstream classrooms (p. 165). Therefore, the first scholarly rationale of this study is to target the first-grade population, as this age is a pivotal grade level or time period for the development of spelling accuracy through academic, language-based instruction and has apparently not been investigated.

Secondly, several researchers have outlined the potential benefits of utilizing group amplification technology in the elementary school classroom, but less attention has been paid to the ñchallengesò of incorporating this form of hearing assistive technology. Various benefits reported have included the teacherôs voice reaching a maximum number of students (Dockrell & Shield, 2012, p. 1164); less vocal strain by the teacher (Da Cruz et al., 2016, p. 42; Dockrell & Shield, 2012, p. 1164); and an increase in on-task academic behavior (Maag & Anderson, 2006, p. 391). Massie and Dillon (2006), however, have also examined the potential ñchallengesò to implementing these group amplification systems in mainstream elementary school classrooms (pp. 79-80). As a result, the second scholarly rationale of this study is to expand upon these previously established ideas and investigate benefits, alongside the ñchallengesò of utilizing this form of hearing assistive technology in first grade classrooms.

Finally, there is a gap in the literature regarding the use of assistive technology with children on the Autism Spectrum who are deaf or hard of hearing or also present with Auditory Processing Disorders. Researchers have examined the use of video self-modeling (Hart & Whalon, 2012, p. 438), ñbehavior analyticò intervention (Easterbrooks & Handley, 2005, p. 403),

and sign language (Shield, Meier, & Tager-Flusberg, 2015, p. 2130) with this sample population. Additionally, Hansen and Scott (2017) conducted a systematic review of current evidence regarding children with this dual diagnosis, with results indicating, ña strong need for additional research in these areasò (p. 1). Therefore, the final scholarly rationale of this study is to attempt to expand upon previously established research and incorporate students on the Autism Spectrum who exhibit challenges in auditory processing as part of this studyôs sample population.

A practical rationale for this study is the ways in which classroom teachers will presumably be able to effectively utilize this information. Mainstream classroom teachers can incorporate new knowledge from this study while working with their first-grade students, as well as mainstreamed students, on the Autism Spectrum. These teachers will become aware of the benefits group amplification systems have to offer classroom peers, as well as students with Autism Spectrum Disorders, in the area of spelling accuracy during academic, language-based instruction. These professionals will also be asked to report on the various ñchallengesò that may present themselves while incorporating the use of this hearing assistive technology with their students.

A second practical rationale is that this study can potentially aid group amplification manufacturers in the creation of new products. Based on the studyôs results, manufacturers may be able to create and market products that stress the clinical effectiveness of their systems in elementary school classrooms for the sample population of first-grade students, including some students with Autism Spectrum Disorders. Additionally, these manufacturers will also be in the position to address potential challenges that may be identified in this study in order to create improved products.

Background

In this section, the basic anatomy of the ear will be reviewed, and an introduction to the use of group amplification systems as a form of hearing assistive technology will be provided. To better understand the sample population of focus throughout this study, foundational knowledge regarding Auditory Processing Disorders and Autism Spectrum Disorders will also be introduced.

There are three main parts of the ear, which include outer, middle, and inner components. The outer ear includes the part of the ear that is easily seen, also known as the pinna or auricle, in addition to the external auditory canal or meatus. The middle ear is an air-filled space containing a chain of three ossicular bones, as well as the Eustachian tube. The inner ear is composed of the cochlea, the sense organ of hearing, and semicircular canals that aid with balance (Martin & Clark, 2015, p. 17). Should any of these areas be missing or damaged, technologies have been developed to augment the resulting impaired auditory skills. These may include hearing aids, designed to amplify sounds in the patientôs environment (Johnson, 2012, p. 154), cochlear implants, comprised of external and internal components to replace damaged cochlear hair cells (Johnson, 2012, pp. 265-266), or hearing assistive technology (HAT), including a wide variety of tools to aid individuals with hearing loss (Johnson, 2012, p. 230). Hearing assistive technologies may be especially appropriate when used by elementary school students with Autism Spectrum Disorders (ASD), including those who also present symptoms of Auditory Processing Disorders (APD). These disorders and the clinical effectiveness of hearing assistive technologies for these students will be explained in greater detail throughout the literature review that will follow this chapter.

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Group amplification systems are a specific type of hearing assistive technology. These devices are composed of four distinct parts: a microphone to pick up the signal, an amplifier to increase the intensity or ñloudnessò of the signal, a transducer to change the signal to amplified waveforms, and a receiver to obtain the signal (Flexer, 1997, para. 3). These devices may be personally attached or coupled to hearing equipment, such as a hearing aid, to benefit an individual patient (Deconde Johnson & Seaton, 2012, p. 297). Alternatively, amplification systems may be coupled in a large group setting, in order to distribute amplified signals to a larger population (Atcherson, Franklin, & Smith-Olinde, 2015, p. 104).

In order to better understand a portion of the sample population throughout this study, it is critical to recognize various features of Auditory Processing Disorders (APD). About 7% of the global population under age 10 years has been diagnosed with APD, with private school students twice as likely to be diagnosed than their public-school peers (Nagao, Reigner, Padilla, Greenwood, Loson, Zavala, & Morlet, 2016, para. 6). Research has yet to identify any direct cause(s) of this disorder, with a wide range of possibilities, such as cognitive, memory, or linguistic challenges, each playing a role in its diagnosis (Bamiou, Musiek, & Luxon, 2001, p. 362). Common symptoms of Auditory Processing Disorders include difficulty in sound localization, processing of auditory information, speech perception and comprehension, and/or development of language (Deconde Johnson & Seaton, 2012, pp. 198-199). Additionally, various developmental disabilities, such as Autism Spectrum Disorders (ASD), may co-occur with this condition.

It is also important to recognize various characteristics of Autism Spectrum Disorders to clearly comprehend some of the sample population to be reviewed throughout this study. It has been estimated that 1% of the global population has been diagnosed with Autism Spectrum

Disorders or ASD (Christensen, Baio, & Van Naarden Braun, 2016, p. 1). Much like Auditory Processing Disorders, research has not identified any specific cause(s) of ASD in children at this time. A combination of genetic factors -- such as family history; or environmental factors -- such as complications during pregnancy, may each play a role in the etiology of ASD (p. 3). A variety of common symptoms of Autism Spectrum Disorders include difficulty with various social skills, stereotypic behaviors, and/or abnormal reactions to a particular sensory environment (Ennis-Cole, 2015, p. 6). Interestingly, ASD is typically referred to as a ñspectrum,ò meaning that the disorder may affect each patient differently, while ranging from mild to severe (Christensen, Baio, & Van Naarden Braun, 2016, p. 1).

With the understanding of Auditory Processing Disorders and Autism Spectrum Disorders, a portion of the sample population throughout this study has been narrowed. However, while it is important to understand the anatomy of the ear, as well as forms of hearing assistive technology, specifically including group amplification systems with elementary school students, a set of key terms must be defined.

Definitions

In order to gain a thorough understanding of this study, several terms need to be defined. The term *group amplification system*, as defined by Berg, Blair, and Benson (1996), commonly makes use of, ñloudspeakers that allow for groups or an entire class of students to listen to the teacherôs voice at an improved S/N [Signal-to-Noise] ratio, no matter where the teacher is in the classroomò (p. 19). Johnson (2012) defined a *frequency-modulated (FM) system* as, ña transmitter that sends the signal via radio waves to a receiver,ò working as, ñthe speaker talks into the microphone that transduces the acoustic signal into an electric signal, which is in turn sent by radio waves to the receiverò (p. 244). An *infrared-receiver (IR) system* is, ñbased on light

waves carrying a signal from one or more transmitters to one of several types of small, specialized receiversò (Atcherson et al., 2015, p. 133). Additionally, *remote-microphone technology* is, ña frequency modulation (FM) or digital transmitter connected to a microphone worn by the primary talker or teacherò (Schafer, Wright, Anderson, Jones, Pitts, Bryant, Watson, Box, Neve, Mathews, & Reed, 2016, p. 3). This latter system operates as, ñthe transmitter wirelessly sends the speech signal from the primary talker or signals from other auditory mediums (e.g., projector, audio player, television) directly to the receiverò (p. 3).

Lastly, in order to better understand a portion of the sample population of this study, both *Auditory Processing Disorders (APD)* and *Autism Spectrum Disorders (ASD)* should be defined. According to the American Speech-Language-Hearing Association (2005), an *Auditory Processing Disorder* or *APD*, ñrefers to difficulties in the perceptual processing of auditory information in the central nervous systemò (p. 1). Simply put, a definition of Auditory Processing Disorders is -- difficulty in ñwhat the brain does with what the ear hearsò (Deconde Johnson & Seaton, 2012, pp. 198-199). *Autism Spectrum Disorder* or *ASD*, is, ña behaviorally defined syndrome characterized by abnormalities in reciprocal social interaction, verbal and nonverbal communication, and restricted repertoire of interests and behaviors, all present from early childhoodò (Alcantara, Weisblatt, Moore, & Bolton, 2004, p. 1107). For persons with ASD, ñsensory processing difficulties are consistently reported amongst individuals with an autism spectrum condition (ASC)ò (Howe & Stagg, 2016, p. 1656).

Description of Method

This study employed a quantitative approach to research through the administration of pre- and posttest measures. Prior to the experimental pretest, lead teachers in two first grade classrooms completed a ñListening Inventoryò for individual students. Utilizing a limited rating

scale from 1 to 3, this screening instrument determined studentsô routine listening or ñperceptionò abilities in the classroom, with 1 as ñRarely,ò and 3 as ñAlways.ò Afterwards, each classroom, containing some students on the Autism Spectrum, completed a spelling pretest of 10 first-grade level words without the use of a group amplification system. Each spelling term was stated once alone, once in a sentence, and once alone. Following the pretest measure, two days of spelling intervention activities were provided for 20-30 minutes each day. After three days, students in each classroom completed the same spelling test of 10 first-grade level words. Each spelling term was stated once alone, once in a sentence, and once alone. During the intervention and posttest procedures, one classroom incorporated the use of a group amplification system, while the students in the other classroom served as the control group, and completed the intervention activities and posttest measure without amplification. Results were analyzed to note student performance on the pre- and posttest compared to the teacherôs ratings on the ñListening Inventory.ò The performance changes of students in each classroom with and without the use of the group amplification system were also analyzed.

Conclusion

This study focused on the benefits and ñchallenges,ò if any, of incorporating various group amplification systems throughout language-based tasks, such as spelling accuracy. Although various grade levels, such as preschool (Nelson et al., 2013, p. 239), have been examined, this study will generate information specifically related to the *first-grade* population, including some students on the Autism Spectrum. This study will also attempt to explain both the benefits and ñchallengesò of utilizing these systems, as previous research has solely focused on the systemsô academic benefits (Dockrell & Shield, 2012, p. 1164). This study aims to provide teachers with new information to incorporate into their work with this sample population, as well

as potentially aid manufacturers in the creation of new amplification products. As the number of mainstreamed students diagnosed with Autism Spectrum Disorders continues to increase, it is critically important to research this topic, as will be addressed in the literature review to follow in Chapter II.

CHAPTER II: LITERATURE REVIEW

The number of elementary-aged students on the Autism Spectrum who are being mainstreamed in general education classrooms has continued to increase in recent years (National Center for Education Statistics, 2016, p. 1). Up to 46% of children on the Autism Spectrum can also present symptoms of Auditory Processing Disorders (APD) in the educational setting (Iliadou, Bamiou, Kaprinis, Kandylis, & Kaprinis, 2009, p. 1029). Due to this changing environment in the general education classroom -- appropriate accommodations, including amplification systems -- are often imperative to academically assist and support this sample population. As the presence of group and personal hearing assistive technologies increase throughout general education classrooms, it is critical to review the different types of amplification systems, as well as their benefit for a variety of sample populations. More specifically, by noting the benefit of group amplification systems for elementary school-age students with Autism Spectrum Disorders (ASD), classroom teachers can potentially implement new educational strategies with these students.

These above-noted justifications are only a sample of examples reflecting the importance for researching the academic benefit of group amplification systems, particularly with students on the Autism Spectrum. The purpose of this chapter is to present a review of the current literature regarding amplification systems, as well as the benefits and/or the ñchallengesò of their use with children on the Autism Spectrum. This chapter will present an overview of both personal and group amplification systems in the classroom, as well as the use of amplification systems with students with hearing impairment and those diagnosed with Autism Spectrum Disorders, who may present additional symptoms of Auditory Processing Disorders.

Personal Amplification Systems

Amplification systems vary in the number of individuals who may hear the increased intensity of a particular signal. As such, the signal of a personal amplification system ñis delivered directly to the individualôs earò (Deconde Johnson & Seaton, 2012, p. 302). These devices can be coupled to a studentôs hearing aid(s) or cochlear implant(s) through an audio shoe (boot) or with separately purchased headphones or earbuds (Atcherson, Franklin, & Smith-Olinde, 2015, pp. 99-100).

Benefits of Personal Amplification Systems

There are numerous benefits to utilizing this form of hearing assistive technology with students. As the increased signal is directly sent to the studentôs hearing aid(s), cochlear implant(s), or headphones, the negative effects of ambient noise are reduced (Nelson, Poole, Muñoz, Nippold, & Pratt, 2013, p. 240). In this way, the student can strictly focus on the signal presented, rather than the distraction of background noise in the classroom. Blake and colleagues (as cited by Purdy, Smart, Baily, & Sharma, 2009) found that personal amplification systems can also increase the amount of on-task and engaged academic behavior in students without hearing loss (p. 844). Finally, personal amplification systems are more mobile, and can be taken with the child to different classrooms or therapy areas for the receipt of the improved signal being available in all environments (Schafer, Mathews, Mehta, Hill, Munoz, Bishop, & Moloney, 2012, p. 33).

Challenges of Personal Amplification Systems

Personal amplification systems, however, can also present some challenges in the elementary school classroom. Nelson and colleagues (2013) concluded that personal amplification systems may be uncomfortable to wear or distracting for some preschool and other students. In addition, these systems may experience technical difficulties, causing limited or no benefit to

students as a result (pp. 244-245). While these technical difficulties can become a burden to the student(s) and for the overall classroom environment, the benefits of amplification devices can additionally be seen in the group setting, as will be further explained in the following section.

Group Amplification Systems

Group amplification systems ñdistribute the teacherôs voice equally throughout the classroom so that every child has full access to what is being spokenò (Deconde Johnson & Seaton, 2012, p. 303). This form of hearing assistive technology can incorporate frequency modulated or infrared waves; and a wearable or remote microphone (RM) can transmit the amplified signal to speaker(s) placed throughout the classroom for all students to hear (Atcherson et al., 2015, p. 104).

Benefits of Group Amplification Systems

There are several benefits to incorporating this form of amplification in the elementary school classroom. According to Flexer, Biley, Hinckley, Harkema, & Holcomb (as cited by Dockrell & Shield, 2012), students are now able to clearly hear information being presented throughout the school day, which will presumably increase their academic engagement in the content material being presented (p. 1163). This greater level of attention and excitement regarding academic activities will potentially help students stay focused while completing assignments.

The teacher will also experience less vocal strain by speaking at a normal volume into the microphone, rather than continuously projecting oneôs voice throughout the entirety of the school day. Larsen and Blair (2008) investigated the impact of group amplification systems on the improvement of the signal-to-noise ratio in fourth grade general education classrooms (pp. 454-455). Four classrooms, each containing 24-26 students, were selected to participate in the study (p. 454). Each teacher utilized an Audio Enhancement Ultimate 2000 dual-channel infrared system throughout classroom instruction, while a time, energy, frequency system (TEF) was incorporated

to gain measurements of noise and reverberation throughout the school day (p. 454). Larsen and Blair found that across all four elementary school classrooms -- utilizing this form of hearing assistive technology -- the teacherôs voice was 13.5 dB louder than the ambient classroom noise. The use of a group amplification system positively affected not only studentsô attention and the overall classroom signal-to-noise ratio, but the teacherôs vocal health as well (p. 456).

Finally, group amplification systems can positively impact studentsô learning and subsequent understanding of literacy concepts presented throughout the school day. According to Flexer (as cited by Barrett, 2011), having clear auditory input relating to the sound structure of a language presents an improved opportunity for students to acquire reading and literacy concepts (p. 30). Therefore, in Flexerôs opinion, the use of a group amplification system positively impacts studentsôknowledge of phonemic awareness in the classroom environment.

Challenges of Group Amplification Systems

On the other hand, group amplification systems may also present some challenges in the general education classroom. As teachers are required to wear a microphone via a neck loop or headset throughout the duration of the school day, they may experience some discomfort related to the wearing of the device (Nelson et al., 2013, p. 243). Should this discomfort become too great a bother to teachers, they may improperly wear the device, which may then not appropriately amplify the voice, or teachers may simply refuse to utilize the system entirely. Most notably, Nelson and her colleagues (2013) found that preschool teachers rated technical difficulties as the most challenging feature of a group amplification system (p. 243). Much like personal amplification systems, technical difficulties can result in the system being of limited or no benefit to students, as well as a disruption to the classroom environment if they require frequent technical support.

Group Amplification Systems and Students with Hearing Impairment

Incorporating group amplification systems as a form of hearing assistive technology in the elementary school classroom has historically been shown to be of benefit to students with hearing impairment. This sample population often utilizes cochlear implant(s) or hearing aid(s).

Group Amplification Systems and Students with Cochlear Implants

The use of a group amplification system in the classroom may improve the overall signal-to-noise ratio (SNR) of the space. Noise in the classroom may arise from external or internal sources, making it difficult to clearly hear the teacherôs voice at all times (Crandell & Smaldino, 2000, p. 363). In a study conducted by Punch and Hyde (2010), researchers found that children utilizing cochlear implants in mainstream elementary school classrooms were only able to follow 40% of the spoken classroom conversation due to the presence of competing noise. In the Punch and Hyde study, a group amplification system may aid these students in clearly following and comprehending spoken language in the classroom, as the amplified signal should be clearly audible over the background noise intensity levels (p. 412).

Group amplification systems may also be of benefit to children utilizing cochlear implants in the classroom due to improved phonemic recognition. Iglehart (2004) completed a research study in order to determine the impact of both wall-mounted and desktop amplification systems in an auditory/oral educational environment. A total of 14 children between the ages of 6 and 14 years old participated in the study, each utilizing bilateral cochlear implants due to their severe-to-profound hearing loss (p. 63). A total of 40 consonant-vowel-consonant (CVC) words were randomly presented to participants via a female speaker utilizing the group amplification device, with participants repeating each word after it was presented (pp. 64-65). Results were statistically significant, indicating that the desktop amplification device was more beneficial to participants.

Mean scores increased from 26.6% with no system use to 43.1% with the use of the desktop device, as well as 26.6% with no system use to 37.8% with the use of the wall-mounted amplification device (p. 66). While the desktop amplification system appeared to be more beneficial to this sample population, Iglehart concluded that the use of either type of group amplification system in the classroom would improve phonemic recognition for students utilizing cochlear implants.

Group Amplification Systems and Students with Hearing Aids

Group amplification systems may also prove to be of benefit to students utilizing hearing aids if students are refusing to wear this form of hearing assistive technology entirely. For example, Coniavitis-Gellerstedt (as cited by Rekkedal, 2015) concluded that 32% of his sample population of elementary school students did not appropriately wear their hearing aids in the classroom due to their perceived lack of benefit or absolute refusal (p. 19). In this case, a group amplification system may aid these students in receiving some form of increased signal when their hearing aid(s) are not in use.

A group amplification system may also be of benefit to this sample populationôs overall academic performance. In the same study, Punch and Hyde (2010) found that about 70% of their elementary-aged participants with hearing aids fell below the average class score in academic achievement, particularly for reading, writing, and mathematics (p. 417). With the use of a group amplification system, these students may be able to receive additional benefit through the receipt of an improved signal during instruction, leading to a greater focus and resulting in improved academic performance (p. 418). This increase in focus and improved academic performance may also be exhibited by students with Auditory Processing Disorders who utilize a group amplification system in their classroom, as will be explained more fully in the sections that follow.

Auditory Processing Disorders

Since up to 46% of children with Autism Spectrum Disorders may additionally present with symptoms of Auditory Processing Disorders, it is important to recognize various features of this syndrome (Iliadou, Bamiou, Kaprinis, Kandylis, & Kaprinis, 2009, p. 1029). Within this section, the researcher will explore the demographics, etiologies, and common characteristics of Auditory Processing Disorders, as well as the benefit of group amplification systems for this sample population.

Demographics

It has been estimated that about 7% of the global population under age 10 years has been diagnosed with Auditory Processing Disorders or APD (Bamiou, Musiek, & Luxon, 2001, p. 361). In order to determine a more precise prevalence of APD in the pediatric population, Nagao, Reigner, Padilla, Greenwood, Loson, Zavala, & Morlet (2016) recently completed a research study. A total of 243 children were referred for an APD evaluation and participated in the study (para. 4). Results indicated that the prevalence of Auditory Processing Disorders for this sample population was found to be 1.94 per 1,000 children. Children who attended private schools were twice as likely to be diagnosed with APD as their peers enrolled in public schools (para. 6). Nagao and colleagues concluded that these results appear to be below the prevalence data regarding APD in the pediatric population, compared to past research, but continued to suggest a strong need for children to be screened for the disorder once they enter the public educational environment (para. 7).

Etiologies

Research has not identified a direct cause of APD in children, with a wide range of possibilities having been suggested, such as cognitive, memory, or linguistic challenges, each

playing a role in the diagnosis of the disorder (Bamiou et al., 2001, p. 362). Auditory Processing Disorders may co-occur with three major categories of disease -- including neurological conditions, abnormal formation of the central nervous system, or additional developmental disorders (p. 362). Neurologically, APD has been additionally present in rare cases of bacterial meningitis or Lyme disease (pp. 362-363). Frequent ear infections at a young age can also place a child at a greater risk for Auditory Processing Disorders later in childhood (Yalçinkaya, 2008, p. 102). Tumors of the central nervous system may occupy areas of the brain critical to audition, simultaneously causing an Auditory Processing Disorder (Bamiou et al., 2001, p. 262). Developmentally, factors such as prematurity, low birth weight, head trauma, or exposure to carbon monoxide at a young age may also play a role in the etiology of an Auditory Processing Disorder (Yalçinkaya, 2008, p. 102). Finally, APD may be combined with additional disabilities, such as Attention Deficit Hyperactivity Disorder (ADHD), developmental dyslexia, or Autism Spectrum Disorders (ASD), as will be further addressed in future sections.

Common Characteristics

Auditory Processing Disorders are often characterized by difficulty in sound localization, processing of auditory information, speech perception and comprehension, and/or the development of language. Typically, studentsô peripheral hearing is within normal limits, but for some, the signal is potentially being transmitted from the cochlea ñimproperly,ò resulting in a unique hearing difference. Simply put, a definition of Auditory Processing Disorders is -- difficulty in ñwhat the brain does with what the ear hearsò (Deconde Johnson & Seaton, 2012, pp. 198-199). This disorder may become noticeable in the early academic years, typically due to the introduction of a new and oftentimes noisy acoustic environment in the classroom and an increased emphasis on academic performance (Bamiou et al., 2001, p. 361).

Students with APD may receive intervention services in a top-down, bottom-up, or sound-based format. Top-down services typically stress the importance of practicing verbal language skills, while bottom-up approaches often focus on aspects of signal discrimination. Sound-based interventions have utilized various styles of music to aid children with decreased sensory, behavioral, emotional, or mental difficulties (Papagiannogoulu, 2015, p. 521). A combination of these intervention options may potentially need to be incorporated with this sample population (Sharma, Purdy, & Kelly, 2012, p. 507). Group amplification systems may also be a helpful intervention tool to utilize with this sample population, as will be addressed in the following section.

Benefits of Group Amplification Systems for Students with Auditory Processing Disorders

The following research studies address the use of group amplification systems for students with Auditory Processing Disorders. Overall, researchers have found a positive relationship utilizing group amplification systems with this sample population.

Johnston, John, Kreisman, Hall, and Crandell (2009) investigated the benefit of amplification systems on students ages 8 to 15 years old with APD (pp. 372-373). A total of 10 children diagnosed with APD and 13 children whose hearing was within normal limits participated in the study, with an amplification system utilized during lecture-based classroom activities (pp. 372-373). Academic performance was evaluated via the *Screening Instrument for Targeting Educational Risk* (SIFTER) (Anderson, 1989, p. 1), while speech perception was measured utilizing the *Hearing In Noise Test* (HINT) (Nilsson, Soli, & Sullivan, 1994, p. 1085), 5 months after the amplification system had been implemented in the classroom (p. 374). While no statistical significance was reported, Johnston and her colleagues concluded that the use of an amplification system improved participantsô overall academic performance, speech perception, and functioning

in social situations when compared with the control group whose hearing was within normal limits. This improvement for participants with APD was additionally noted by their parents based on a questionnaire, specifically probing their childrenôs improvement in both academic and social situations (pp. 375-378).

Incorporating group amplification systems in classrooms may also benefit students with APD through an increased focus during top-down or bottom-up intervention activities. Sharma and colleagues (2012) compared student performance throughout intervention periods when utilizing an amplification system as compared to no system use. Activities ranged from language instruction, such as following directions, to auditory discrimination, such as phonological awareness training (p. 511). These researchers found that implementing amplification systems throughout the studentsô intervention periods significantly improved participantsô scores on language tasks. Although results were not statistically significant, both language instruction and phonological awareness training improved when the amplification system was in use (p. 514).

Group amplification systems have been shown to be of benefit not only during the intervention period, but throughout whole-group language instruction as well. Students with APD may benefit from the use of a group amplification system in the classroom due to an increase in speech perception and comprehension. These individuals will often experience difficulty in the classroom due to its noisy environment. Through the use of a group amplification system, however, students are often able to focus on the teacherôs voice, or the signal, over the classroom background noise (Deconde Johnson & Seaton, 2012, p. 215).

Leung and McPherson (2006) designed a research study to compare the use of the group amplification system ñPhonic Earò to a public- address system in presenting clear, understandable speech in the presence of competing noise. Four elementary school classrooms were involved in

the study, each containing students with APD (pp. 290-291). Speech intensity levels were measured with the use of no amplification, the ñPhonic Earò group amplification system, and the public-address system (p. 292). Results indicated that the average speech intensity of the public-address system was 4 dB lower than the ñPhonic Earò group amplification system (p. 294). Leung and McPherson concluded that group amplification technology benefits students with Auditory Processing Disorders through the presentation of a more clear, audible signal over background classroom noise.

Group amplification systems may also prove to be of benefit to students with APD through a potentially measurable increase in attentive behavior. Blake, Field, Foster, Platt, and Wertz (1991) investigated the impact of amplification systems on the attentive behavior of elementary school students during the teaching of reading, science, math, and spelling subjects (p. 112). They found that students significantly improved on four specific attentive behaviors, including eye contact, body positioning, lack of movement, and lack of background conversation when the amplification system was in use during these subject areas. Results indicated that an increase in eye contact was found to be the most significant improvement (Blake et al., 1991, p. 113). Utilizing a group amplification system in the classroom may benefit students with APD as they are able to acutely attend to the verbal instruction presented. Students with Autism Spectrum Disorders may also benefit from the use of a group amplification system in the classroom, as will be explained in the sections that follow.

Autism Spectrum Disorders (ASD)

In order to better understand a portion of the sample population of this study, it is critical to recognize various features of Autism Spectrum Disorders (ASD). In this section, the researcher

will describe the demographics, etiologies, and common characteristics of persons with Autism Spectrum Disorders.

Demographics

It has been estimated that about 1% of the global population has been diagnosed with Autism Spectrum Disorders or ASD (Christensen, Baio, & Van Naarden Braun, 2016, p. 1). Specifically, in the United States, prevalence is 1 in 68 births or 1.5% in children ages 8 years or younger (p. 1). ASD is 3-4 times more likely to impact the lives of males rather than females, and its effects continue to last throughout a personôs life (National Institute on Deafness and other Communication Disorders, 2016, p. 1).

Etiologies

Research has not identified a direct cause(s) for ASD in children, with a combination of genetic and environmental factors both apparently playing a potential role (Christensen, Baio, & Van Naarden Braun, 2016, p. 3). Strong evidence supports the etiology of family history on ASD. This evidence indicates that having a sibling or twin with an Autism Spectrum Disorder will increase the likelihood that the child will also have ASD (p. 3). The older age of a mother or father, as well as single gene disorders, such as Fragile X Syndrome, may also play some potential roles in causation of Autism Spectrum Disorders (p. 3). Suspected evidence also supports the idea of family history of immune-associated conditions, such as thyroid disease, being a possible etiology for an Autism Spectrum Disorder in a child. Lastly, genetic mutations or complications during pregnancy are potential factors in the etiology of ASD (p. 3). The Centers for Disease Control and Prevention is currently developing the ñStudy to Explore Early Developmentò in order to better understand these factors, as well as many others, that may play a role in the etiology of Autism Spectrum Disorders in the pediatric population. The CDC study

will include both genetic and environmental factors with a large sample population (p. 3). Specifically, the CDC study was in response to an increase in parental concern about the possibility of an Autism Spectrum Disorder following vaccination (Rao & Andrade, 2011, p. 95). A detailed account of this study is beyond the scope of this chapter. For more information, please visit https://www.cdc.gov/ncbddd/autism/seed.html.

Common Characteristics

According to the American Psychiatric Association (2016), an Autism Spectrum Disorder (ASD) is ña complex developmental disorder that can cause problems with thinking, feeling, language, and the ability to relate to othersò (p. 1). ASD is commonly referred to as a ñspectrum,ò meaning that the disorder may affect each patient differently while ranging from mild to severe (Christensen, Baio, & Van Naarden Braun, 2016, p. 1).

There are three characteristics that clearly define an individual with ASD, commonly referred to as the ñtriadò of symptoms (Ennis-Cole, 2015, p. 6). Each characteristic is also outlined in the Diagnostic and Statistical Manual of Mental Disorders (DSM) 5 (see Appendix A).

Symptoms may first include difficulty with various *social skills*. Socially, those with ASD may experience difficulty maintaining eye contact with a speaker or taking turns with a conversational partner (Ennis-Cole, 2015, p. 6). *Receptive and expressive language* may also be affected in a patient with Autism Spectrum Disorders, especially through a lack of creative play or understanding information across multiple contexts (p. 6). *Behavior* may be a challenging feature of patients with Autism Spectrum Disorder. Interestingly, *"stereotypical" behavior*, such as following a schedule or routine, may actually be beneficial in helping patients with ASD stay on track both academically and within and in the larger world. Repetitive behaviors, such as

squeals or hand movements (ñflailingò or ñflappingò), may also be frequently observed (p. 11). Lastly, those with Autism Spectrum Disorders may present difficulties in reaction to a particular sensory environment (Alcantara, Weisblatt, Moore, & Bolton, 2004, p. 1107). This difficulty may include hyperacusis, or an increased sensitivity to auditory stimulation, as well as challenges in detecting and comprehending speech in the presence of background noise (p. 1107). Classrooms with a poor signal-to-noise ratio (SNR) may be improved for students with Autism Spectrum Disorders through the use of a group amplification system, as will be further explained in future sections.

Group Amplification Systems and Students with Autism Spectrum Disorders

Children with Autism Spectrum Disorders may also utilize group amplification systems in the general education classroom. In order to understand the use of this hearing assistive technology with *this* portion of the sample population, some background information regarding this population and hearing assistive technology is considered necessary.

Auditory Processing Strengths in Children with Autism Spectrum Disorders

Auditory processing in children with Autism Spectrum Disorders may be enhanced through an increase in comprehension of auditory stimuli or overall pitch perception. Due to these abilities, strengths in auditory processing for this sample population will be broken down into speech and musical environments (Remington & Fairnie, 2017, p. 460).

Auditory processing strengths related to speech perception.

In a conversational environment, children with ASD may present an increased understanding of auditory content presented (p. 462). Remington and Fairnie (2017) completed a research investigation in order to understand the auditory comprehension patterns of children with Autism Spectrum Disorders. These researchers had both typically-developing and

participants with ASD listen to a scene between four characters wrapping presents and preparing food for a party. After a short period of time, an additional character entered the auditory environment, continuously repeating the phrase, ñIôm a gorilla,ò for 19 seconds (p. 462). Results indicated that 47% of participants on the Autism Spectrum noticed this ñgorillaò character in the background of the scene, while only 12% of typically-developing participants were aware of this character, demonstrating a significant difference between groups. All participants, however, correctly answered content questions that followed this listening environment (p. 462). Remington and Fairnie concluded that although participants with ASD largely acknowledged this outside auditory stimulus, they were accurately able to attend to the central component of the conversation, suggesting a strong understanding of overall auditory content (pp. 462-463).

Auditory strengths related to music perception.

The following studies have examined music perception abilities in patients with Autism Spectrum Disorders. These researchers have observed a significant increase in pitch perception and sensitivity in patients with ASD compared to their typically developing peers.

Quintin, Bhatara, Poissant, Fombonne, and Levitin (2013) designed a research study in order to examine the processing of musical sequences in children with ASD. Typically developing and participants with ASD were observed while utilizing the MusicBlocks^{TM} toy for this experiment, with five corresponding cubes each playing their own melody. Each participant was instructed to listen to the musical sequence played by the MusicBlocks^{TM} base, and then insert the corresponding sound cubes into the base in the correct sequence to create the same melody (p. 257). Scores were tallied based on the number of cubes inserted into the correct location on the base (pp. 257-258). Results indicated that there were no significant differences between the two groups of subjects on this musical puzzle task. However, Quintin and his

colleagues found that there was an increase in perceptual functioning and memory related to the auditory domain in patients with ASD (p. 260).

Children with ASD may present additional auditory processing strengths through improved pitch sensitivity in musical settings. Bonnel, Mottron, Peretz, Trudel, Gallun, and Bonnel (2003) designed a research study to examine the ability of children with Autism Spectrum Disorders to detect a change in pitch during a melody. Researchers asked typically-developing students and students with ASD to listen to a set of two tones and to then describe if the tones were the same or different after listening to each for several seconds. Participants were also asked if the second tone was ñhigherò or ñlowerò than the first (p. 227). Results were not significant, but indicated that participants with Autism Spectrum Disorders were better able to discriminate the pure-tones as similar or different than their typically-developing peers. Participants with ASD were also better able to distinguish the second tone as ñhigherò or ñlowerò than the first, compared to the typically-developing group (pp. 228-229). From these results, Bonnel and colleagues concluded that pitch discrimination in music is an ñabsolute peakò (p. 231), or large strength in patients with Autism Spectrum Disorders.

Children with Autism Spectrum Disorders may also present a strength in auditory processing through the ability to segment a melody into individual chords. Heaton (2003) designed a research study to investigate the ability of children with ASD to ñdisembed,ò or distinguish, an individual chord from a melody (p. 543). A total of 14 participants with ASD were first familiarized with four different, individual animal tones. They then listened to a group of three tones at once, and were asked to distinguish which animal tone was missing (p. 546). Results indicated that children with Autism Spectrum Disorders performed significantly better on this listening identification task than their typically-developing peers utilized as a control

group (pp. 546-547). From these data, Heaton concluded that some children with ASD appear to have improved musical abilities in analyzing a melody and distinguishing an individual note from a group.

From the above studies, it is clear that patients with Autism Spectrum Disorders demonstrate several strengths in the area of music perception. Researchers have specifically noted an increase in pitch perception and sensitivity when compared to control subjects, which included typically-developing peers.

Auditory Processing Challenges in Children with Autism Spectrum Disorders

Auditory processing in children with Autism Spectrum Disorders may also be hindered by abnormal reactions to a particular sensory environment. As such, challenges in auditory processing for this sample population are broken down into behavioral and neurophysiological components (O'Conner, 2012, p. 837).

Auditory processing challenges related to behavior.

Behaviorally, children with ASD may present difficulties in perceiving differences in pitch (p. 838). Heaton and colleagues (as cited by O'Connor, 2012), completed a research study in order to examine the processing of pitch in children with Autism Spectrum Disorders. These researchers had study participants match pure-tone or speech stimuli to pictures of various animals. Results were not significant, but Heaton and colleagues found that participants with Autism Spectrum Disorders were highly accurate on the identification of pure-tone sounds, and struggled with the identification of speech stimuli. These researchers concluded that children with ASD may present difficulties with speech perception (p. 838).

Children with Autism Spectrum Disorders may also present behavioral challenges through the abnormal processing of auditory information while in the presence of background

noise. Groen, Van Orsouw, Ter Huurne, Swinkels, Van Der Gaag, Buitelaar, and Zwiers (2009) investigated speech recognition scores in children with ASD while in the presence of competing ñpinkò or ñrippleò noise (p. 744). Groen and his colleagues concluded that a ñdipò or decrease in background noise inversely corresponded with an increase in speech recognition scores, with no significant differences resulting. These findings suggested that children with ASD may struggle with speech recognition in a noisy environment (p. 746).

Lastly, children with Autism Spectrum Disorders may present behavioral difficulties through abnormal functioning in the classroom or home environments. Fernández-Andrés, Pastor-Cerezuela, Sanz-Cervera, and Tárraga-Mǫnguez (2015) conducted a research study utilizing the *Sensory Processing Measure* (SPM) (Miller-Kuhaneck, Henry, Glennon, & Mu, 2007, p. 170) in order to identify the main challenges participants with ASD faced in the educational or home settings (p. 206). A total of 79 children between the ages of 5 and 8 years participated in the study, with parents filling out responses to the SPM (p. 204). These researchers found that parental reports on the SPM indicated their childôs difficulty with sensory systems, social participation, planning, and generating original ideas. Most notably, Fernández-Andrés and colleagues found that the highest percentage of difficulty for this sample population was in hearing and following subsequent directions, with 63.4% of participants struggling in this sensory domain (p. 207). From these statistically significant results, researchers concluded that verbal instruction or unpredictable noises in the classroom or home environments were more difficult for children with Autism Spectrum Disorders to follow and comprehend (p. 210).

Auditory processing challenges related to neurophysiological components.

Children with Autism Spectrum Disorders may also present neurophysiological differences that impact their auditory processing. The auditory cortex of the brain is comprised

of both primary and secondary regions. The primary region of the auditory cortex is responsible for processing pure-tone sounds. The secondary regions are believed to be accountable for processing more complex auditory stimuli and are thought to be physically larger on the left side of the brain in a child who is typically developing (OôConnor, 2012, p. 841). MRI research conducted by Shapleske and colleagues (as cited by OôConnor, 2012) supported this claim, and has shown that secondary regions on the left side of the brain in patients with Autism Spectrum Disorders were smaller in size when compared with their typically developing peers (p. 841). Based on these results, Shapleske and colleagues concluded that this smaller secondary region in the auditory cortex may account for the difficulties in speech perception and recognition many patients with ASD face (p. 841).

Patients with ASD may also have decreased activity in Broadmannôs Area 22, a portion of the brain critical for speech processing and subsequent understanding (Papagiannopoulou, 2015, p. 518). Boddaert, Belin, Chabane, Poline, Barthélémy, Mouren-Simeoni, Brunelle, Samson, and Zilbovicius (2003) conducted a research study in order to compare cerebral blood flow in patients with Autism Spectrum Disorders while listening to speech-like sounds and at rest (p. 2057). Five patients were tested utilizing Positron Emission Tomography (PET) throughout three different testing conditions. The first condition simply measured cerebral blood flow during a period of rest, while the remaining two conditions presented speech-like auditory stimuli (p. 2059). Statistically significant results indicated that less cerebral activation was observed in Broadmannôs Area 22 ï the inferior temporal gyrus ï during the conditions when speech-like stimuli were presented (p. 2060). These researchers concluded that this decreased activation may account for difficulties in auditory processing common to many patients with ASD (p. 2060). Based on these findings, the challenges of auditory processing for patients with

ASD may be improved through the use of a group amplification system in the classroom, as will be addressed in the following section.

Auditory Processing Challenges Ameliorated by Group Amplification Systems

The following research studies address the use of a group amplification system with students diagnosed with Autism Spectrum Disorders, similar to *this* study. Overall, several research studies have found a positive relationship between the use of this hearing assistive technology with this sample population. These results show the promising application of this research in the mainstream classroom.

Rance, Saunders, Carew, Johansson, and Tan (2014) investigated the impact of amplification systems on listening abilities of students with ASD from ages 8 to 15 years (p. 353). Speech perception was measured by utilizing the *Consonant-Nucleus-Consonant Word Test* (Lehiste & Peterson, 1959, p. 280), which primarily focuses on three letter words. Daily listening skills were measured through a ñtake home trial periodò (p. 354), in which students utilized the system in their classroom for 2 weeks, followed by a 2-week period of no system use (p. 354). During these time periods, classroom teachers were asked to record their thoughts and observations regarding study participantsô listening skills. Results in speech perception showed that study participantsô scores significantly improved when the group amplification systems were in use (p. 355). Furthermore, teacher evaluations of study participants following their 2-week trial period (with amplification) included positive comments, specifically reflected in observations noting increased listening comprehension, improved classroom behavior, and overall attention benefits (p. 355). These researchers concluded that the use of such amplification systems may prove to be beneficial to this sample population in the general education classroom.

Group amplification systems may aid students with Autism Spectrum Disorders through an increase in speech recognition abilities while in the presence of background noise in the general education classroom. For example, Schafer and colleagues (2016) investigated the benefit of remote-microphone (RM) technology for students with ASD ages 6 to 17 years in mainstream classrooms. Speech in noise measures were evaluated using the *Bamford-Kowal-Bench Speech in Noise Test* (Bench, Kowal, & Bamford, 1979, p. 108), in which participants listened and repeated back sentences while varying levels of background noise were also present (p. 7). Listening comprehension was evaluated utilizing the *Ross Information Processing Assessment* (RIPA) (Ross-Swain, 1996, p. 1) in which participants were asked to recall auditory information recently presented and answer a variety of grade-level mathematics and literacy questions (p. 7). Results indicated that participantsô scores on both the speech in noise and RIPA measures were significantly different. Most notably, these scores significantly improved when the RM system was in use throughout the general education classroom, with participants noting improvements in following verbal instruction when no visual cues were present, hearing in the presence of background noise, and hearing in large group situations (p. 11). The researchers concluded that this sample population can gain substantial benefit from utilizing this form of hearing assistive technology in the classroom (p. 15).

Utilizing a group amplification system may additionally help students on the Autism Spectrum effectively process information presented throughout the school day. Wiley, Gustafson, and Rozniak (2014) designed a qualitative research study to examine the various needs of parents who had children ages 3-4 years, both on the Autism Spectrum and who were deaf or hard of hearing (p. 40). Severity of hearing loss ranged from mild unilateral to profound bilateral, with the severity of Autism Spectrum Disorders also differing between each child (pp.

42-43). Wiley and colleagues asked families ñfocus group questionsò to determine assorted parental needs (p. 42). One familyôs results emphasized the positive use of an amplification device in their childôs classroom. This family stated that their child became distressed very easily if the amplification system was not in use, and that it specifically aided their child in processing verbal information presented in the classroom environment (pp. 45-46). From the overall results, Wiley and her colleagues concluded that amplification devices may be a helpful tool in aiding this sample population, as well as their parents, in providing helpful classroom and life instruction.

Group amplification systems may also increase productive communication and social interaction for students with ASD in the classroom. Rance, Chisari, Saunders, and Rault (2017) conducted a research study to examine the benefit of Phonak Roger© devices for students ages 6 to 12 years with ASD (p. 2012). Rance and colleagues first had participants fill out the *Abbreviated Profile of Hearing Aid Benefit* (APHAB) (Cox & Alexander, 1995, p. 176) to gauge the amount of listening difficulty participants encountered in their current educational environment (p. 2013). Pure-tone audiometric testing was then completed as a baseline measure in order to determine participantsô current threshold levels (pp. 2012-2013). Throughout the duration of this study, participants utilized the Phonak Roger© device for a trial period of 1-2 weeks for 4-6 hours per day. During this time, participants were administered the *Consonant-Nucleus-Consonant (CNC) Word Test,* as well as incorporating the device into the participantsô educational and home settings (p. 2013). Following this trial period, participants filled out the APHAB once more, with parents filling out the *Child Behavior Checklist* (Achenbach, 2001, p. 1) as a corresponding measure (p. 2013).

Results from the initial APHAB data participants rated day-to-day situations as the worst listening scenario presented, followed by results rising to the normal range for home and educational environments, following the 1-2 week trial period (Rance, Chisari, Saunders, & Rault, 2017, p. 2016). Additionally, pre- and post-test parent checklists indicated a significant decrease in their childôs social anxiety when the Roger© system was in use (pp. 2016-2017). From these data, Rance and colleagues concluded that group amplification systems, specifically the Phonak Roger© device, may decrease social tension and improve listening comprehension for students with Autism Spectrum Disorders (p. 2018).

Finally, group amplification systems may decrease stress levels throughout both individualized and group instruction for students with ASD. In a second part to the research study introduced above, Rance and colleagues (2017) also examined cortisol levels in students with ASD, ages 13 to 14 years, to note their physiologic stress levels while group amplification systems were in use (p. 2010). Participants first completed audiometric testing in a quiet classroom environment with minimal background noise. The following two scenarios each presented a small activity for participants, with questions posed throughout its completion to maintain attention (p. 2015). In one of these scenarios, the speakerôs voice was unamplified, while the next scenario utilized the Phonak Digimaster 5000© amplification system (p. 2015). A minor amount of ambient noise at <50 SPL was additionally present during this time in order to mimic background noise in a typical classroom environment. Saliva samples were collected five minutes before and 25 minutes after the beginning of each activity period, and were kept at room temperature for five days before undergoing testing for cortisol (p. 2014). Results indicated no significant increase in cortisol concentration throughout the session without an amplification system; however, a significant decrease in cortisol concentration was shown over the course of

the amplified session (p. 2018). Rance and colleagues therefore concluded that the use of a group amplification system may decrease listening stresses in the educational environment experienced by students with Autism Spectrum Disorders (pp. 2018-2019).

From the above studies, it is clear that the use of group amplification systems in the general education classroom can have many positive impacts on students with Autism Spectrum Disorders. Specifically, findings have noted an increase in attentive behavior, improved listening comprehension, and enhanced listening in the presence of background noise, for these students.

Conclusion

The number of students with Autism Spectrum Disorders who are being mainstreamed in general education classrooms has continued to increase in recent years. As such, it is imperative to understand and implement appropriate, reasonable accommodations, including amplification systems, to support this sample population in the mainstream classroom. To this end, this chapter has presented a review of the current literature regarding amplification systems, as well as the benefits and ñchallengesò of their use with students, including those who have ASD. Specifically, this chapter has presented an overview of both personal and group amplification systems, the use of this hearing assistive technology with students who have hearing impairment, as well as the use of this technology with students on the Autism Spectrum who may present additional symptoms, specifically, Auditory Processing Disorders. The following chapter will review the methods designed to address the benefits and/or challenges of utilizing group amplification systems with first-grade students throughout academic, language-based tasks.

CHAPTER III: METHOD

In order to examine the academic benefits and/or challenges of group amplification systems during language-based tasks, this study employed a quantitative approach to research and was completed in a two-part procedure. Lead teachersô listening ratings and studentsô performance on spelling tests were measured while staying in line/following with the already established or current school curriculum in two first-grade classrooms in a local elementary school. This chapter will outline the method by which this study was completed, including an explanation regarding the use of experimental research. Additionally, information concerning the study participants and materials incorporated throughout the study will be discussed, as well as a detailed description of the studyôs procedures.

Justification of Method

Experimental research was selected by the researcher because, according to Fisher (1962), ñexperimental observations areé designed to form a secure basis of new knowledgeò (p. 8). Through both the quantitative results and qualitative observations of this study, first-grade teachers may learn more about amplification strategies to implement with students for future spelling testing experiences. As there has also been little to no research conducted regarding the benefits and/or challenges of group amplification systems in the first-grade classroom, experimental research regarding this topic was deemed the most efficient method to introduce new information and experiences regarding this research topic.

Additionally, ñit is possible to draw valid inferences from the results of experimentationé from observations to hypothesesò (p. 3). Based on the results of this study, the researcher translated the collected numerical data into practical application strategies for lead teachers in first-grade classrooms to consider in order to incorporate the use of group amplification systems.

Lastly, through experimental research, the researcher, ñcan schedule treatments and measurements for optimal statistical efficiencyò (Campbell & Stanley, 2015, p. 1). In this way, the researcher has access to treatment groups when they are most available. Specifically, for this study, the researcher scheduled the pretest procedure on the first day of data collection, prior to the implementation of a group amplification system in one of the classrooms. Following this pretest procedure, two days of spelling intervention activities, which included the use of a group amplification system in one classroom, provided students with the opportunity for auditory reinforcement prior to the spelling posttest on the final day of data collection. This scheduling ensured that students in each classroom received the same data collection procedures daily, excluding the use of a group amplification system in one classroom for intervention and posttest measures.

Participants

Participants included lead teachers and students in two first-grade classrooms at an area elementary school in rural Ohio, incorporating some students diagnosed with Autism Spectrum Disorders. Prior to the beginning of data collection, the researcher asked each teacher regarding the number of students on an Individualized Education Plan (IEP) in his/her classroom. Of these students on an IEP, the researcher then asked for the number of students diagnosed with an Autism Spectrum Disorder. No additional personal information about these students was disclosed however, such as any studentôs name, sex, or age, preventing the linkage of an IEP to a specific student. A total of 34 students completed this study, with 17 students in Classroom A and 17 students in Classroom B.

Instruments

The first part of this research study was completed utilizing a researcher-designed ñListening Inventoryò (see Appendix B). This screening instrument was composed of six questions and was adapted from items in the *Children's Auditory Performance Scale (CHAPS)* (Smoski, Brunt, & Tannahill, 1998, p. 1), *Listening Inventory for Education (LIFE)* (Anderson & Smaldino, 1998, p. 1), *Classroom Listening Scale* (Barrett, Huisingh, Zachman, Blagden, & Orman, 1992, p. 1), and *LittlEARs* (Kuhn-Inaker, Welchbold, Tsiakpini, Connix, & DôHaese, 2003, p. 1). Utilizing a limited three-point scale, each lead teacher rated individual studentôs routine listening or ñperceptionò abilities on a scale from 1 (Rarely) to 3 (Often). The second part of this research study was completed using a spelling list adapted from the current curriculum, as well as researcher-designed lesson plans detailing two days of spelling intervention (see Appendices C and D). The spelling list was composed of 10 words tailored to the lead teachersô standard curriculum. Each lesson plan also outlined the daily content to be addressed, as well as provided a detailed description of the lesson procedure. Materials for the first lesson included an Epson projector, ñSpelling Word Tongue Twisterò worksheets, and practice spelling test forms. Materials for the second lesson included Bingo game cards, assorted Bingo game markers, and practice spelling test forms. The group amplification system utilized in Classroom A throughout the intervention and posttest procedures was a LightSpeed Redcat system.

Procedures

Prior to the start of data collection, The College of Woosterôs Human Subjects Research Committee approved this study on November 2, 2017 (see Appendix E). Approval was also granted from the specific school district superintendent on November 12, 2017 (see Appendix F).

The individual school principal lastly approved this study on November 19, 2017 (see Appendix G).

Following the receipt of the above-noted approvals, teachers in two first-grade classrooms were first asked to complete the researcher-designed ñListening Inventoryò for each student. As teachers are constantly busy with classroom teaching tasks and grading assignments, among other responsibilities, this inventory was designed to be brief. At the time of the final day of data collection, prior to the administration of the posttest measure, each lead teacher was also asked to revise any inventory responses, should they have observed any notable change in student behavior throughout the experimental procedures.

The next methodological step of this study was the implementation of the four-day experimental procedures. Throughout these procedures, data were first collected in Classroom A, and were then collected in Classroom B due to each classroomôs academic schedule.

The first step was the administration of a pretest to the class members of each classroom, consisting of 10 grade-level spelling words, without the use of an amplification device in either classroom. This list of spelling terms was dictated by the teachersô standard curriculum. Each word was stated once alone, once in a sentence, and once alone.

Following this pretest completion, two days of spelling intervention were provided for 20-30 minutes each day. During these intervention periods, Classroom A incorporated the use of a group amplification device, while Classroom B completed intervention with no amplification as a control measure.

On the first day of spelling intervention, students completed a ñSpelling Word Tongue Twisterò worksheet. Students were encouraged to write silly rhyming sentences while incorporating a chosen spelling word into their written work. This primary day of intervention

concluded with a practice test of five randomly selected spelling words. Each word was stated once alone, once in a sentence, and once alone.

The second day of spelling intervention had students participate in ñSpelling Word Bingo.ò Various spelling words were stated aloud by the researcher, with students placing various sizes and colors of Bingo markers on their game board. If a student completed a Bingo row/card, they were requested to verbally spell each word in their line(s). This second day of intervention concluded with a practice spelling test of the remaining five spelling words. Each word was stated once alone, once in a sentence, and once alone.

Three days following the spelling pretest, each student completed a posttest of the same 10 spelling words. Throughout this testing procedure, Classroom A incorporated the use of a group amplification system, while Classroom B completed testing without amplification as a control measure. This list of spelling terms was scheduled for testing during this specific week as a part of each lead teacherôs standard curriculum. Each word was stated once alone, once in a sentence, and once alone.

Results from the pre- and post-test spelling measures were analyzed to compare studentsô scores from the pre- to post-test measures, with special interest regarding the scores of those potential students with Autism Spectrum Disorders. Studentsôscores were also compared with attention to the teachersôratings on the Listening Inventory. Of particular interest was if students who scored in the low range on the inventory received higher spelling scores with the use of an amplification device. This topic will be further discussed in Chapter IV, which will report the results of this research study.

CHAPTER IV: RESULTS AND DISCUSSION

The purpose of this study was to determine the academic benefits and challenges, if any, of incorporating a group amplification system throughout language-based tasks. These tasks specifically included spelling accuracy for first-grade students, including several students who had the diagnosis of Autism Spectrum Disorders. This chapter will first provide an analysis of the data collected throughout this studyôs experimental procedures, followed by a discussion of these results.

Demographics

A total of 34 first-grade students participated in the study, with 17 students in Classroom A and 17 students in Classroom B. Of these 34 participants, 33 students completed all parts of the study, including pre- and posttest measures, as well as intervention activities, resulting in a 97% participation rate. One student from Classroom B did not complete all parts of the data collection procedures; therefore, this studentôs scores were completely eliminated from the data results and analyses to follow.

Gender and Age

In Classroom A, there was a total of eight females (47.1%) and nine males (52.9%). Students in this classroom ranged in age from 6-7 years, with nine six-year-old students (52.9%) and eight seven-year-old students (47.1%). In Classroom B, there was a total of eight females (50%) and eight males (50%). Students in this classroom ranged in age from 6-7 years, with seven six-year-old students (43.8%) and nine seven-year-old students (56.3%).

Individualized Education Plan (IEP)

In each classroom, lead teachers were asked to identify the number of students who were on an Individualized Education Plan (IEP). Of these students on IEPs, the teachers also identified the number of students diagnosed with an Autism Spectrum Disorder. No further personal information about these students was disclosed, such as their name, sex, or age. In Classroom A, one student was on an IEP (5.9%). This student was reportedly diagnosed with an Autism Spectrum Disorder. In Classroom B, three students were on an IEP (18.8%). Of these three students, one was reportedly diagnosed with an Autism Spectrum Disorder or 33.3% of the students on an IEP; and reflected 6.3% of the students in the classroom.

Listening Inventory

Prior to the beginning of this research study, the lead teachers in Classroom A and Classroom B were each asked to complete a ñListening Inventoryò for each student in their classroom (again, see Appendix B). This instrument was designed to rate studentsô listening or ñperceptionò abilities in the classroom during specific tasks. Responses were collected on a limited scale from 1 (Rarely) to 3 (Always). Overall, the mean Listening Inventory score for the 17 students in Classroom A was 2.60, while the mean Listening Inventory score for the 16 students in Classroom B was 2.53. Lead teachersô ratings for individual students in both Classroom A and Classroom B are presented in Tables 1 and 2, respectively.

Table 1
Listening Inventory Ratings for Classroom A: Individual Students

Student # Code	Q1	Q2	Q3	Q4	Q5	Q6	Mean	SD
2	3	3	2	3	3	3	2.83	0.41
3	3	3	3	3	3	3	3	0
4	3	2	1	2	3	2	2.17	0.75
5	3	3	2	3	3	3	2.83	0.41
6	2	1	1	1	2	1	1.33	0.52
7	3	3	3	3	3	3	3	0
8	3	3	2	3	3	3	2.83	0.41
9	3	3	2	3	3	3	2.83	0.41
10	3	3	2	3	3	3	2.83	0.41
11	3	2	2	3	3	2	2.5	0.55
12	3	3	3	3	3	3	3	0
13	3	3	3	3	3	3	3	0
14	3	3	3	3	3	3	3	0
15	3	2	2	2	2	2	2.17	0.41
16	2	2	2	2	2	2	2	0
17	3	3	2	3	3	3	2.83	0.41
18	2	2	2	2	2	2	2	0
Overall Mean:							2.60	

Ratings: 1 = Rarely
2 = Neutral
3 = Always

Table 2
Listening Inventory Ratings for Classroom B: Individual Students

Student # Code	Q1	Q2	Q3	Q4	Q5	Q6	Mean	SD
19	2	1	1	1	1	1	1.17	0.41
20	2	1	2	1	2	1	1.5	0.55
21	3	3	3	3	3	3	3	0
22	3	3	3	3	3	3	3	0
23	3	2	2	3	3	2	2.5	0.55
24	3	3	3	3	3	3	3	0
25	3	3	3	3	3	3	3	0
26	3	3	3	3	3	3	3	0
27	3	3	3	3	2	2	2.67	0.52
28	3	3	3	3	3	3	3	0
29	3	3	3	3	3	3	3	0
30	3	3	3	3	3	3	3	0
32	3	3	2	2	2	2	2.33	0.52
33	3	2	2	2	2	2	2.17	0.41
34	2	1	1	1	1	1	1.17	0.41
35	3	3	3	3	3	3	3	0
Overall Mean:							2.53	

Ratings: 1 = Rarely
2 = Neural
3 = Always

Based on these individual ratings, studentsô results were then categorized based on a range from low to high scores. The results of the Listening Inventory ranges for students in each classroom are presented in Tables 3 and 4, respectively.

Table 3
Listening Inventory Rating Ranges for Classroom A: Student Groups

Range	Frequency (in %)	n
Low (1.00-1.66)	5.9	1
Mid (1.67-2.33)	23.5	4
High (2.34-3.00)	70.6	12

Table 4
Listening Inventory Rating Ranges for Classroom B: Student Groups

Range	Frequency (in %)	n
Low (1.00-1.66)	18.8	3
Mid (1.67-2.33)	12.5	2
High (2.34-3.00)	68.8	11

Spelling Pre- and Posttest Measures

Each student completed a spelling pretest of 10 grade-level words, following the teachersô standard curriculum. Neither classroom incorporated a group amplification device during the spelling pretest procedure. Following two days of spelling intervention activities, students were again tested on the same 10 grade-level spelling words. Classroom A, however, incorporated the use of a group amplification system during the intervention activities and the posttest procedure, while Classroom B did not, as a control measure. Overall, the mean pretest score in Classroom A was 7.00, while the mean posttest score was 8.76. The mean pretest score in Classroom B was 9.06, while the mean posttest score was 9.44. The mean change score for Classroom A was +1.76, while the mean change score for Classroom B was +0.44. The results of the spelling pre- and posttest results for individual students in Classroom A and Classroom B, as well as individual studentsô corresponding Listening Inventory range, are presented in Tables 5 and 6, respectively.

Table 5
Spelling Pre- and Posttest Results for Classroom A

Student # Code	Pretest Score	Posttest Score	Change	SD	LI Range
2	6	9	+3	2.12	H
3	10	10	0	0	H
4	1	6	+5	3.54	M
5	5	8	+3	2.12	H
6	3	10	+7	4.95	L
7	10	10	0	0	H
8	9	10	+1	0.71	H
9	10	10	0	0	H
10	9	10	+1	0.71	H
11	8	9	+1	0.71	H
12	10	10	0	0	H
13	10	10	0	0	H
14	10	10	0	0	H
15	0	7	+7	4.95	M
16	1	1	0	0	M
17	10	10	0	0	H
18	7	9	+2	1.41	M
Overall Mean:	7.00	8.76	+1.76		

Listening Inventory (LI) Ranges: L = Low (Mean LI score of 1.00-1.66)
M = Mid (Mean LI score of 1.67-2.33)
H= High (Mean LI score of 2.34-3.00)

Table 6
Spelling Pre- and Posttest Results for Classroom B

Student # Code	Pretest Score	Posttest Score	Change	SD	LI Range
19	8	9	+1	0.71	L
20	5	7	+2	1.41	L
21	9	10	+1	1.41	H
22	10	10	0	0	H
23	9	10	+1	1.41	H
24	10	10	0	0	H
25	10	10	0	0	H
26	9	9	0	0	H
27	10	10	0	0	H
28	10	10	0	0	H
29	10	10	0	0	H
30	10	9	-1	0.71	H
32	10	10	0	0	M
33	9	10	+1	0.71	M
34	5	7	+2	1.41	L
35	10	10	0	0	H
Overall Mean:	9.06	9.44	+0.44		

Listening Inventory (LI) Ranges: L = Low (Mean LI score of 1.00-1.66)
M = Mid (Mean LI score of 1.67-2.33)
H= High (Mean LI score of 2.34-3.00)

Overall results from Classroom A indicated a range of pretest responses, with a low score of 0 and a high score of 10. Following the intervention activities and implementation of the group amplification system, posttest results again showed a range of responses, with a low score of one and a high score of 10. However, nine students in Classroom A initially performed well on the pretest measure, earning a total score of 9/10 or 10/10 (even before experiencing the intervention activities and the introduction of the group amplification system). Due to this pre-intervention ceiling effect, these initial pretest results suggested little (or no) ñgrowth roomò for these nine students. The results of the eight students who began with a pretest score of lower than nine, or the **"focus students,"** are presented in Figure 1.

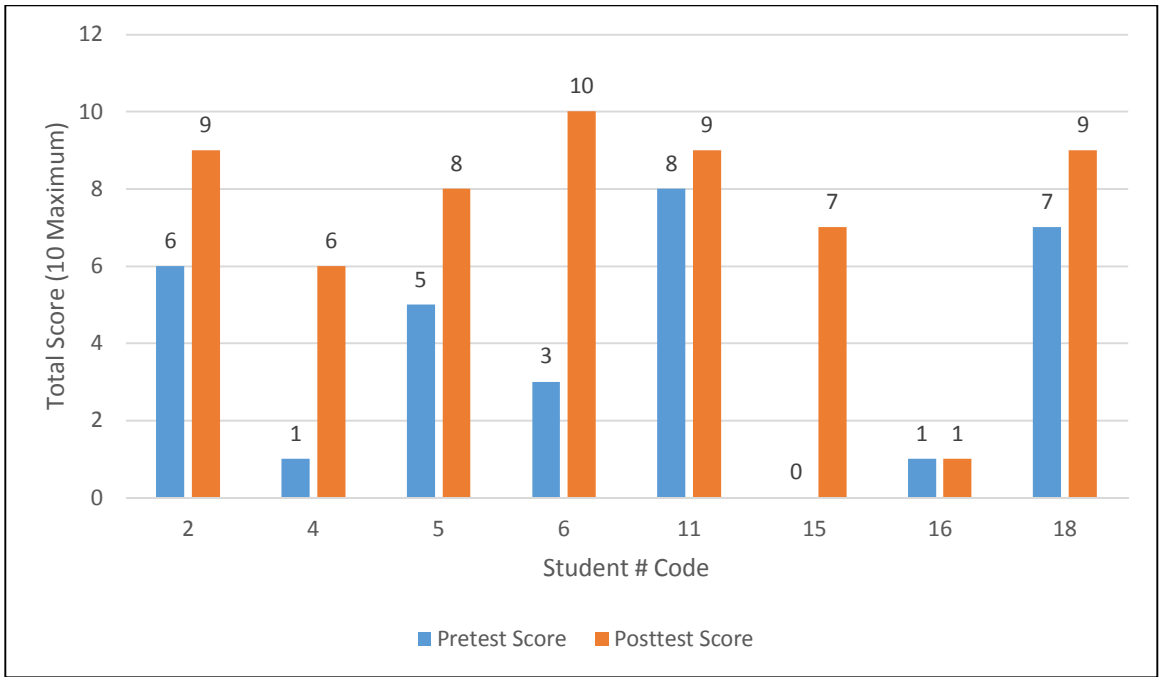


Figure 1. Spelling pre- and posttest scores for **focus students** in Classroom A

Results from Classroom B showed a low score of five and a high score of 10 on the pretest measure (reflecting a range of results which was smaller than that of Classroom A). Following the intervention activities, posttest results indicated a low score of seven and a high score of 10 (again, noting range of results was much smaller than in Classroom A). Thirteen students in Classroom B also initially performed well on the pretest measure, earning a total score of 9/10 or 10/10 (even before experiencing the intervention activities). Again, due to this pre-intervention ceiling effect, these initial pretest results provided little (or no) ñgrowth roomò for these 13 students. The results of the three students who began with a pretest score lower than nine, or the **"focus students,"** are presented in Figure 2.

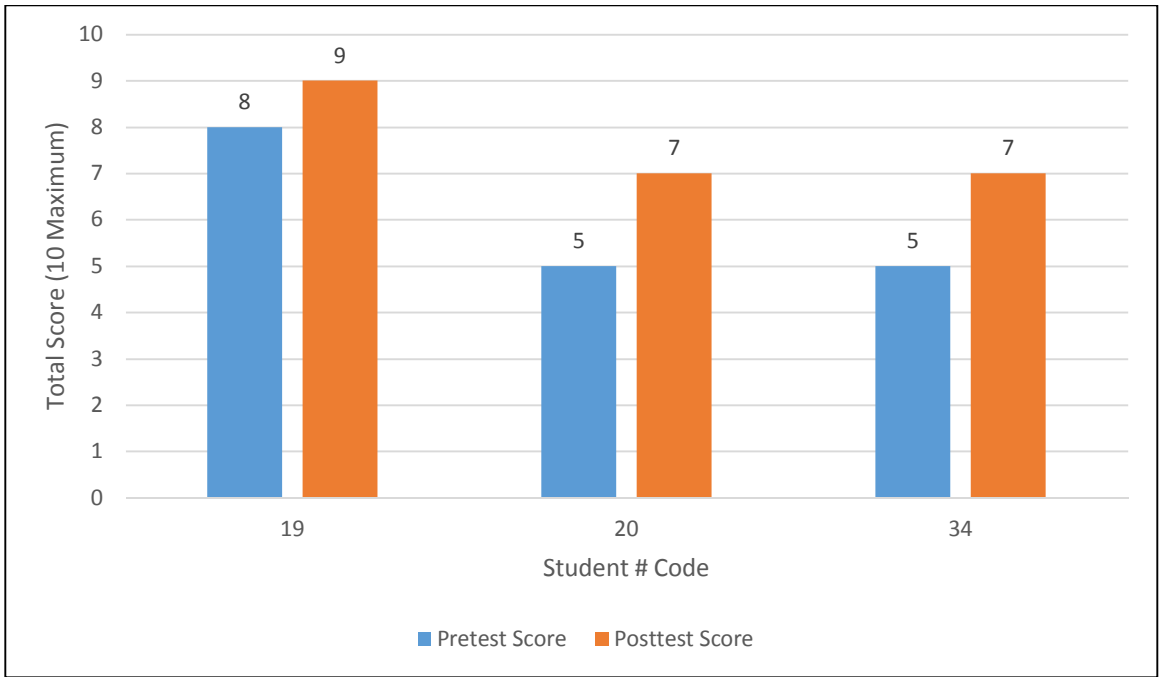


Figure 2. Spelling pre- and posttest scores for **focus students** in Classroom B

Statistical Difference Between Classrooms

To examine the relationship between the two classrooms and the respective studentsô scores on the studyôs variables, five independent samples t-Tests were conducted. These measures included the Listening Inventory, listening-in-noise tasks, pretest measure, posttest measure, as well as the change score from pretest to posttest measures, and will be discussed more fully in the sections that follow.

Listening Inventory Means

To determine the relationship between classrooms on the studentsô average Listening Inventory scores, an independent samples t-Test was conducted. This statistical measure included all student participants from each classroom. Results were not statistically significant between Classroom A (M = 2.60, SD = 0.49) and Classroom B (M = 2.53, SD = 0.68), t(27.14) = 0.31, p = 0.219 on studentsô overall Listening Inventory scores.

Listening in Noise

To compare the studentsô abilities when listening in noise between classrooms, the researcher examined each classroom teacherôs responses to Question 6 on the ñListening Inventoryò: ñCompared to his/her classmates, does this student routinely stay focused when background noise is present?ò This statistical measure included only the **focus students** from each classroom, or those students who scored below a total of nine on the spelling pretest. Results were not statistically significant between Classroom A (M = 2.13, SD = 0.64) and Classroom B (M = 1.00, SD = 0.00), $t(7.00) = 4.97$, $p = 0.129$ on studentsô abilities when listening in noise.

Spelling Pre- and Posttest

To analyze the difference between each classroom and the studentsô resulting pre- and posttest scores, two independent samples t-Tests were conducted. These statistical measures included only the **focus students** from each classroom, or those students who scored below a total of nine on the spelling pretest. Results were not statistically significant between Classroom A and Classroom B on the spelling pretest, as well as the spelling posttest, and are presented in Table 7.

Table 7
Focus Students' *Pre- and Posttest Results for Classrooms A & B*

	Classroom A		**Classroom B**				
	M	*SD*	*M*	*SD*	*t*	*df*	*p*
Pretest	3.88	3.04	6.00	1.73	-1.45	6.74	0.110
Posttest	7.38	2.88	7.67	1.15	-0.24	8.69	0.339

Change Score

In order to determine if there was a difference between classrooms and the studentsô change scores from pre- to posttest measures, an independent samples t-Test was conducted.

This statistical measure included only the **focus students**, or those who scored below a total of nine on the spelling pretest. Results were statistically significant between Classroom A (M = 1.76, SD = 2.44) and Classroom B (M = 0.44, SD = 0.81), $t(19.72) = 2.12$, $p = 0.002$* on studentsô change score from pre- to posttest measures.

Listening Inventory Category

To investigate the relationship between studentsô ñListening Inventory Categoryò and various variables in each classroom, six one-way ANOVAs were completed. These statistical measures included the spelling pretest, spelling posttest, and change score in each classroom.

Spelling Pretest

In order to analyze the relationship between the studentsô ñListening Inventory Categoryò and their pretest scores, an ANOVA was completed for each classroom. These statistical measures included all student participants in each classroom. In Classroom A, there was a significant difference between individual studentôs ñListening Inventory Categoryò and their resulting pretest score (F (2, 14) = 16.52, $p = 0.000$*). In Classroom B, there was also a significant difference between studentsô ñListening Inventory Categoryò and their resulting pretest score (F (2,13) = 24.95, $p = 0.000$*). The post-hoc analyses revealed that there was a significant difference between students categorized in the ñLowò and ñMidò categories (p = 0.001*), as well as between students categorized in the ñLowò and ñHighò categories (p = 0.000*). Results for each classroom are presented in Tables 8 and 9, respectively.

Table 8
Listening Inventory Category and Students' Pretest Scores: ***Classroom A***

	Students' Pretest Scores		
Listening Inventory Category	***M***	***SD***	***n***
Low (1.00-1.66)	3.00	0.00	1
Mid (1.67-2.33)	2.25	3.20	4
High (2.34-3.00)	8.92	1.73	12

Table 9
Listening Inventory Category and Students' Pretest Scores: ***Classroom B***

	Students' Pretest Scores		
Listening Inventory Category	***M***	***SD***	***n***
Low (1.00-1.66)	6.00	1.73	3
Mid (1.67-2.33)	9.50	0.71	2
High (2.34-3.00)	9.73	1.67	11

Spelling Posttest

The researcher also examined the relationship between the studentsô ñListening Inventory Categoryò and their resulting posttest scores. Therefore, an ANOVA was completed for each classroom. These statistical measures again included all student participants in each classroom. Results were statistically significant for Classroom A (F (2,14) = 8.46, p = 0.004*), as well as Classroom B (F (2,13) = 17.58, p = 0.000*). The post-hoc analyses revealed that there was a significant difference between students categorized in the ñLowò and ñMidò categories (p = 0.002*), as well as between students categorized in the ñLowò and ñHighò categories (p = 0.000*). The results for individual classrooms are presented in Tables 10 and 11, respectively.

Table 10
Listening Inventory Category and Students' Posttest Scores: ***Classroom A***

	Students' Posttest Scores		
Listening Inventory Category	***M***	***SD***	***n***
Low (1.00-1.66)	10.00	0.00	1
Mid (1.67-2.33)	5.75	3.40	4
High (2.34-3.00)	9.67	2.33	12

Table 11
Listening Inventory Category and Students' Posttest Scores: ***Classroom B***

	Students' Posttest Scores		
Listening Inventory Category	***M***	***SD***	***n***
Low (1.00-1.66)	7.67	1.15	3
Mid (1.67-2.33)	10.00	0	2
High (2.34-3.00)	9.82	1.03	11

Change Score

In order to determine if there was a relationship between individual studentsô ñListening Inventory Categoryò and their change scores, an ANOVA was completed for each classroom. These statistical measures included all student participants in each classroom. In Classroom A, there was a significant difference between studentsô ñListening Inventory Categoryò and their resulting change score (F (2, 14) = 8.39, p = 0.004*). In Classroom B, there was also a significant difference between studentsô ñListening Inventory Categoryò and their resulting change score (F (2,13) = 9.35, p = 0.003*). The post-hoc analyses revealed that there was only a significant difference between students categorized in the ñLowò and ñHighò categories (p = 0.002*). Results for each classroom are presented in Tables 12 and 13, respectively.

Table 12
Listening Inventory Category and Students' Change Scores: ***Classroom A***

	Students' Change Scores		
Listening Inventory Category	***M***	***SD***	***n***
Low (1.00-1.66)	7.00	0.00	1
Mid (1.67-2.33)	3.50	3.11	4
High (2.34-3.00)	0.75	2.44	12

Table 13
Listening Inventory Category and Students' Change Scores: ***Classroom B***

	Student's Change Scores		
Listening Inventory Category	***M***	***SD***	***n***
Low (1.00-1.66)	1.67	0.58	3
Mid (1.67-2.33)	0.50	0.71	2
High (2.34-3.00)	0.09	0.54	11

Relationship Among Variables

To examine the relationship between several variables in each classroom, six correlation measures were completed. These experimental measures included listening-in-noise tasks, as well as spelling pre- and posttest measures.

Listening in Noise and Spelling Pretest

The researcher examined the relationship between each teacherôs responses to Question 6 on the ñListening Inventoryò: ñCompared to his/her classmates, does this student routinely stay focused when background noise is present?ò -- to studentsô performance on the spelling pretest measure, as a group amplification system was not present in either classroom during the pretest data collection. As such, two separate correlation measures were completed, including Classroom A and Classroom B as separate entities. These statistical measures included only the **focus students**, or those who scored below a total of nine on the spelling pretest. Results were not statistically significant for either classroom, and are presented in Table 14.

Table 14
Focus Students' *Listening in Noise and Pretest Measures*

Classroom(s)	***r***	***p***	***n***
Classroom A	0.547	0.160	8
Classroom B*	--	--	3

Note: Correlation could not be computed for Classroom B as one of the variables was constant*

Listening in Noise and Spelling Posttest

The researcher also analyzed the relationship between Question 6 on the ñListening Inventoryò: ñCompared to his/her classmates, does this student routinely stay focused when background noise is present?ò -- to studentsô performance on the spelling posttest measure, as a group amplification system was implemented in Classroom A during the posttest data collection. Two separate correlation measures were run, including Classroom A and Classroom B as separate entities. These statistical measures again included only the **focus students**, or those who scored below a total of nine on the spelling pretest. Results were not statistically significant for either classroom, and are presented in Table 15.

Table 15
Focus Students' *Listening in Noise and Posttest Measures*

Classroom(s)	*r*	*p*	*n*
Classroom A	0.302	0.467	8
Classroom B*	--	--	3

Note: Correlation could not be computed for Classroom B as one of the variables was constant*

Spelling Pre- and Posttest Scores

In order to determine if there was a relationship between spelling pre- and posttest scores, two separate correlation measures were run, including Classroom A and Classroom B as separate entities. These statistical measures included only the **focus students**, or those who scored below and total of nine on the spelling pretest. Results were statistically significant only for Classroom B, and are presented in Table 16.

Table 16
Focus Students *Pre- and Posttest Measures: Overall Scores*

Classroom(s)	*r*	*p*	*n*
Classroom A	0.610	0.108	8
Classroom B	1.000	0.000*	3

Note: $p<0.05$ indicates significance*

Discussion

The following sections will present a discussion of the previously reported statistical results. A qualitative discussion of observations noted throughout the data collection procedure will also be presented.

Gender and Age Demographics

There was a total of 33 participants in the study, with one more male than female participant. Specifically, in Classroom A, there was one more male than female participant, whereas the sample was split evenly between males and females in Classroom B. This shows a fairly equal distribution of male and female students in each classroom, as well as the overall sample.

When examining the **focus students**, or those who scored below a total of nine on their spelling pretest, a different combination of male and female participants emerged. Specifically, in Classroom A, there were more female focus students (five of eight), whereas all three focus students in Classroom B were male. However, when analyzing the total number of focus students between both classrooms, there were more male than female focus students (six versus five). This greater number of male focus students aligns with several research reports regarding the greater prevalence of learning disabilities and differences, including Autism Spectrum Disorders, in the male population (National Institute on Deafness and other Communication Disorders, 2016, p. 1).

The age range of participants was narrow, varying between six or seven years old. Specifically, in Classroom A, there was a greater number of six-year-old students (9 of 17), while Classroom B had a greater number of seven-year old students (9 of 16). This information indicates a minor difference in age distribution between these classrooms.

Individualized Education Plan (IEP) Demographics

In order to determine the number of students on an Individualized Education Plan (IEP) in each classroom, the researcher asked each lead teacher to report the number of students on an IEP in each classroom, as well as the number of students, if any, diagnosed with an Autism Spectrum Disorder. In Classroom A, one student was on an IEP for an Autism Spectrum Disorder. In Classroom B, three students were on an IEP, with one of these students reportedly presenting with an Autism Spectrum Disorder. These data show an equal distribution of participants (one) with a reported Autism Spectrum Disorder in each classroom.

As discussed by Rance, Saunders, Carew, Johansson, and Tan (2014), a common benefit of utilizing group amplification systems with students on the Autism Spectrum is an increase in

attentive behaviors, followed by an increase in listening comprehension abilities (p. 355). Although these specific studentsô identifying information and data results are unknown due to confidentiality, the researcher can speculate that the students on an IEP in each classroom, including those reportedly diagnosed with Autism Spectrum Disorders, benefitted from the use of a group amplification system during spelling intervention and posttest procedures based on previous research.

Listening Inventory

Prior to the administration of pre- and posttest measures, as well as two days of spelling intervention activities, the two lead teachers were asked to complete a ñListening Inventoryò for each student in their classroom. This six-question tool was designed to measure individual studentsô listening or ñperceptionò abilities during language-based tasks in the classroom.

When analyzing the results of individual students in Classroom A, a trend of lower teacher responses was particularly noted for Question 3: ñCompared to his/her classmates, does this student routinely understand information the first time it is presented?ò These lower responses suggested that several students in Classroom A required multiple presentations of information in order to clearly understand a particular concept. However, when grouping individual student responses into a range of results, the majority of students in Classroom A fell into the ñHighò category, with 12 of the 17 students with a total score between 2.34 and 3.00. These results indicated that the majority of students in Classroom A displayed ñstrongò listening or ñperception" abilities. The range of results also indicated only one student in the ñLowò category, with a total score between 1.00 and 1.66. This number may reflect the single student on an IEP in Classroom A [*Note.* It is unknown if this student with the low ñListening Inventoryò score was the student on an IEP, due to confidentiality purposes].

When analyzing the results of individual students in Classroom B, no observable trend was noted for lower teacher responses to any specific ñListening Inventoryò question. Additionally, when grouping individual student responses into a range of results, the majority of students in Classroom B fell into the ñHighò category, with 11 of the 16 students with a total score between 2.34 and 3.00. Based on these results, it can be concluded that the majority of students in Classroom B were rated as having ñstrongò listening or ñperceptionò abilities. The range of results also displayed three students in the ñLowò category, with a total score between 1.00 and 1.66. This number may reflect the three students on an IEP in Classroom B [*Note.* The researcher cannot state with certainty that those students with the low ñListening Inventoryò scores were the students on IEPs due to confidentiality purposes].

Statistical Difference Between Classrooms

The following sections will discuss the previously reported statistical results regarding the relationship between the two classrooms and the studentsô performance on a variety of variables. These measures included the ñListening Inventory,ò listening-in-noise tasks, the pretest measure, the posttest measure, as well as the change score from pretest to posttest measures.

Listening Inventory Means

According to the ñListening Inventoryò data, there was no significant difference between the classrooms on the studentsô overall ñListening Inventoryò scores. Means between Classroom A and Classroom B were close and fell in the ñHighò ñListening Inventoryò category, with a total score between 2.34 and 3.00. These results suggested that students in both classrooms generally excel in listening or ñperceptionò tasks in the classroom. However, the mean was slightly higher for Classroom A (M = 2.60, SD = 0.49), suggesting that students in this classroom

may have stronger listening or ñperceptionò abilities than those students in Classroom B *(M* = 2.53, *SD* = 0.68). Also, the standard deviation was higher for Classroom B, suggesting a greater variability of teacher responses on this questionnaire than those responses for students in Classroom A. Specific students may struggle with these listening tasks, and were observed as such during the data collection procedure, as will be discussed in the sections that follow.

Listening in Noise

While the listening-in-noise results were not of statistical significance, the mean of Classroom B (*M* = 1.00, *SD* = 0.00) was lower than that of Classroom A (*M* = 2.13, *SD* = 0.64), suggesting that the three **focus students** in Classroom B may struggle more with listening-in-noise tasks than those in Classroom A. The standard deviation was zero for Classroom B, showing that all focus students in this classroom received the same low score (1.00) from their teacher on this ñListening Inventoryò question. These results suggested that students in Classroom B could potentially benefit from the use of a group amplification system in their classroom, as they had earned a low score regarding their listening-in-noise abilities.

Spelling Pretest

The spelling pretest results indicated that there was no significant difference between **focus students** in Classrooms A and B regarding their initial knowledge of this specific list of spelling words, since group amplification was not utilized in either classroom during this testing procedure. However, the mean pretest score was higher in Classroom B (*M* = 6.00, *SD* = 1.73), suggesting that this group of students may have had more knowledge of this list of spelling words when compared to Classroom A (*M* = 3.88, *SD* = 3.04). The standard deviation was higher in Classroom A, as these studentsô individual pretest scores had a greater variability than those students in Classroom B.

Spelling Posttest

According to Table 7, there was not a significant difference between the students in Classroom A and Classroom B on their resulting posttest scores. Mean posttest scores between these two groups *both* increased from the mean scores of the pretest measure, suggesting that **focus students** in both classrooms obtained higher scores on the posttest, regardless of the use of a group amplification system in Classroom A. This improvement may be due to intensive practice on this specific list of spelling words during the previous two days of intervention activities, or because of outside practice with parents or guardians in the home environment. Mean scores between Classroom A and Classroom B were also high in number and were close to one another, suggesting that students in both classrooms performed well on this posttest measure. However, the standard deviation was higher in Classroom A (M = 7.38, SD = 2.88), suggesting there was a greater variability of posttest scores in this classroom rather than for the students in Classroom B (M = 7.67, SD = 1.15).

Change Score

The change score results showed that there was a significant difference between the classrooms on **focus students'** change scores from pre- to posttest measures. Specifically, the mean change score was higher for Classroom A (M = 1.76, SD = 2.44), suggesting that these eight focus students had an overall increased change score from the three students in Classroom B (M = 0.44, SD = 0.81). The standard deviation was also higher for Classroom A, suggesting that these eight focus students had a greater variability of their change scores than the three focus students in Classroom B.

This statistical significance suggests that the use of the group amplification system in Classroom A had benefits. A common benefit of group amplification systems is that they allow

students the ability to hear information clearly presented during the school day through improvement of the signal-to-noise ratio in the classroom (Dockrell & Shield, 2012, p. 1163). As the Classroom A focus students were able to hear the researcherôs voice at an improved signal-to-noise ratio, they may have been able to increase their spelling posttest scores by a greater amount, than the focus students in Classroom B, who received no intervention activities, nor the posttest administration, with the provision of enhanced amplification.

Listening Inventory Category

The following sections discuss the relationship between studentsô ñListening Inventoryò category and a variety of variables in each classroom. These statistical measures included the spelling pretest, spelling posttest, and change score in each classroom.

Spelling Pretest

These results first displayed the difference in pretest means between the two classrooms, most significantly between students in the ñLowò and ñHighò ñListening Inventoryò categories (p = 0.000*). Although only one student was a part of the ñLowò category in Classroom A (M = 3.00, SD = 0.00), his/her mean pretest score was half of the mean pretest score for those students in the ñLowò category in Classroom B (M = 6.00, SD = 1.73). The mean pretest scores were higher in Classroom B for students in both ñMidò (M = 9.50, SD = 0.71) and ñHighò categories (M = 9.73, SD = 1.67). These data indicated that although these students may have scored lower on their ñListening Inventory,ò they were still able to achieve high pretest scores, potentially due to their initial knowledge of this specific list of spelling words.

Spelling Posttest

These results displayed a significant difference between individual studentôs ñListening Inventoryò categories and their resulting posttest scores in each classroom, most significantly

between students scoring in the ñLowò and ñHighò ñListening Inventoryò categories (p = 0.000*). The student in the ñLowò category on their ñListening Inventoryò improved to a perfect posttest mean score in Classroom A (M = 10.00, SD = 0.00). Mean posttest scores also increased for students in both ñMidò (M = 5.75, SD = 3.40) and ñHighò categories (M = 9.67, SD = 2.33) in Classroom A when compared to their mean pretest scores. These improvements in posttest scores may be due to the introduction of the group amplification system in this classroom during intervention and posttest procedures, as was noted by Johnston and her colleagues (2009), who observed an improved academic performance through the use of a group amplification system with their sample population of students with Auditory Processing Disorders (pp. 375-378).

Mean posttest scores also improved in Classroom B, but to a lesser degree. This improvement may be due to focused spelling practice through two days of intervention activities as part of the data collection procedure, but may be smaller in amount due to the lack of the group amplification system in this classroom.

Change Score

From the change score results, it was evident that studentsô ñListening Inventoryò categories did not impact their change scores from spelling pre- to posttest measures in either classroom. Specifically, in Classroom A, this significant difference may be due to the introduction of a group amplification system during intervention and posttest procedures. ñLowò students, or those that struggle with listening or ñperceptionò tasks in the classroom, likely received a poor rating score on their ñListening Inventory.ò However, the amplification system may have allowed this group of students to experience an increase in listening comprehension due to the increased signal, resulting in a greater change score by their posttest measure. These results support the findings concluded by Rance, Chrisari, Saunders, and Rault (2017, p. 2016),

as their sample population of students with Autism Spectrum Disorders similarly experienced an increase in listening comprehension with language-based tasks. These results may also be partially explained by the higher mean change score for low-range students in Classroom A (*M* = 7.00, *SD* = 0.00) as compared to Classroom B (*M* = 1.67, *SD* = 0.58).

Relationships Among Variables

The following sections discuss the relationship between a variety of variables in each classroom. These measures included listening-in-noise tasks, as well as spelling pre- and posttest measures.

Listening in Noise and Spelling Pretest

For Classroom A, the pretest results suggested that there was not a relationship between **focus students'** listening-in-noise abilities, as rated by their teacher, and their resulting pretest scores. For example, even though a student may have a difficult time listening in noise and obtained a low rating score from their teacher on Question 6 of the ñListening Inventory,ò their pretest score was not impacted by this rating. This lack of significance may be due to the pretest procedure in Classroom A. As students were not accustomed to the researcher being a familiar figure in the classroom, they appeared to be quieter during administration of the pretest measure. As such, those students who struggle with listening-in-noise tasks were not negatively affected, as there was little classroom conversation to negatively impact their pretest score.

For Classroom B, a correlation measure could not be computed due to a constant variable of ñListening Inventoryò responses for all focus students. Therefore, it is unknown if there was a relationship between focus studentsô listening-in-noise abilities, as recorded by their lead teacher, and their corresponding pretest scores.

Listening in Noise and Spelling Posttest

For Classroom A, these posttest results suggested that there was not a relationship between **focus students'** listening-in-noise abilities, as rated by their teacher, and their resulting posttest scores. For example, even though a student may have a difficult time listening in noise and obtained a low rating score from their teacher on Question 6 of the ñListening Inventory,ò their posttest score was not impacted by this rating. This lack of significance may be due to the unknown variable of the potential increased practice of spelling terms in the home environment. As these students scored below a nine on their spelling pretest, they may have studied this list of words more extensively throughout the week with parents or guardians at home. As a result, their scores were not impacted by classroom conversation, as they had prepared prior to the spelling posttest and felt comfortable during the experimental procedure.

The introduction of a group amplification system in Classroom A may have also positively impacted these students. As the group amplification system presented spelling terms at an improved signal-to-noise ratio, those students who may struggle with listening-in-noise tasks were able to potentially overcome this difficulty and perform well on their posttest measure, regardless of their low ñListening Inventoryò score. These results align with those found by Schafer and colleagues (2016) who concluded that the use of a remote-microphone (RM) device results in elementary school students receiving an improved signal-to-noise ratio during literacy-based tasks (p. 15). Punch and Hyde (2010) also obtained similar results with their sample population of elementary-school students with cochlear implants (p. 412).

For Classroom B, a correlation measure could not be computed due to a constant variable of ñListening Inventoryò responses for all focus students. Therefore, it is unknown if there was a

relationship between focus studentsô listening-in-noise abilities, as recorded by their lead teacher, and their corresponding posttest scores.

Spelling Pre- and Posttest Scores

The statistically significant results suggested a strong, positive relationship ($p = 0.000$*) between pre- and posttest measures for **focus students** in Classroom B. For example, a focus studentôs high score on a pretest measure likely equated with an additional high score on the posttest measure in this classroom. On the other hand, a focus studentôs low score on a pretest measure likely equated with an additional low score on a posttest measure for Classroom B. The correlation value was also higher for Classroom B, at a total of 1.000, suggesting a stronger relationship between pre- and posttest scores in this classroom rather than Classroom A.

The lack of significance in Classroom A may be due to the introduction of a group amplification system during the posttest procedure. According to Flexer (as cited by Barrett, 2011), having clear auditory input relating to the sound structure of a language presents an improved opportunity for students to acquire reading and literacy concepts (p. 30). As the researcherôs voice was presented at an improved signal-to-noise ratio during this testing procedure, for the literacy concept of spelling, focus students in this classroom may have been able to improve their posttest scores, regardless of their pretest results, resulting in these two measures not demonstrating a relationship.

Qualitative Discussion on Data Collection Procedures

The following sections describe various observations and anecdotal notes recorded throughout the data collection procedures conducted at a local, rural elementary school. No student will be mentioned by name to protect confidentiality. All data were collected each day between 12:00 and 1:00 p.m., following the studentsô recess period, over the course of four days.

The researcher spent approximately 20-30 minutes in each classroom each day, starting with Classroom A and then moving to Classroom B, due to the differing academic schedules in each classroom.

Pretest Procedures

Upon the studentsô arrival in Classroom A, the lead teacher informed the researcher that one student had switched school districts the prior week, bringing the total number of students down to 17 in this classroom. After the students entered the room and were seated, the researcher was introduced to the students by the teacher. The researcher then presented a brief ñchild-friendlyò overview of the data to be collected, and administered *assent* forms for each student to sign. After these forms were collected, the lead teacher also signed all forms to provide additional approval. While pretest worksheets were passed out, all students set up privacy folders to protect their individual work from others. The pretest was then administered with each word stated once alone, once in a sentence, and once alone. This same procedure was completed in Classroom B following Classroom A. However, two students were absent from Classroom B during this time. The lead teacher administered both studentsô pretests during the following recess period, utilizing the same example sentences presented by the researcher during the formal testing procedure.

Intervention #1 Procedures

During the second day of data collection, the researcher engaged in spelling intervention activities with students. Due to time constraints, an introductory exercise was eliminated, with students completing only the main portion of the lesson in both classrooms (the tongue-twister activity). At the end of the activity, students were administered a spelling practice test of five randomly selected words on their list. Privacy folders were not utilized during this time. Words

were stated once alone, once in a sentence, and once alone. This testing procedure was conducted identically in both Classroom A and Classroom B. However, the spelling word list was inadvertently displayed on the white board through the third word of the spelling practice test in Classroom B. It is unknown if this accidental visual aid impacted these studentsô resulting practice test scores. One student was again absent in Classroom B during this time, and was administered the spelling practice test during the following recess period, utilizing the same example sentences as presented by the researcher during the formal classroom testing procedure.

Intervention #2 Procedures

Throughout the third day of data collection, the researcher engaged in additional spelling intervention activities with students. Due to time constraints, an introductory exercise was again eliminated, with students completing only the main portion of the lesson, ñSpelling Bingo,ò in both classrooms. Since Classroom A already had Bingo supplies, such as game markers, previously distributed to students, Classroom A was able to play ñSpelling Bingoò for the majority of the intervention time period. In contrast, adults in Classroom B spent some time distributing Bingo game markers during the intervention period, resulting in students playing ñSpelling Bingoò for a shorter portion of the intervention time period. At the conclusion of this activity, students were again administered a spelling practice test, incorporating the remaining five randomly selected words. Privacy folders were not utilized during this time. Words were stated once alone, once in a sentence, and once alone. This procedure was executed identically in both classrooms, with all students present in both classrooms during this time.

Posttest Procedures

During the final day of data collection, students were administered a spelling posttest. Privacy folders were utilized by all students during this time, similarly to the pretest procedure.

Each word was stated once alone, once in a sentence, and once alone. This procedure was more quickly completed in Classroom B, due to a birthday celebration prior to the researcherôs entrance. Due to this somewhat abbreviated schedule, students in Classroom B appeared to be extremely distracted during the posttest procedure, with several students conversing among peers rather than engaging in full attention to their posttest task. Additionally, one student was again absent during administration of the posttest in Classroom B. As this student was only present for a single day of data collection, his/her results were completely eliminated from the data results and analysis.

General Observations

At the conclusion of the data collection procedure, several observations could be made regarding both Classroom A and Classroom B. First, organization and discipline appeared to be the norm in Classroom A. The students in this classroom appeared to be aware of their responsibilities in the classroom, and eagerly participated in all data collection activities under the guidance of their lead teacher. Students in Classroom B, however, seemed easily distracted, with several reluctant to participate in the data collection activities. These students appeared to be especially distracted during the posttest procedure, potentially due to the changed schedule which developed.

It should also be noted that one student in Classroom A was pulled out of the room each day prior to the beginning of data collection to speak with an intervention specialist. During this time, the student appeared to relax and prepare for the afternoon of academics, which initially appeared to help others participate in the data collection activities. As this student needed several verbal prompts and reminders to continue completing his/her work during data collection, however, it is unknown if his/her results reflected his/her best academic work.

Finally, it can be noted that students were seated in the same desk arrangement in both Classroom A and Classroom B. Lead teachers informed the researcher that the more academically-advanced students were seated toward the back of the classroom, while those struggling or ñat-riskò were seated toward the front. As such, the researcher made sure to walk around the classroom during each day of data collection, particularly in the front of the classroom, to ensure that all students, especially those struggling or ñat-risk,ò were engaged and hearing the appropriate directions.

CHAPTER V: CONCLUSION

The purpose of this chapter is to address the studyôs major conclusions, as well as the implications of these conclusions. The studyôs limitations, including those of the study design and of the participants, will also be noted. Recommendations for future studies will be provided, and final thoughts about the study will be concluded. You will recall, the purpose of this study was to determine the academic benefits and challenges, if any, of utilizing group amplification systems during language-based tasks, such as spelling accuracy, with first-grade students. After analyzing the data obtained from this study, it was determined that the use of this hearing assistive technology was indeed effective in improving studentsô spelling test scores from pre- to posttest measures.

Major Conclusions

Three main conclusions will be shared from this study. These conclusions address individual studentôs change scores from pre- to posttest measures, listening-in-noise abilities, and ñListening Inventoryò scores.

The first major conclusion was that *the use of a group amplification system for intervention and posttest procedures in Classroom A positively impacted students' change scores, or growth from pre- to posttest measures.* As evidenced by statistically significant findings, students in Classroom A had a greater change score than students in Classroom B, who completed intervention and posttest procedures without amplification.

A second major conclusion was that *the use of a group amplification system positively impacted students with poor listening-in-noise skills through improvement of the signal-to-noise ratio*. This finding was evidenced by the lack of significance between studentsô listening-in-noise abilities, as documented by their teachers on the researcher-designed ñListening Inventory,ò and

their spelling posttest scores in Classroom A. Through the use of a group amplification system at the time of the posttest procedure, students with poor listening-in-noise abilities were presumably able to overcome this difficulty, due to the improvement of the signal-to-noise ratio, and in fact, obtained a high score on their posttest measure, resulting in no relationship being found among these variables.

A final major conclusion was that *individual student's poor listening or "perception" skills, as documented by their teachers, did not similarly result in a low change score from pre- to posttest measures*. This finding was evidenced by the greater change score for students scoring in the ñLowò ñListening Inventoryò category, as compared to students scoring in the ñMidò and ñHighò categories. Although lead teachers categorized these students poorly regarding their listening or ñperceptionò skills in the classroom, this group of ñLowò students was able to achieve a greater change score than those students in the ñMidò and ñHighò ñListening Inventoryò categories.

Implications of the Research Findings

These major findings also have implications to discuss. Dockrell and Shield (2012) suggested that incorporating students with ñeducational needsò in the elementary-school classroom may be an additional indicator of the effectiveness of group amplification systems in the educational environment (p. 1174). The first major finding of this study suggested that the use of a group amplification system in a first-grade mainstream classroom, which included some students with ñeducational needs,ò was indeed effective through the academic improvement of individual studentôs scores. This finding supports Dockrell and Shieldôs suggestion for future research in addressing the effectiveness of group amplification systems in first-grade mainstream classrooms.

From this study, classroom teachers can also implement new knowledge, specifically regarding the signal-to-noise ratio, when working with their elementary-school students. By understanding that the use of a group amplification system improves the signal-to-noise ratio in the classroom, lead teachers can incorporate the use of this hearing assistive technology more frequently throughout the school day, particularly for those students who may struggle with listening-in-noise tasks.

Finally, the researcher-designed ñListening Inventoryò appeared to be able to aid classroom teachers in acquiring initial information regarding individual studentôs listening or ñperceptionò skills in the classroom. When observing the results of this questionnaire, however, it should be kept in mind that predictions regarding individual studentôs academic abilities may be difficult based on their resultant ñListening Inventoryò category alone.

Limitations

In addition to the above-noted conclusions, the study also had some limitations, including those of the study design and regarding the participants, that ideally should be avoided in future research. Both types of limitations will be discussed more fully in the sections that follow.

Limitations of the Study Design

The first limitation of the study design was the short time period allotted for the two days of spelling intervention activities during the experimental procedures. Students only participated in these intervention activities for 20-30 minutes per classroom each day. As such, these short time periods may not have been the best indicator of the value of a group amplification system in Classroom A, as this group of students was only minimally exposed to this hearing assistive technology. Classroom B was also not adequately prepared with readily-available materials, such

as game markers, for the ñSpelling Word Bingoò game on the second day of intervention, causing this group of students to receive even less time engaged in this intervention activity.

A second limitation to the studyôs design was that lead teachers were the only individuals to complete a ñListening Inventoryò for each of their students, rather than involving the researcherôs input as well. The researcher was only able to make qualitative observations regarding individual studentôs listening or ñperceptionò skills in the classroom, rather than numerically scoring a ñListening Inventoryò for individual students.

A final limitation of this studyôs design was that experimental procedures were completed in the same classroom order each day, first in Classroom A, then in Classroom B. This scheduling was because of each classroomôs individual academic schedule. Due to this aspect of the study, however, the researcher was unable to vary the presentation of experimental procedures, such as the spelling pre- and posttest measures, as well as the intervention activities, between classrooms. As such, the researcher may have been more ñengagedò with Classroom A as they were always the first group to receive the researcherôs attention.

Limitations of the Participants Investigated

The small number of students in each classroom reportedly diagnosed with an Autism Spectrum Disorder was a limitation regarding the participants for this study. Due to this low number of students diagnosed with ASD in each classroom, the researcher was unable to focus on this sample population, as was originally intended. Also, one student reportedly diagnosed with an Autism Spectrum Disorder was removed from his/her classroom prior to the beginning of data collection each day. Therefore, this studentôs data were completely eliminated from the results, further reducing the amount of study participants with ASD.

Recommendations for Future Research

Based on the framework of this study, future research can be completed related to this topic. First, having a longer time period allotted for each day of spelling intervention activities may be beneficial. Throughout this longer time period, the researcher would incorporate the planned opening exercises previously eliminated from each lesson plan in the current study. Students in Classroom A would also gain additional time with exposure to a group amplification system, which may be a strong indicator of the impact of this hearing assistive technology in their elementary-school classroom.

Having both lead teachers and the researcher complete a ñListening Inventoryò regarding individual studentôs listening or ñperceptionò skills in the classroom is a further suggestion. With the addition of the researcherôs numerical data for individual students, comparisons could be made regarding both the lead teachersô and researcherôs responses, noting that the lead teachers have interacted with their students for a far longer portion of the school year.

A third suggestion would be to vary the presentation of experimental procedures, such as the spelling pre- and posttest measures, as well as the intervention activities, between the two classrooms involved in the study. For example, if Classroom A completed the spelling pretest first, then Classroom B would be the first group to participate in intervention activities on the following day. This ñcounter balancingò of the tasks would allow the researcher to be equally ñengagedò with both classrooms throughout experimental procedures, as no classroom would always complete these procedures before the other.

Taking note of each studentôs skills in written and spoken English prior to the beginning of the experimental procedures may also be useful. If a studentôs primary language is not English, their results would arguably be analyzed with this information in mind, as limited

English proficiency might impact their resulting scores or at least be recognized as an additional variable.

A fourth suggestion would be to involve a larger number of classrooms throughout the studyôs experimental procedures. As the researcher was only able to work with two first-grade classrooms in one elementary school, incorporating the use of additional first-grade classrooms may be an indicator of the value of a group amplification system for elementary school students.

A final suggestion would be to conduct this study at a specialized school or program for students with Autism Spectrum Disorders. As the researcher was unable to fully evaluate the impact of a group amplification system on this sample population during the current study, this new location would allow for a focus on groups of students with ASD. To determine that all student participants are of the same ñlevelò of ASD, entrance criteria regarding these studentsô skills and educational abilities, such as spoken and written language, behavior, or spelling skills; would ideally need to be evaluated prior to the beginning of the study. By completing this study with students who are reportedly diagnosed with Autism Spectrum Disorders, however, the true impact of a group amplification system on this sample population could be better evaluated.

Final Thoughts

A variety of both scholarly and practical rationales were delineated prior to the completion of the studyôs experimental procedures. These rationales included the importance of future research on hearing assistive technology in the elementary-school classroom, particularly group amplification systems, with first-grade students. According to past research, students with hearing impairment, those with Auditory Processing Disorders, and those with Autism Spectrum Disorders have benefitted from the use of this hearing assistive technology. Throughout this studyôs experimental procedures, however, I was able to observe several typically-developing

students improve their spelling posttest scores through the use of a group amplification system as well. As a future educational audiologist, it seemed obvious that this studyôs findings should bring increased awareness to the benefits of group amplification systems for all students in the elementary-school classroom, especially during tasks of spelling accuracy.

The Independent Study process was extremely rewarding, especially through my focus on educational audiology, an area to which I am truly passionate. At first, I was unsure if I would be able to complete my proposed experiment in any elementary school, let alone in the incredible school district which took me under their wing for this portion of my research. The ability to conduct this experiment and collect hands-on data alongside my advisor was a way to truly see the benefits of group amplification systems outlined in the literature, and then put into practice. The Independent Study process has also solidified my decision to work with elementary school students, particularly those with hearing loss, in my future career. Overall, I hope to not only continue research related to my Independent Study throughout my time in graduate school, but to carry this experience into my professional life as well.

REFERENCES

Achenbach, T. M., & Rescorla, L. A. (2001). Manual for the ASEBA School-Age Forms & Profiles. Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families.

Alcantara, J. I., Weisblatt, E. L., Moore, B. J., & Bolton, P. F. (2004). Speech-in-noise perception in high-functioning individuals with autism or Aspergerôs syndrome. *Journal of Child Psychology and Psychiatry, 45*(6), 1107-1114. doi: 10.1111/j.1469-7610.2004.t01-1-00303.x

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.).* Arlington, VA: American Psychiatric Publishing.

American Psychiatric Association. (2016, February). Help with Autism Spectrum Disorder. Retrieved from https://www.psychiatry.org/patients-families/autism.

American Speech-Language-Hearing Association. (2005). (Central) auditory processing disorders ï The role of the audiologist. Retrieved from http://www.phon.ucl.ac.uk/courses/spsci/audper/ASHA%202005%20CAPD%20statement.pdf

Anderson, K. (1989). S.I.F.T.E.R.: Screening Instrument For Targeting Educational Risk in children identified by hearing screening or who have known hearing loss: User's manual. Danville, IL: Interstate Printers.

Anderson, K., & Smaldino, J. (1998). Listening Inventory for Education. Tampa, FL: Educational Audiology Association.

Atcherson, S. R., Franklin, C. A., & Smith-Olinde, L. (2015). *Hearing assistive and access technology*. San Diego, CA: Plural Publishing.

Bamiou, D. E., Musiek, F. E., & Luxon, L. M. (2001). Aetiology and clinical presentations of auditory processing disorders: A review. *Archives of Diseases in Childhood, 85*, 361-365.

Barrett, J. (2011). Do you have sound classrooms? *NZ Principal,* 29-32.

Barrett, M., Huisingh, R., Zachman, L., Blagden, C., & Orman, J. (1992). The Listening Test. Austin, TX: LinguiSystems, Inc.

Bench, J., Kowal, A., & Bamford, J. (1979). The BKB (Bamford-Kowal-Bench) Sentence Lists for partially-hearing children. *British Journal of Audiology, 13*, 108-112.

Berg, F. S., Blair, J. C., & Benson, P. V. (1996). Classroom acoustics: The problem, impact, and solution. *Language, Speech, and Hearing Services in Schools, 27*(1), 16-20.

Blake, R., Field, B., Foster, C., Platt, F., & Wertz, P. (1991). Effect of FM auditory trainers on attending behaviors of learning disabled children. *Language, Speech, and Hearing Services in Schools,* 22, 111-114.

Boddaert, M. D., Belin, P., Chabane, N., Poline, J., Barthélémy, C., Mouren-Simeoni, M., é Zilbovicius, M. (2003). Perception of complex sounds: Abnormal pattern of cortical activation in autism. *The American Journal of Psychiatry, 160*(11), 2057-2060.

Bonnel, A., Mottron, L., Peretz, I., Trudel, M., Gallun, E., & Bonnel, A. M. (2003). Enhanced pitch sensitivity in individuals with autism: A signal detection analysis. *Journal of Cognitive Neuroscience, 15*(2), 226-235. doi: 10.1162/089892903321208169

Campbell, D. T., & Stanley, J. C. (2015). *Experimental and quasi-experimental designs for research*. Evanston, IL: Ravenio Books.

Christensen, D. L., Baio, J., & Van Naarden Braun, K. (2016). Community report on Autism. *Centers for Disease Control and Prevention*, 1-43.

Cox, R. M., & Alexander, G. C. (1995). The Abbreviated Profile of Hearing Aid Benefit. *Ear Hear, 16*(2), 176-186.

Crandell, C. C., & Smaldino, J. J. (2000). Classroom acoustics for children with normal hearing and with hearing impairment. *Language, Speech, and Hearing Services in Schools, 31*, 362-370. doi: 0161ï 1461/00/3104ï 0362

Da Cruz, A. D., Silverio, K. C., Da Costa, A. R., Moret, A. L., Lauris, J. R., & Jacob, R. T. (2016). Evaluating effectiveness of dynamic soundfield system in the classroom. *Noise and Health, 18*(80), 42-49. doi: 10.4103/1463-1741.174386

Deconde Johnson, C. & Seaton, J. B. (2012). *Educational audiology handbook (2nd ed.)*. Clifton Park, NY: Cengage Learning.

Dockrell, J. E., & Shield, B. (2012). The impact of sound-field systems on learning and attention in elementary school classrooms. *Journal of Speech Language and Hearing Research, 55*(4), 1163-1176. doi: 10.1044/1092-4388(2011/11-0026)

Easterbrooks, S. R., & Handley, C. M. (2005). Behavior change in a student with a dual diagnosis of deafness and pervasive developmental disorder: A case study. *American Annals of the Deaf, 150*(5), 401-407. doi: 10.1353/aad.2006.0001

Ennis-Cole, D. (2015). Autism Spectrum Disorders (ASD) and technology. In J. M. Spector, M. J. Bishop, & D. Ifenthaler (Eds.), *Technology for learners with Autism Spectrum Disorders,* (pp. 1-13). Denton, TX: Springer International Publishing.

Fernández-Andrés, M. I., Pastor-Cerezuela, G., Sanz-Cervera, P., & Tárraga-Mqnguez, R. (2015). A comparative study of sensory processing in children with and without autism spectrum disorder in the home and classroom environments. *Research in Developmental Disabilities, 38,* 202-212.

Fisher, R. A. (1962). *The design of experiments (8th ed.).* New York, NY: Hafner Publishing Company Inc.

Flexer, C. (1997). Individual and sound-field FM systems: Rationale, description, and use. *The Volta Review, 99*(3), 133-162.

Groen, W. B., Van Orsouw, L., Ter Huurne, N., Swinkels, S., Van Der Gaag, R. J., Buitelaar, J. K., & Zwiers, M. P. (2009). Intact spectral but abnormal temporal processing of auditory processing in autism. *Journal of Autism and Developmental Disorders, 39*(5), 742-750.

Hanson, S., & Scott, J. (2017). A systematic review of the autism research with children who are deaf or hard of hearing. *Communication Disorders Quarterly,* 1-5.

Hart, J. E., & Whalon, K. J. (2012). Using video self-modeling via iPads to increase academic responding of an adolescent with autism spectrum disorder and intellectual disability. *Education and Training in Autism and Developmental Disabilities, 47*(4), 438-446.

Heaton, P. (2003). Pitch memory, labelling, and disembedding in autism. *Journal of Child Psychology and Psychiatry, 44*(4), 543-551. doi: 10.1111/1469-7610.00143

Howe, F. E., & Staag, S. D. (2016). How sensory experiences affect adolescents with an autistic spectrum condition within the classroom. *Journal of Autism and Developmental Disorders, 46*, 1656-1668. doi: 10.1007/s10803-015-2693-1.

Iglehart, F. (2004). Speech perception by students with cochlear implants using sound-field systems in classrooms. *American Journal of Audiology, 13*(1), 62-72. doi: 10.1044/1059-0889(2004/009)

Iliadou, V., Bamiou, D. E., Kaprinis, S., Kandylis, D., & Kaprinis, G. (2009). Auditory processing disorders in children suspected of learning disabilities: A need for screening? *International Journal of Pediatric Otorhinolaryngology, 73*(7), 1029-1034. doi: 10.1016/j.ijporl.2009.04.004

Johnson, C. E. (2012). *Introduction to auditory rehabilitation: A contemporary issues approach*. Upper Saddle River, NJ: Pearson Education Inc.

Johnston, K. N., John, A. B., Kreisman, N. V., Hall, J. W., & Crandell, C. C. (2009). Multiple benefits of personal FM system use by children with auditory processing disorder (APD). *International Journal of Audiology, 48*(6), 371-383. doi: 10.1080/14992020802687516

Kuhn-Inaker, H., Welchbold, V., Tsiakpini, L., Connix, F., & DõHaese, P. (2003). LittlEARs Auditory Questionnaire: Parents Questionnaire to Assess Auditory Behavior. Innsbruck, Austria: MED-EL.

Larsen, J. B., & Blair, J. C. (2008). The effect of classroom amplification on the signal-to-noise ratio in classrooms while class is in session. *Language Speech and Hearing Services in Schools, 39*(4), 451-460. doi: 10.1044/0161-1461(2008/07-0032)

Lehiste, I., & Peterson, G. E. (1959). Linguistic considerations in the study of speech intelligibility. *Journal of the Acoustical Society of America, 31*(3), 280ï 286.

Leung, S., & McPherson, B. (2006). Classrooms for children with developmental disabilities: Sound-field and public address amplification systems compared. *International Journal of Disability, Development & Education, 53*(3), 287-299. doi:10.1080/10349120600847508

Maag, J. W., & Anderson, J. M. (2006). Effects of sound-field amplification to increase compliance of students with emotional and behavior disorders. *Behavioral Disorders, 31*(4), 378-393.

Martin, F. N., & Clark, J. G. (2015). *Introduction to audiology (12th ed.)*. Upper Saddle River, NJ: Pearson Education Inc.

Massie, R., & Dillon, H. (2006). The impact of sound-field amplification in mainstream cross-cultural classrooms: Part 2 ï Teacher and child opinions. *Australian Journal of Education, 50*(1), 78-94.

Miller-Kuhaneck, H., Henry, D. A., Glennon, T. J., & Mu, K. (2007). Development of the Sensory Processing Measure ï School: Initial studies of reliability and validity. *American Journal of Occupational Therapy, 61,* 170-175. doi: 10.5014/ajot.61.2.170

Nagao, K., Reigner, T., Padilla, J., Greenwood, L. A., Loson, J., Zavela, S., & Morlet, T. (2016). Prevalence of auditory processing disorder in school-aged children in the mid-atlantic region. *Journal of the American Academy of Audiology, 27*(9), 691-700. doi: https://doi.org/10.3766/jaaa.15020

National Center for Education Statistics. (2016, December). Elementary and secondary education. Retrieved from https://nces.ed.gov/programs/digest/d15/ch_2.asp.

National Institute on Deafness and Other Communication Disorders. (2016, July). Statistics on voice, speech, and language. Retrieved from https://www.nidcd.nih.gov/health/statistics/statistics-voice-speech-and-language.

Nelson, D. G., & Nelson, D. K. (1997). Teacher and student satisfaction with freefield FM amplification systems. *The Volta Review, 99*(3), 163-170.

Nelson, L. H., Poole, B., Muñoz, K., Nippold, M., & Pratt, S. (2013). Preschool teachers' perception and use of hearing assistive technology in educational settings. *Language, Speech & Hearing Services In Schools, 44*(3), 239-251. doi:10.1044/0161-1461(2013/12-0038)

Nilsson, M., Soli, S.D., & Sullivan, J. A. (1994). Development of the Hearing In Noise Test for the measurement of speech reception thresholds in quiet and noise. *Journal of the Acoustical Society of America, 95*(2), 1085-1099.

O'Connor, K. (2012). Auditory processing in autism spectrum disorder: A review. *Neuroscience & Biobehavioral Reviews, 36*(2), 836-854. doi:10.1016/j.neubiorev.2011.11.008

Papagiannopoulou, E. A. (2015). Auditory processing in ASD & sound-based intervention. *Music Perception*, *32*(5), 515-529. doi:10.1525/MP.2015.32.5.515

Punch, R., & Hyde, M. (2010). Children with cochlear implants in Australia: Educational settings, supports, and outcomes. *Journal of Deaf Studies & Deaf Education, 15*(4), 405-421.

Purdy, S. C., Smart, J. L., Baily, M., & Sharma, M. (2009). Do children with reading delay benefit from the use of personal FM systems in the classroom? *International Journal of Audiology, 48*(12), 843-852. doi: 10.3109/14992020903140910

Quintin, E. M., Bhatara, A., Poissant, H., Fombonne, E., & Levitin, D. J. (2013). Processing of musical structure by high-functioning adolescents with autism spectrum disorders. *Child Neuropsychology, 19*(3), 250-275. doi: 10.1080/09297049.2011.653540

Rance, G., Chrisari, D., Saunders, K., & Rault, J. L. (2017). Reducing listening-related stress in school-aged children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 47*(7), 2010-2222. doi: 10.1007/s10803-017-3114-4

Rance, G., Saunders, K., Carew, P., Johansson, M., & Tan, J. (2014). The use of listening devices to ameliorate auditory deficit in children with autism. *Pediatrics, 164*(2), 352-357. doi: 10.1016/j.jpeds.2013.09.041

Rao, T. S., & Andrade, C. (2011). The MMR vaccine and autism: Sensation, refutation, retraction, and fraud. *Indian Journal of Psychiatry, 53*(2), 95-96. doi: https://dx.doi.org/10.4103%2F0019-5545.82529

Rekkedal, A. M. (2015). Students with hearing loss and their teachersô view on factors associated with the studentsô listening perception of classroom communication. *Deafness & Education International, 17*(1), 19-32. doi: 10.1179/1557069X14Y.0000000040

Remington, A., & Fairnie, J. (2017). A sound advantage: Increased auditory capacity in autism. *Cognition, 166*, 459-465.

Ross-Swain, D. (1996). Ross Information Processing Assessment (2nd ed.). Retrieved from http://health.utah.edu/occupational-recreational-therapies/docs/evaluations-reviews/ripa+.pdf

Schafer, E., Mathews, L., Mehta, S., Hill, M., Munoz, A., Bishop, R., & Moloney, M. (2013). Personal FM systems for children with Autism Spectrum Disorders (ASD) and/or Attention-Deficit Hyperactivity Disorder (ADHD): An initial investigation. *Journal of Communication Disorders, 46*(1), 30-52. doi:10.1016/J.JCOMDIS.2012.09.002

Schafer, E., Wright, S., Anderson, C., Jones, J., Pitts, K., Bryant, D., ... Reed, M. (2016). Assistive technology evaluations: Remote-microphone technology for children with Autism Spectrum Disorder. *Journal of Communication Disorders, 64*, 1-17. doi: 10.1016/j.jcomdis.2016.08.003

Sharma, M., Purdy, S. C., & Kelly, A. S. (2012). A randomized control trial of interventions in school-aged children with auditory processing disorders. *International Journal of Audiology, 51*(7), 506-518. doi: 10.3109/14992027.2012.670272

Shield, A. A., Meier, R. P., & Tager-Flusberg, H. (2015). The use of sign language pronouns by native-signing children with autism. *Journal of Autism and Developmental Disorders, 45*(7), 2128-2145. doi: 10.1007/s10803-015-2377-x

Smoski, W., Brunt, M., & Tannahill, J. C. (1998). Childrenôs Auditory Performance Scale. Westminster, CO: Educational Audiology Association.

Wiley, S., Gustafson, S., & Rozniak, J. (2014). Needs of parents of children who are deaf/hard of hearing with Autism Spectrum Disorder. *Journal of Deaf Studies and Deaf Education, 19*(1), 40-49. doi: 10.1093/deafed/ent044

Yalçinkaya, F. F. (2008). Understanding auditory processing disorders. *Turkish Journal of Pediatrics, 50*(2), 101-105.

Appendix A

The Diagnostic and Statistical Manual of Mental Disorders (DSM) 5

Data is retrieved from the 2013 Diagnostic and Statistical Manual of Mental Disorders (DSM) 5, authored by the American Psychiatric Association. This particular section outlines common characteristics of Autism Spectrum Disorders (ASD).

Autism Spectrum Disorder

Diagnostic Criteria 299.00 (F84.0)

A. Persistent deficits in social communication and social interaction across multiple contexts, as manifested by the following, currently or by history (examples are illustrative, not exhaustive, see text):
   1. Deficits in social-emotional reciprocity, ranging, for example, from abnormal social and failure of normal back-and-forth conversation; to reduced sharing of interests, emotions, or affect; to failure to initiate or respond to social interactions.
   2. Deficits in nonverbal communicative behaviors used for social interaction ranging, for example, from poorly integrated verbal and nonverbal communication; to abnormalities in eye contact and body language or deficits in understanding and use of gestures; to a total lack of facial expressions and nonverbal communication.
   3. Deficits in developing, maintaining, and understanding relationships, ranging, for example, from difficulties adjusting behavior to suit various social contexts; to difficulties in sharing imaginative play or in making friends; to absence of interest in peers.

   Specify current severity:

   Severity is based on social communication impairments and restricted, repetitive patterns of behavior (see Table 2).

B. Restricted, repetitive patterns of behavior, interests, or activities, as manifested by at least two of the following, currently or by history (examples are illustrative, not exhaustive, see text):
   1. Stereotyped or repetitive motor movements, use of objects, or speech (e.g., simple motor stereotypes, lining up toys or flipping objects, echolalia, idiosyncratic phrases).
   2. Insistence on sameness, inflexible adherence to routines, or ritualized patterns of verbal or nonverbal behavior (e.g., extreme distress at small changes, difficulties with transitions, rigid thinking patterns, greeting rituals, need to take the same route or eat the same food every day).
   3. Highly restricted, fixated interests that are abnormal in intensity or focus (e.g., strong attachment or preoccupation with unusual objects, excessively circumscribed or preservative interests).

4. Hyper- or hyporeactivity to sensory input or unusual interest in sensory aspects of the environment (e.g., apparent indifference to pain/temperature, adverse response to specific sounds or textures, excessive smelling or touching of objects, visual fascination with lights or movement).

Specify current severity:
Severity is based on social communication impairments and restricted, repetitive patterns of behavior (see Table 2).

C. Symptoms must be present in the early developmental period (but may not become fully manifest until social demands exceed limited capabilities, or may be masked by learned strategies later in life).
D. Symptoms cause clinically significant impairment in social, occupational, or other important areas of current functioning.
E. These disturbances are not better explained by intellectual disability (intellectual developmental disorder) or global developmental delay. Intellectual disability and autism spectrum disorder frequently co-occur; to make comorbid diagnoses of autism spectrum disorder and intellectual disability, social communication should be below that expected for general developmental level.

Note: Individuals with a well-established DSM-IV diagnosis of autistic disorder, Aspergerôs disorder, or pervasive developmental disorder not otherwise specified should be given the diagnosis of autism spectrum disorder. Individuals who have marked deficits in social communication, but whose symptoms do not otherwise meet criteria for autism spectrum disorder, should be evaluated for social (pragmatic) communication disorder.

Appendix B

Listening Inventory

The researcher-designed ñListening Inventoryò was adapted from the Childrenôs Auditory Performance Scale, Listening Inventory for Education, Classroom Listening Scale, and LittlEARs. Utilizing Likert-type questions, each studentôs routine listening or ñperceptionò abilities were rated on a scale from 1 (Rarely) to 3 (Often).

Listening Inventory

Adapted from: *Children's Auditory Performance Scale, Listening Inventory for Education, Classroom Listening Scale, and LittlEARs*

For each question, please circle the numerical value that best represents this student's listening or "perception" abilities in the classroom. Each scale ranges from 1 (Rarely) to 3 (Always).

Student Name/Initials: _____ Chronological Age: _____ Number Code: ____

Compared to his/her classmates, does this student routinely…	***1 - Rarely***	***2 – Neutral***	***3 - Always***
1. Follow simple instructions (e.g., ñLine up at the door.ò)?	1	2	3
2. Follow ñmulti-partò instructions (e.g., ñGet your jacket and line up at the door.ò)?	1	2	3
3. Understand information the first time it is presented?	1	2	3
4. Stay focused during large group activities?	1	2	3
5. Stay focused when socializing with peers in small groups?	1	2	3
6. Stay focused when background noise is present?	1	2	3

Student Name/Initials: _____ Chronological Age: _____ Number Code: ____

Compared to his/her classmates, does this student routinely…	***1 - Rarely***	***2 – Neutral***	***3 – Always***
1. Follow simple instructions (e.g., ñLine up at the door.ò)?	1	2	3
2. Follow ñmulti-partò instructions (e.g., ñGet your jacket and line up at the door.ò)?	1	2	3
3. Understand information the first time it is presented?	1	2	3
4. Stay focused during large group activities?	1	2	3
5. Stay focused when socializing with peers in small groups?	1	2	3
6. Stay focused when background noise is present?	1	2	3

Student Name/Initials: _____ Chronological Age: _____ Number Code: ____

Compared to his/her classmates, does this student routinely…	***1 - Rarely***	***2 – Neutral***	***3 - Always***
1. Follow simple instructions (e.g., ñLine up at the door.ò)?	1	2	3
2. Follow ñmulti-partò instructions (e.g., ñGet your jacket and line up at the door.ò)?	1	2	3
3. Understand information the first time it is presented?	1	2	3
4. Stay focused during large group activities?	1	2	3
5. Stay focused when socializing with peers in small groups?	1	2	3
6. Stay focused when background noise is present?	1	2	3

Appendix C

Spelling Intervention Lesson Plan #1

The lesson plan outlines the introductory exercise, main lesson procedure, and closing activity during the first day of spelling intervention. The duration of this lesson was approximately 20-30 minutes.

Lesson Plan #1

Pre-Lesson Content

What will the students DO during the lesson?

- After receiving a list of ten spelling words, first-grade students will be able to ñRainbow Writeò a chosen word on the SmartBoard with minimal error.
- After receiving a list of ten spelling words, first-grade students will be able to create two ñSpelling Word Tongue Twistersò with minimal error.

What will the students LEARN as a result of participating?

- Students will learn how to ñRainbow Writeò specific spelling words, incorporating SmartBoard technology.
- Students will learn how to create tongue twisters, involving a spelling word in their writing.

How will you KNOW/ASSESS that they learned what you expected?

- Students will complete a practice test of five spelling words at the conclusion of the lesson. This practice test will serve as an exit slip for students.

Lesson Introduction

- To engage students in spelling as the focus of this lesson, students will complete a ñRainbow Writeò introductory activity. During this time, a student volunteer will write a chosen spelling word on the SmartBoard screen in two colors. Following their writing, students in one classroom will use the group amplification microphone to spell their selected word, while the other classroom will not incorporate the group amplification system as a control measure.*

*This activity was eliminated during the studyôs experimental procedures due to time constraints.

Teaching Procedure/Practice

- **Hook:** Students will complete a ñRainbow Writeò activity. A student volunteer will write a chosen spelling word on the SmartBoard screen in two colors. Following their writing, students in one classroom will use the group amplification microphone to spell their selected word, while the other classroom will not utilize the group amplification system as a control measure (15 minutes).*
- **Main Lesson:** First, the researcher will have a short discussion with students about tongue twister sentences and how they are created. Following this discussion, students will each receive a ñSpelling Word Tongue Twistersò worksheet. Students will be required to create their own two tongue twisters, involving two spelling words of their choice. After the majority of students have created their tongue twisters, student volunteers in one classroom can share their creations with the class via the group amplification microphone, while the other classroom will not utilize the group amplification system as a control measure (20 minutes)
- **Closure:** The lesson will conclude with a short practice test of five spelling words. Words will be stated once alone, once in a sentence, and once alone. The researcher will read each word with the group amplification microphone in one classroom, while the other classroom will not incorporate the group amplification system as a control measure (10 minutes).

*This activity was eliminated from the studyôs experimental procedures due to time constraints.

Lesson Conclusion

- To successfully end this lesson, students will complete a short practice test of five spelling words. Words will be stated once alone, once in a sentence, and once alone. The researcher will read each word with the group amplification microphone in one classroom, while the other classroom will not incorporate the group amplification system as a control measure. This practice test will also serve as an exit slip for students.

Appendix D

Spelling Intervention Lesson Plan #2

This lesson plan outlines the introductory exercise, main lesson procedure, and closing activity during the second day of spelling intervention. The duration of this lesson was approximately 20-30 minutes.

Lesson Plan #2

Pre-Lesson Content

What will the students DO during the lesson?

- After receiving a list of ten spelling words, first-grade students will be able to solve a ñWord Jumbleò puzzle of a specific spelling word on the SmartBoard with minimal error.
- After receiving a list of ten spelling words, first-grade students will be able to play ñSpelling Word Bingoò as a large group with minimal error.

What will the students LEARN as a result of participating?

- Students will learn how to solve a ñWord Jumbleò puzzle by unscrambling a set of letters and writing them in the correct order to create a spelling word.
- Students will learn how to play ñSpelling Word Bingoò by filling their game card correctly as spelling words are verbally stated.

How will you KNOW/ASSESS that they learned what you expected?

- Students will complete a practice test of five spelling words at the conclusion of the lesson. This practice test will serve as an exit slip for students.

Lesson Introduction

- To engage students in spelling as the focus of this lesson, students will complete a ñWord Jumbleò puzzle activity. During this time, a student volunteer will unscramble a set of letters on the SmartBoard screen to correctly create a spelling word. Following their writing, students in one classroom will use the group amplification microphone to spell their selected word, while the other classroom will not incorporate the group amplification system as a control measure.*

*This activity was eliminated from the studyôs experimental procedures due to time constraints.

Teaching Procedure/Practice

- **Hook:** Students will complete a ñWord Jumbleò puzzle activity. A student volunteer will unscramble a set of letters to create a chosen spelling word on the SmartBoard screen. Following their writing, students in one classroom will use the group amplification microphone to spell their selected word, while the other classroom will not utilize the group amplification system as a control measure (15 minutes).*
- **Main Lesson:** First, the researcher will pass out a set of ñSpelling Word Bingoò cards, and explain the game directions for students. Following these directions, the researcher will verbally call out various spelling terms, with students placing a game piece on the corresponding word. After a student has received a Bingo, they must spell each word covered. During this game, the researcher will use the group amplification microphone to call spelling words in one classroom, while the other classroom will not utilize the group amplification system as a control measure (20 minutes)
- **Closure:** The lesson will conclude with a short practice test of five spelling words. Words will be stated once alone, once in a sentence, and once alone. The researcher will read each word with the group amplification microphone in one classroom, while the other classroom will not incorporate the group amplification system as a control measure (10 minutes).

*This activity was eliminated from the studyôs experimental procedures due to time constraints.

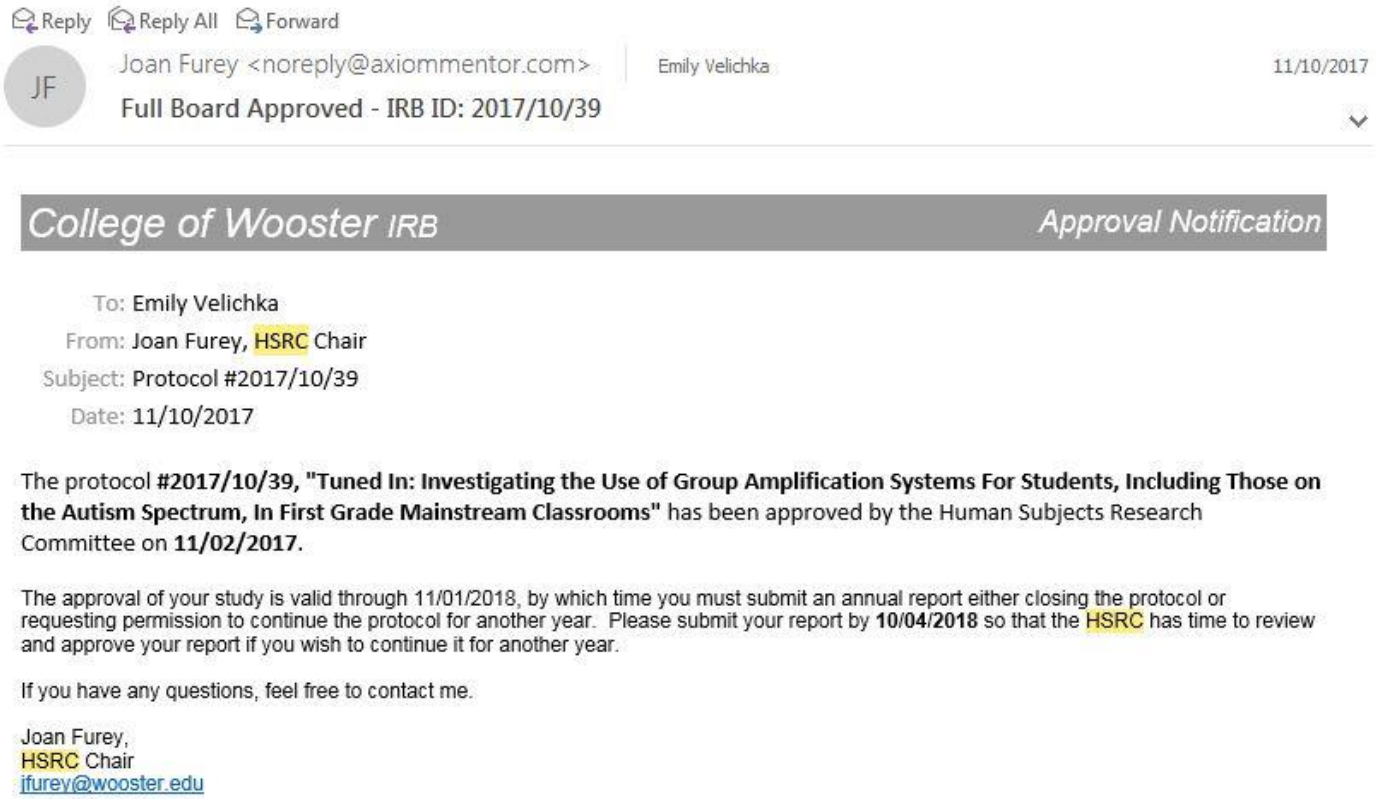
Lesson Conclusion

- To successfully end this lesson, students will complete a short practice test of five spelling words. Words will be stated once alone, once in a sentence, and once alone. The researcher will read each word with the group amplification microphone in one classroom, while the other classroom will not incorporate the group amplification system as a control measure. This practice test will also serve as an exit slip for students.

Appendix E

The College of Wooster Human Subjects Research Committee (HSRC) Approval

The College of Wooster HSRC approved this study on November 2, 2017. This full board approval occurred before any of this studyôs data was collected.



Reply Reply All Forward

JF

Joan Furey <noreply@axiommentor.com> Emily Velichka 11/10/2017

Full Board Approved - IRB ID: 2017/10/39

College of Wooster IRB *Approval Notification*

To: Emily Velichka
From: Joan Furey, HSRC Chair
Subject: Protocol #2017/10/39
Date: 11/10/2017

The protocol **#2017/10/39, "Tuned In: Investigating the Use of Group Amplification Systems For Students, Including Those on the Autism Spectrum, In First Grade Mainstream Classrooms"** has been approved by the Human Subjects Research Committee on **11/02/2017**.

The approval of your study is valid through 11/01/2018, by which time you must submit an annual report either closing the protocol or requesting permission to continue the protocol for another year. Please submit your report by **10/04/2018** so that the HSRC has time to review and approve your report if you wish to continue it for another year.

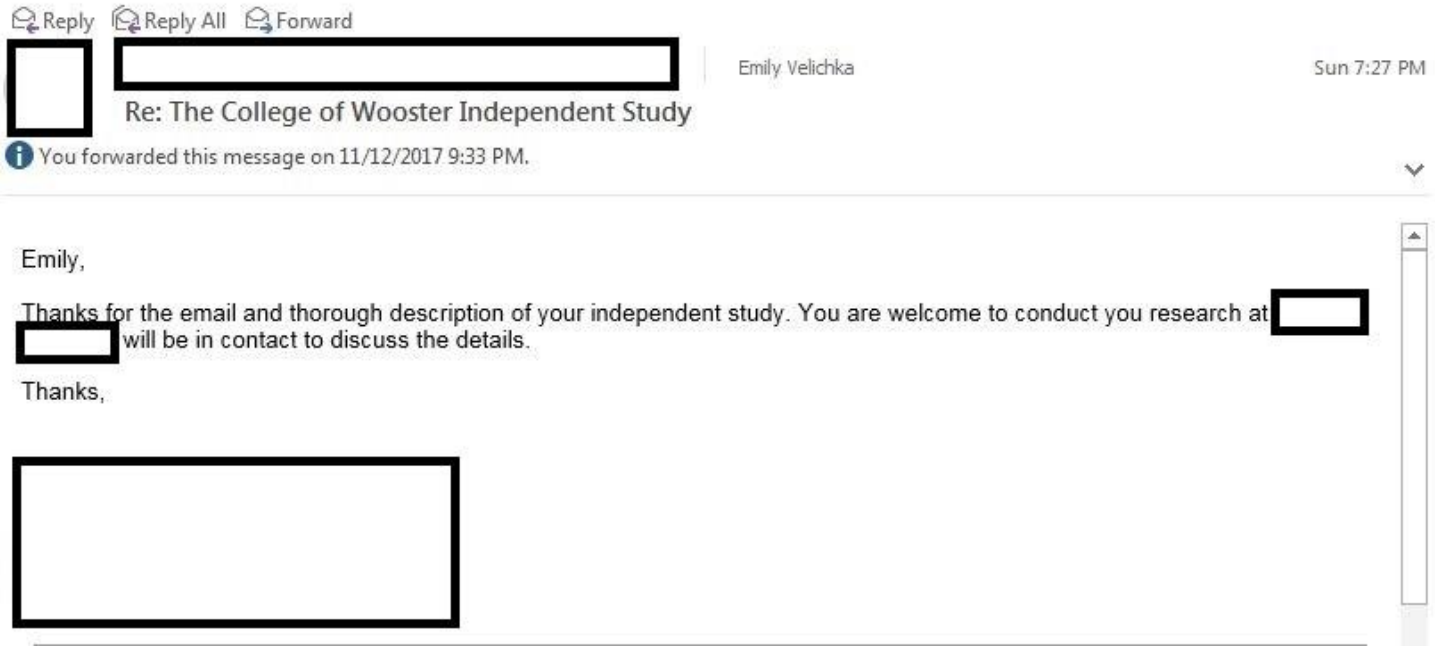
If you have any questions, feel free to contact me.

Joan Furey,
HSRC Chair
jfurey@wooster.edu

Appendix F

School District Superintendent Approval

A local, rural school district was the proposed location of this studyôs experimental process. As such, the district Superintendent approved this study on November 12, 2017. This approval occurred before any of this studyôs data was collected. Names and other information have been removed to protect identity.



Appendix G

Elementary School Principal Approval

A local, rural elementary school was the proposed location of this studyôs experimental process. As such, the elementary school Principal approved this study on November 19, 2017. This approval occurred before any of this studyôs data was collected. Names and other information have been removed to protect identity.