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Noise-Cancelling Headphones as an Intervention to Maintain Classroom Time Spent On-Task for Students With Autism Spectrum Disorder

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Abstract

A single-subject research design was utilized to study the effects of noise-cancelling headphones on students with autism spectrum disorder (ASD) in the classroom. Academic success has long been linked to students' time spent on-task in the classroom. Interventions to maintain time spent on-task have been studied and researched but many, currently employed, are not considered to be evidence-based practices (EBP). This is due to the rigorous criteria an EBP requires. Aversion and avoidance to sensory stimuli has long been studied as a common symptom for children with ASD; auditory sensory overload is one of these hypersensitivities affecting children of this population. The inability to habituate to novel classroom noises, for students with ASD, may facilitate inattention and lack of academic success. Compulsory education and the federal mandate to educate children in his/her least restrictive environment often places students, of all abilities, in a general education classroom, for partial or a full school day. Educators, therefore, are responsible for implementing all accommodations and modifications, inclusive of students with ASD. The specific accommodations and modifications are delineated by the students' individualized education plan, including accommodations to maintain time spent on-task. This study explored the effectiveness of classroom use of noise-cancelling headphones utilizing a nonconcurrent multiple baseline design across participants and curricula to visually analyze the functional relationship between noise-cancelling headphones and time spent on-task. This was implemented to answer the following research questions: (1) does the use of noise-cancelling headphones increase time spent on-task for students with ASD, measured by time spent in active listening, active engagement during independent reading tasks; (2) does the use of noise-cancelling headphones increase time spent on-task for students with ASD, measured by time spent in active listening, active engagement during independent math tasks; (3) do the participants view the usage of the noise-cancelling headphones as socially valid and effective; finally (4) do the participants' teachers view the usage of the noise-cancelling headphones as socially valid and effective? Behaviorism theory was the foundation for this study; simply stated, a behavior will increase (on-task behavior) with removal, or prevention, of an aversive stimulus (auditory input). This is completely dependent on behavioral function, specifically, escape or avoidance of certain auditory input. Increased behavior as a result of removal of an aversive stimulus is also known as negative reinforcement. Therefore, it was hypothesized that with use of noise-cancelling headphones, ambient noise would be removed from the students' environments and time spent on-task in math and reading would increase. It was also hypothesized that all the participants and the participants' teachers would find the intervention socially valid and effective. If the teachers view the intervention as easily implemented and effective, the practitioner becomes the researcher. If the participants view the intervention as beneficial, increasing classroom time spent on-task may result in increased academic success. Visual analyses of level, trend, and variability were used to interpret data through graphing momentary time sampling data in baseline and intervention phases. Reliability would have been established through inter-observer agreement (IOA), however, due to COVID-19, IOA was not collected and the data presented are hypothetical. Results from the visual analyses demonstrate a positive functional relationship between increased time spent on-task and noise-cancelling headphone use.

Additionally, this study would have employed a social validity survey to answer research questions three and four.

Dedication

This is dedicated to my family; the one I was born into, and the one I chose.

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COVID -19

Due to the onset of the infectious virus COVID-19 within the United States (U.S.), many businesses, activities, and travel plans were impacted. In March of 2020, the majority of the U.S. had issued a stay at home order, implementing curfews as well as travel restrictions, based on the COVID-19 data coming from New York (Muccari et al., 2021). By the fall of 2020, the United States had a COVID-19 prevalence close to seven million, and over 200,000 deaths, surpassing the amount of deaths in the Vietnam War (CDCa, 2020). Because of the effects of the virus, the U.S. had limited all non-essential businesses inclusive of restaurants, bars, concerts, professional sports games, shopping malls, car dealerships, etc. Physical school attendance was also included in the shutdown. According to the Centers for Disease Control (CDCa, 2020), COVID-19 is assumed to spread from person to person through close contact via respiration and the passing of sputum from one individual to another. Additionally, those not displaying symptoms of the virus may be unknown carriers and spread the virus to others. The spread of COVID-19 is applicable to all learning environments, such as a school. According to CDC (2020a) warnings, all students, teachers, administrators, researchers, staff, volunteers, parents, etc. are vulnerable to infection and transmission.

In order to limit the community-spread of the virus, brick and mortar schools were closed and educational learning was shifted to in-home online learning. As of February 2, 2021, many schools, in many states, remained remote. According to UNICEF.org (2021), between March 11, 2020 and February 2, 2021, schools all over the world have been remote for over 95 instructional days, representative of half a typical school year. Additionally, UNICEF.org (2021) reports some schools, both nationwide and international, have had physical schools closed for almost the entirety of 2020 and into 2021. Limiting the presence of nonessential personnel in the classroom setting, or other settings, is critical to the eventual full reopening of schools (CDC, 2021). Additional policies and procedures have been, or will be, implemented in order to physically reopen schools to full capacity. Many of these policies and procedures will include limiting the presence of non-essential workers in the classroom. The researcher is considered non-essential to the classroom; thereby, limiting the researcher's presence in schools.

Implications Affecting the Current Study

Prior to the dissemination of information regarding the severity of COVID-19, the researcher's committee had accepted this study's dissertation proposal, and data collection within the Washoe County School District (WCSD) had begun. The Institutional Review Board (IRB) process was completed and WCSD had also approved the study, allowing the researcher to begin data collection. As the virus spread, more knowledge of how it was contracted was released, and more schools closed to limit the contagious spread within the community. As of May 2020, the CDC stated non-essential visitors, volunteers, and activities including external groups would be extremely limited. With this information, the data collection of the approved dissertation proposal ceased. The previously approved study required social interaction with students and teachers within an educational setting; therefore, required data could not be collected as more information about how COVID-19 spreads surfaced and schools closed to face-to-face learning.

It was then proposed the researcher would complete an alternative dissertation. The alternative dissertation, as accepted by the committee, was to include hypothetical data created by the committee chair, Dr. Shanon Taylor, and analyzed by the researcher. The provided hypothetical data were applied into the previously approved study requiring face-to-face learning. The current dissertation is completed with hypothetical data regarding the use of noise-cancelling headphones, for students with autism spectrum disorder (ASD) in a classroom setting, to maintain time spent on-task. Though the full IRB and WCSD process had been completed for the face-to-face, in classroom, research, it was suspended due to the severity of COVID-19. Therefore, some completed sections of the study may have a different verb tense than the parts of the study that were unable to be completed.

Additional Articles for Reference

In addition to the completion of this study with hypothetical data, the committee asked the researcher to conduct a supplementary study and write-up with actual data. This study involved conducting a survey, via different facets of social media, requesting anonymous demographics and information from educators all over the U.S. regarding their use of noise-cancelling headphones for students with ASD. The article is included at the end of this dissertation (see Appendix L). The data from this survey show many educators currently employ noise-cancelling headphones, as an accommodation, for students with ASD. The use of noise-cancelling headphones, as an intervention to maintain time spent on-task for students with ASD, is not currently delineated as an evidence-based practice (EBP); however, survey findings show many educators utilize the noise-cancelling headphones for students with auditory hypersensitivity. Moreover, the use of noise-cancelling headphones has been observed for students of all abilities; this discovery leads to additional questions and research possibilities regarding the use of noise-cancelling headphones for all students.

An additional study conducted on classroom technology use is also included at the end of this dissertation (see Appendix M). This study explores the literature on the use of "high-tech" classroom technology for students with ASD, specifically iPads/tablets. Additionally, this study examines the quality of current research on iPad use for students with ASD. The current use of classroom high-tech technology is further discussed in the following study, however, the aforementioned article delves deeply into the quality of research on iPads/tablets for students with ASD. This additional article relates to the initial dissertation study through classroom technology use and social validity measures in research design.

Dissertation Contents

This alternative dissertation includes the following components: (1) a chapter on the effects of COVID-19 on this study's data collection; (2) a single-subject design depicting a multiple baseline across hypothetical participants with use of momentary time sampling data collection and visual analyses, followed by references and appendices; (3) a survey study on educators'/administrators' current use of and opinion(s) of noise-cancelling headphones in the classroom/school, for students with ASD; this survey was disseminated across various social media platforms It is followed by references and appendices, and finally; (4) an additional study on the use of high-tech technology (i.e., iPads) in the classroom for students with ASD, followed by references and an appendix.

Chapter 1

Introduction

Autism spectrum disorder (ASD), as defined by the CDC (2019), is a developmental disability that may cause challenges within social and interpersonal relationships, communication deficits, as well as behavioral difficulties. The CDC (2019) also states that individuals with a diagnosis of ASD may communicate, interact, behave, and also may learn differently than individuals without an ASD diagnosis. Some symptoms associated with ASD according to the CDC are as follows: The individual may (a) not point at objects to show interest, (b) not follow someone's else's pointing finger to an object when directed or non-directed, (c) have difficulty relating to others, (d) avoid eye contact, (e) have difficulty with empathy or understanding emotion, (f) prefer not to be touched by others, (g) have difficulty expressing needs, (h) have difficulty adapting to deviation from a familiar routine, (i) exhibit echolalia. Furthermore, the National Institute for Mental Health (NIMH; 2018) classifies ASD as a disorder characterized by (a) ongoing social deficits inclusive of communication; (b) repetition of specific behaviors; and (c) limited interests in objects, people, and/or activities. These are generally recognized by age two and can impair the individual's performance at school, work, etc. The CDC (2019) shows that an average of one in every 54 (1.85%) eight-year olds has a diagnosis of ASD; that number continues to increase. ASD is seen across genders and all ethnicities. The etiology of ASD is unknown and there is no known cure. Additionally, no clear direction in the management of ASD symptoms through therapies and/or treatments has been provided by the above entities (Taylor & Urquhart, 2018).

High ASD prevalence and with incidence increasing exponentially, nearly all educators (general and special) teaching children age 6–21 have or have had a student with ASD in the classroom (Anderson et al., 2018). ASD in the classroom can manifest in many ways. Congruent with the ASD delineations above, a student may exhibit limited or severe educational and/or social differences in both special and general education classrooms.

Over the past ten years, the number of students with autism attending and included in mainstream educational settings has increased (Bradley, 2016). Wolery and Hemmeter (2011) discuss inclusion in the least restrictive environment (LRE) for students with autism as a direct access point to the general education curricula and a method to promote the development of social skills. Some form of inclusion in the LRE for students with ASD is not only beneficial but also required by the Individuals with Disabilities Act (IDEA; 2004), which states:

> To the maximum extent appropriate, children with disabilities, including children in public or private institutions or other care facilities, are educated with children who are not disabled, and special classes, separate schooling, or other removal of children with disabilities from the regular educational environment occurs only when the nature or severity of the disability of a child is such that education in the regular classes with the use of supplementary aids and services cannot be achieved satisfactorily.
>
> §300.324(d)(2).

Placing students with ASD into a general education classroom has many benefits (e.g., social benefits, access to typically developing peers, access to the general curriculum).

Odom et al. (2011) and Wolery and Hemmeter (2011) discuss how inclusion results in crucial outcomes for children with disabilities (e.g., ASD) including, but not limited to, belonging, participating, as well as support of development in social competency. In addition to this, all students with and without disabilities may benefit from an inclusive setting (Odom et al., 2011). There are many benefits of inclusionary practices in a general education classroom, but there are potential barriers for students with ASD (e.g., excessive sensory input).

Suarez (2012) concludes that children with ASD have a low threshold for sensory input, which may lead to an overreaction or under reaction to different sensory information. As discussed above, the definition of ASD includes an aversion to human touch, a difficulty in adapting to novel situations, and the repetition of specific behaviors (e.g., hand flapping, rocking, etc.). These symptoms have a common theme; they are sensory-centered. According to Tomchek and Dunn (2007), auditory hypersensitivity is the most commonly reported sensory processing impairment in ASD. Sensory sensitivities, specifically to noise, are a commonly reported and highly misunderstood symptom of the disorder (Fodstad et al., 2020). Furthermore, a child's avoidance of auditory stimuli may inhibit the development of desired conditional social stimuli resulting in limitations in acquisition of reinforcement functions, discrimination techniques, and also an ability to generalize (Bijou & Ghezzi, 1999). This shows exposure to auditory stimuli, eliciting avoidance or escape, may lead to future social and educational issues. The correlation between aversion to environmental noise and the inability to habituate is further discussed.

Thompson and Spencer (1966), define habituation as the decrease in the strength of a response after repeated presentations of the same stimulus. In application to noise, habituation is the decrease in attending to noise after repeated, consistent presentations of the same noise (e.g., the air conditioning unit). Kenzer et al. (2013), discuss habituation as attending to a stimulus at the occurrence of the stimulus, but as the stimulus is repeatedly presented, attention may decrease. Dishabituation is discussed as the presentation of a novel stimulus after habituation has occurred and the formerly habituated stimulus resumes attention (Kenzer et al., 2013). Inability to habituate or dishabituation may be factors leading to time spent off-task for students with ASD.

The symptoms of ASD, described above, delineate how sensory overload can inhibit academic learning in an educational environment inclusive of high levels of classroom noise. Bijou and Ghezzi (1999) state children with ASD may have differences in their sensory processing center leading to a tendency to escape or avoid specific stimuli. According to Hudac et al. (2018), children with ASD exhibit more differences in the processing and encoding of sensory information than their typically developing peers, and they also may exhibit differences in cognitive control over environmental changes with use of habituation. “Auditory avoidance is a common trait seen in children with ASD; it can be seen that many avoid loud noises and loud speech, often covering his/her ears” (Wing, 1966, p. 8, as stated in Bijou & Ghezzi, 1999)

With limited habituation abilities, students with ASD may attend to or avoid novel, loud, or unfamiliar sounds present in an inclusive classroom, limiting acquisition of curriculum. Rowe et al. (2011) found ambient occupied classroom noise, or decibel (dB) levels, were often above recommended levels. Northern and Downs (1978; as cited in Fodstad et al., 2020), established acceptable noise parameters around 55 dB levels. Knecht et al. (2002) determined the ambient dB level of an unoccupied classroom should not exceed 30 dB; and an occupied classroom should range between 40-50 dB levels. However, they found only four of the 32 schools in the study met acceptable levels.

IDEA delineates access to the general education classroom and access to typically developing peers, in an inclusive setting, as a mandatory method of providing services to students with disabilities (Crosland & Dunlap, 2012; Jimenez et al., 2007; Odom et al. 2011); which further demonstrates the necessity of effective, easily implemented classroom interventions to reduce sensory stimulation (e.g., auditory).

Discussed below are the following: (a) statement of the problem, (b) a brief discussion of on-task behavior, (c) educating students with ASD in the inclusive classroom, and (d) why maintaining on-task classroom behaviors is important.

Statement of the Problem

On-task student behaviors are necessary for academic success. This is also true for students with ASD. Sensory processing difficulties are a common symptom for students with ASD; consequently, on-task behaviors may be affected. Ambient classroom noise may exacerbate, or lead to, off-task behaviors, impacting academic success.

Students with an individualized education plan (IEP) are required to participate in his/her LRE, which may include the inclusive classroom. On-task behavior, leading to academic success, may be hindered by inclusive classroom noise-levels. Additionally, the educator is often tasked with effective intervention implementation. With limited educator training and/or difficult intervention implementation, lack of on-task behavior may be inevitable.

Many current practices, or interventions, to maintain time spent on-task in a classroom for students with ASD, are implemented in restrictive, or clinical, settings to eliminate extraneous variables. Clinical implementation also helps determine intervention validity. These interventions, however, may lack research in general-education classroom settings. In a restrictive/clinical setting, the intervention implementation may not necessarily translate to a naturalistic setting (e. g. a classroom), where the intervention is most needed (see Lloyd et al., 2016). Hence, in order to implement an intervention in the classroom, the educator must become the researcher.

Following is a brief description of on-task classroom behavior follows, as well as a discussion of why maintaining time spent on-task is crucial for academic success.

On-Task Behavior

On-task behavior is an indicator of attention and focused student behavior to instruction; yet, despite much research on maintaining on-task behavior, designing effective, easily implemented, scalable interventions to reinforce and maintain on-task behavior has been a challenging feat for educators and researchers (Godwin et al., 2016). Skinner (1965) discusses how the traditional teacher has found that students will not exhibit on-task behavior unless they are concerned with the consequences of their work. This demonstrates that the academic outcome must have relevance to the student in order to elicit on-task behavior. Rowe et al. (2011) described on-task behavior as “directing the face toward the lesson and visual engagement of the information presented” (p. 231). Szwed and Bouck (2013) operationally define time spent on-task as attending to appropriate materials (e.g., a math worksheet, the speaking teacher, completing activities, asking for appropriate assistance, etc.). Though it is crucial to academic success, educators may struggle with implementation of the current EBP's for maintaining time spent on-task.

Maintaining On-Task Behavior

Research beginning in the 20th century has demonstrated the detrimental effects of noise have been shown to affect psychological, physiological, and social components of the human psyche (Smith & Riccomini, 2013). Because noise has been shown to have ill effects on many aspects of life, noise should be considered when discussing issues with education and on-task behavior. Morgan (1917) experimented with the effects of noise on memory and academic learning. In this study, the participants were presented with an envelope containing new information in both a noisy and quiet environment. Morgan (1917) concluded participants retained less information and had a lower attention span in the noisy environment than those in the quiet environment. Morgan's work demonstrates how lesson retention is more difficult in a noisy environment.

Classrooms can be highly distracting, noisy places (Knecht et al., 2011; Rowe et al., 2011), where numerous groups of students do a variety of academic tasks with constant discussion and movement. Students are often pulled out of the inclusive classroom for additional services and other students may be talking out of turn. The school-wide intercom is activated several times per day; the classroom phone rings sporadically, there are bells or tones to indicate subject changing/lunch break, the air conditioning unit may start, or there may be construction nearby. All of these present auditory stimuli. Knecht et al. (2002) found majority of the schools in the study exceeded recommended decibel (dB) levels. Distracting noise(s) may lead to aversion/avoidance of auditory input for a student with ASD (see Bijou & Ghezzi, 1999); and the inability to habituate may elicit off-task behaviors. For example, Baker et al. (2008) state that sensory processing and issues with modulation affect as many as 95% of people with ASD, and Pfeiffer et al. (2008) state students who have difficulty modulating sensory information within the classroom will have difficulty attending to classroom curriculum. This difficulty in modulating sensory information shows a need for classroom sensory monitoring and student accommodations and interventions.

Currently Used Interventions to Maintain/Increase Time Spent On-Task

There are few evidence-based practices (EBPs) currently employed in the classroom to maintain attending and on-task behavior for students with ASD (Odom et al., 2015; Odom et al., 2010b; Wong et al., 2015). The EBPs discussed in this study include a functional behavior assessment (FBA) leading to a differential reinforcement of alternative behavior (DRA), video modeling (VM), video self-modeling (VSM), Social Stories™, and individual work systems. These EBPs are often effective in maintaining time spent on-task for students with ASD; however, they often involve researcher implementation. The EBPs may also involve large amounts of time, different types of technology, and constant data collection, making it very difficult for the general education teacher to implement with fidelity (Anderson et al., 2015; Buggey & Ogle, 2011; Finn et al., 2015; Hitchcock et al., 2003; Lloyd et al., 2016; Moore et al., 2013; Reynhout & Carter, 2009). The tedious requirements of EBP implementation show general education teachers require access to an easily implemented interventions to maintain time spent on-task for students with ASD in the inclusive classroom.

Sensory processing deficits, more specifically, auditory processing deficits, for students with ASD, often inhibit time -spent on-task. In order to combat extraneous classroom noise, Kinnealey et al. (2012) conducted a study with students with ASD wherein the walls of the classroom were altered to make them sound absorbing. The results show, through noise reduction, attending behavior increased, engagement increased, and there were academic improvements. Additionally, Smith and Riccomini (2013) conducted a study including students with and without a learning disability (LD); noise-reducing headphones were available as an accommodation during a test. The participants were given a reading comprehension assessment, with exposure to both conditions (i.e., intervention use during the first assessment, lack of intervention use for second assessment). The results show a significant increase in reading comprehension scores for many students with LD as 20 of the 35 students with LD showed an increase in scores while wearing the noise reducing headphones (effect size = .59). This research supports use of noise-cancelling headphones to increase academic scores for students with disabilities.

Smith and Riccomini (2013) additionally suggest the benefits of noise reducing headphones for students during certain times of day or when the classroom noise exceeds recommendations. Ikuta et al. (2016) found that earmuffs had a positive behavioral effect with reduction of auditory stimuli in children with ASD, and Rowe et al. (2011) found that, in an auditory environment with sound levels at or above recommended classroom levels, headphones prolonged and increased consistent attention to the task. Pfeiffer et al. (2019) concluded noise-controlled headphones for "children with ASD may reduce sympathetic activation" (p. 2).

Additionally, noise-cancelling headphones are easily implemented in the classroom (see additional survey study below). They can be individualized and are cost-efficient, making them an easily accessed, low-tech tool with potential to increase time spent on-task, theoretically improving academic success. The significance of this study and contribution to research is discussed below.

Significance of the Study

The current study contributes to practice by exploring a cost-efficient, easily implemented intervention to maintain classroom on-task behaviors for students with ASD. By increasing time spent on-task, it can be assumed academic success would follow (see Morgan, 1917; Smith & Riccomini, 2013). This contribution may lead to maintaining or increasing on-task behavior for students with ASD during classroom work and also shows generalization potential toward other life applications (e.g., reading for pleasure, homework completion, etc.). Furthermore, this study solely pertains to the field of special education, specifically ASD. Many students receiving special education services may benefit from the effects of noise-cancelling headphones in order to promote time spent on independent classroom tasks. Morgan (1917) and Smith and Riccomini (2013) further discuss noise as detrimental in a learning environment, limiting curriculum acquisition [for students of all abilities], which shows the importance of minimizing distractibility with an ultimate goal of academic success.

Purpose of the Study

The purpose of the current study was to explore the effects of a simple, cost-efficient, and non-invasive accommodation to combat everyday classroom distractions and interruptions in an inclusive classroom for students with ASD. Educators are tasked with intervention implementation and data collection while continuing to teach and attend to all classroom students, demonstrating a need for an effective, easily employed accommodation. This study explores that need by creating a researcher out of an educator.

This study includes four components: (1) investigation of the effects of noise-cancelling headphones on time spent on task in reading, for students with ASD; (2) investigation of the effects of noise-cancelling headphones on time spent on task in math, for students with ASD; (3) determining if the participants view the headphones as socially valid and effective and; (4) determining if the participants' teachers view the headphones as socially valid and effective.

Theoretical Framework

The theory of behaviorism was used to guide this study. Behaviorism is based upon the observable and lawful relations between and across observable stimuli and responses that follow stimuli exposure (Boghossian, 2006). Skinner (1965) stated that we are concerned with causes of human behavior; we want to know why [humans] behave as they do, and any condition or event that demonstrates an effect on behavior must be considered. "In the discovering and analyzing of behavioral causes we can then predict behavior to the extent where we can manipulate [behavioral contingencies], thereby controlling behavior" (p. 23). Behaviorists view consciousness as an indefinable, unobservable, and unusable concept, and concluded in 1912 the work would lie with the observable and the tangible (Watson & Kimble, 1998). Looking inside the organism for behavioral explanations will overshadow the overtly available variables within that organism's current environment (Skinner, 1965). Tolman (1925) concluded when describing a specific behavior, one must also consider "toward-which or from-which the behavior is directed to determine the purpose" (p. 39). Through observation of toward-which or from-which an individual's behavior is directed, it is possible to determine the behavioral function. Once behavioral function is determined, that behavior can theoretically be altered. Behavioral function is determined through observation, data collection, and often operant or reinforcement contingency manipulation.

The study of behavior relies heavily on observed behavior; so within an educational context, the individual's behavior must be observable (e.g., remaining seated, hand raising) and measureable (e.g., frequency, duration). A student's classroom behavior may increase or decrease when seeking desired academic grades or other reinforcers (Boghossian, 2006). Additionally, Skinner (1965) discusses how the traditional teacher has found that students will not behave on-task unless he/she is concerned with the consequence. This demonstrates that the academic outcome must have relevance to the student in order to elicit on-task behavior(s). This study explores observable and measureable on-task behaviors with use of an intervention. These are delineated by research questions one and two, discussed below.

Research Questions

The current study asks the following questions:

(1) Does the use of noise-cancelling headphones increase time spent on-task for students with autism, measured by time spent in active listening, active engagement during independent reading tasks?

(2) Does the use of noise-cancelling headphones increase time spent on-task for students with autism, measured by time spent in active listening, active engagement during independent math tasks?

(3) Do the participants view the usage of the noise-cancelling headphones as socially valid and effective?

(4) Do the participants' teachers view the usage of the noise-cancelling headphones as socially valid and effective?

Hypotheses

The current study examines the following hypotheses:

(1) Participants will increase the percentage of time spent on-task in independent reading tasks with use of the independent variable.

(2) Participants will increase the percentage of time spent on-task in independent math tasks with use of the independent variable.

(3) The participants will view the independent variable as socially valid and effective.

(4) The participants' teachers will view the independent variable as socially valid and effective.

Definitions of Key Terms

Included in the following list are important key terms found in the current study. In addition to these, the reader should be aware that on-task behaviors and attending behaviors are used interchangeably as are un-attending behaviors and off-task behavior, intervention, independent variable, and noise-cancelling headphones, as well as visual analysis and visual inspection, single-subject design and single-subject research.

On-task behavior: active listening (i.e., eyes on the appropriate speaker, body positioned forward, not talking), active engagement (i.e., following the instructor's requests, appropriate responding when solicited, eyes on the appropriate material in front of student, actively engaged in note taking, highlighting, etc.), or ignoring other inappropriate or untimely sources of sensory input (e.g., other students talking out of turn, people entering or leaving the classroom).

Off-task behavior: inactive listening (i.e., eyes looking anywhere but the appropriate speaker, body not positioned forward, talking out of turn), inactive engagement (i.e., not following the instructor's requests, inappropriate responding, eyes on inappropriate stimuli, not actively engaged in note taking, highlighting, etc.), or attending to inappropriate sources of sensory input (e.g., other students talking out of turn, people entering or leaving the classroom).

Habituation: a term utilized to describe how repetitive presentation of a stimulus may lead to a lack of responses from a participant (Kenzer et al., 2013).

Sensory processing: acquiring environmental information through the use of sensory input (tactile, auditory, visual, etc.) in order to organize and interpret information and respond with appropriate motor and behavioral responses (Kranowitz, n.d.).

Visual analysis: interpreting and analyzing a graph from data collection, in order to find a pattern inclusive of four dimensions: trend, level, variability (Cakiroglu, 2012, p. 22). Visual analysis is considered the traditional method for data interpretation within single-subject design (SSD); statistical analysis is deemed unnecessary if the change [in behavior] is visually obvious in the graphed data (Parsons & Baer, 1986; as cited in Perdices & Tate, 2009).

Delimitations

This study investigates the effects of noise-cancelling headphones on attending behaviors for three students diagnosed with ASD in their individual classroom setting. First, this study is delimited to elementary students with ASD; second, this study is delimited to the classroom setting; third, this study takes place in one region of the country, in one school district.

Additionally, this study employs a multiple baseline design across participants, requiring a high reliance on visual analyses; and finally, the intervention is implemented across two subject areas, non-concurrently, for each participant, perhaps increasing comfort toward the novel intervention.

Summary

Chapter 1 provides an introduction overview, statement of the problem, significance of the study, purpose of the study, research questions, theoretical framework, definitions, and lastly delimitations of this study. The relevant literature is presented in Chapter 2; study methodology is presented in Chapter 3.

Chapter 2

Literature Review

The following chapter begins with defining autism spectrum disorder (ASD) and the symptomology behind it, as well as how these symptoms may affect curricula acquisition. It focuses on the relevant literature and the importance of including students with ASD in the general education classroom, with an emphasis on the least restrictive environment (LRE). It also discusses why intervention implementation may present difficulties for educators. In addition to this, theories of why maintaining time spent on-task in the classroom is difficult, what constitutes an EBP, as well as the EBPs currently employed to maintain time spent on-task are discussed. The current technologies used in the classroom to maintain time spent on-task are also included. Finally, a simple, effective tool easily implemented by teachers in an inclusive setting to maintain time spent on-task for students with ASD is introduced.

Autism Spectrum Disorder

Autism spectrum disorder (ASD) is currently defined by the Centers for Disease Control and Prevention (CDC, 2019) as a developmental disability that can impair social, communicative, and behavioral aspects of an individual's life. It is further defined by Crespi (2016) as a neurodevelopmental disorder characterized by social and communicative deficits combined with restrictive and/or repetitive language, movements, and/or behaviors. The CDC provides guidelines on ASD symptoms including: (a) lack of interest in objects, (b) lack of interest in direction or non-direction, (c) difficulty relating to others, (d) avoidance of eye contact, (e) difficulty with empathy or understanding emotion, (f) aversion to touch or other sensory input, (g) difficulty expressing needs, (h) difficulty adapting to deviation from a familiar routine, (i) exhibition of echolalia. Furthermore, the National Institute for Mental Health (2018) classifies ASD as a disorder characterized by (a) ongoing social deficits inclusive of communication; (b) repetition of specific behaviors; (c) limited interests in objects, people, and/or activities, which are generally recognized by age two and can impair the individual's performance at school, work, personal, etc. ASD was once characterized as an extremely rare disorder; but is now recognized as the most common neurological disorder-affecting children (Leblanc et al., 2009). Scientists are still unaware of the etiology of ASD and attribute it to a genetic condition or multiple causes, some of which are still unknown (CDC, 2019).

The ASD spectrum includes a wide range of functionality of individuals with this disorder. What was previously diagnosed individually as Asperger's syndrome, pervasive developmental disorder—not otherwise specified, and autistic disorder are now diagnosed more broadly diagnosed as ASD (CDC, 2019). Individuals with ASD may vary in intelligence scores, social skills, and levels of independence. For example, the ability of individuals with ASD to problem-solve and acquire information can range from a severe impairment to extremely gifted; some individuals need assistance with day-to-day activities, while others can live independently (CDC, 2019). Because ASD is often diagnosed at a very young age, many general educators are tasked with providing high–quality, student–centric instruction within the LRE.

Least Restrictive Environment and the Inclusive Classroom

Educators in inclusive classrooms are expected to attend to the learning differences of all students in the classroom. In an inclusive setting, an educator may have between 5–30 students at one time, leading to attention requirements from all the students simultaneously. The inclusive classroom is an approach to including students with disabilities in the general-education classroom; more broadly, it is an approach to eliminate classroom exclusion based on certain factors (e.g., ability, race, socio-economic status, gender, religion; Ainscow & Sandill, 2010). Inclusion is a term for differentiated instruction as an approach to enable teachers to plan and implement instruction for students of all abilities (Smit & Humpert, 2012). Requirements of inclusionary classroom practices are rooted in the federal law ensuring students of all abilities are served and educated in his/her LRE, with access to the general education curriculum IDEA, (2004), states:

> To the maximum extent appropriate, children with disabilities, including children in public or private institutions or other care facilities, are educated with children who are not disabled, and special classes, separate schooling, or other removal of children with disabilities from the regular educational environment occurs only when the nature or severity of the disability of a child is such that education in the regular classes with the use of supplementary aids and services cannot be achieved satisfactorily.
>
> §300.324(d)(2).

The student’s LRE is determined by the individualized education plan (IEP) team and this student must be exposed to, and able to learn from, this environment. Past research has demonstrated that an inclusive setting may not always meet the students’ classroom needs and may not provide resources and support to the general educator in order to provide high-quality instruction (Vaillant, 2011); however, educators are required to provide high-quality instruction despite lack of support and resources in this setting (Tarr et al., 2012). In order to comply with LRE requirements, general educators must have the necessary tools and resources for students of all abilities.

In the broad spectrum of students' abilities, an ASD diagnosis is increasingly prevalent in the general education setting. According to the CDC (2019), one child out of every 54 has a diagnosis of ASD. This demonstrates high prevalence; and it is assumed that nearly all educators (general and special) teaching students ages 6–21 have a student with ASD in the classroom (Anderson et al., 2018). Inclusion for students with ASD is a direct access point to the general education curricula and a method by which to promote the development of social skills (Wolery & Hemmeter, 2011). In addition to this, Finn et al. (2015), expressed the difficulty of including students with ASD into the general education classroom due to the learning differences, focus, and pacing; showing a need for interventions designed to maintain focus.

Maintaining On-Task Classroom Behaviors

Educators have long known that attending school on a consistent basis and engaging in school activities are related to academic achievement (Odell, 1923). Engaging in school activities, or attending to what is being taught, with interest, increases dedicated time to classroom curricula through cultivation of a commitment to learning. Limited time engaged in appropriate academic tasks, limits the completion of tasks and hinders material comprehension.

Classroom success is dependent on a multitude of factors and setting students up for success is a difficult task faced by educators today. Maintaining/increasing time spent on-task is crucial to academic success (see Odell, 1923). Forsythe (1977) operationally defines time spent on-task in the classroom as the appropriate attending to curricula and participating in classroom activities. Equally, Szwed and Bouck (2013) operationally define time spent on-task as attending to appropriate materials (e.g., a math worksheet, the speaking teacher, completing activities, asking for appropriate assistance, etc.). Maintaining appropriate classroom behaviors is essential for academic success (Fisher, 2009; Odell, 1923), dictating a need for classroom interventions. “If an educator’s goal is to encourage thinking and improve academic achievement, it is necessary to create learning environments facilitating engagement and time spent on-task” (Fisher, 2009, p. 175). The theories of causation of off-task classroom behaviors, discussed below, provide insight into the currently used interventions.

Many theories exist as to what supports maintenance of on-task behaviors. For example, Norman (1968) discussed his theory of attention as selective mechanism of different sources of sensory input, only after the representation in storage (a temporary interest and a permanent interest) has been activated. He further adds that “we would not know when relevant information has arrived unless we conduct analyses on them; we would like the selection mechanism to analyze sensory input well enough to allow for selection or non-selection” (p. 523). Classroom students are tasked with decision-making regarding choices between academic lesson engagement and participation in off-task behaviors (Killian et al., 2013).

Another theory regarding time spent off-task is motivational conflict theory as defined by Hofer (2007):

> Pupils pursue a multitude of goals, making them susceptible to motivational conflicts, especially between academic and non–academic goals. In such a situation a pupil has to decide which goal to pursue right now. Because the

> pursuant goal requires the investment of time, attention, and effort, a person committed to one goal takes time and resources away from competing goals. A motivational conflict may arise when a person has to decide between two highly valued actions, or it may occur when a person is already performing one activity and another opportunity comes into play (p. 31).

Lack of on-task behavior is a behavioral attention shift from one activity to another when the alternate activity is more appealing than the current goal; this continues when a student fails to coordinate academic and non-academic goals (Hofer, 2007). If a student is presented with an alternative goal (e.g., doodling in his/her notebook, talking to a classmate, looking out the window, etc.), the alternative goal may be more appealing, leading the student to choose the non-academic goal. The correlation between on-task behavior and academic success for students with ASD is discussed further.

Maintaining On-Task Classroom Behaviors for Students With Autism

As discussed above, ASD is characterized by symptoms that may inhibit the ability to attend. The inability to habituate to environmental stimuli as a form of sensory processing difficulty or hypersensitivity resulting in high reactivity in the nervous system is a common symptom (Pfeiffer et al., 2019). Children diagnosed with ASD tend to have sensory processing abnormalities, inclusive of the difficulty in processing low levels of auditory stimuli (Ghezzi & Bijou, 1999). Auditory processing differences are the most common sensory processing impairment in students with ASD (Tomcheck & Dunn, 2007), and sensory processing disorder is often concurrently diagnosed with ASD, with rates as high as 90% (Suarez, 2012). With a high prevalence, and increased incidence of

ASD, public education is tasked with intensive interventions to increase participation and attending in order to improve academic achievement (Kinnealey et al., 2012).

Inadequate attending skills are common in children with disabilities and are often correlated with the lack of academic success in a general education classroom (Holifield et al., 2010). Auditory-based difficulties may exacerbate this classroom issue. Additionally, Tomchek and Dunn (2007) concluded 95% of their participant sample of students with ASD demonstrated processing difficulty in filtering of auditory input and were "inattentive and under-responsive" (p. 198). This further supports that students with ASD exhibit difficulties in auditory processing, thereby leading to difficulty in maintaining on-task behaviors, demonstrating a need for effective interventions. How to determine an evidence-based practice (EBP) and which EBPs are currently employed, to maintain time spent on-task for students with ASD, are further discussed.

Evidence-Based Practices

Determination of Evidence-Based Practices

Several criteria must be met in order for an intervention/practice to be considered an evidence-based practice (EBP). Referenced as many as 700 times since 2005, the Horner Criteria are considered by some in the special education field to be the guide for evaluating single-subject research (Wendt & Miller, 2012). In addition to Horner et al. (2005), the Institute of Education Sciences' publication, What Works Clearinghouse (WWC): Procedures and Standards Handbook (IES, 2015), contains updated information on quality SSD research and factors included in high quality research. The requirements of SSD research, as indicated by Horner et al. (2005), are discussed below.

According to Horner et al. (2005), there are seven key indicators of quality single subject design research: (a) description of participants, (b) dependent variable, (c) independent variable, (d) baseline condition, (e) experimental condition, (f) internal validity, and (g) social validity.

Description of Participants and Setting

Quality SSD research requires operational descriptions of the participants' demographics, diagnoses, as well as an indication of previous exposure to the intervention, the research setting, and how the participants were selected (Wolery & Ezell, 1993).

Dependent Variable

Quality SSD research requires one or more dependent variable(s) (DV) that is/are operationally defined (e.g., self-injurious behavior defined as lifting right hand to the mouth, breaking the plane of the mouth and using teeth to break the skin of the right hand); which allows for valid and consistent assessment of that variable and allows for replication of the assessment process (Horner et al., 2005). DVs are measured repeatedly, which is necessary for consistency, inter-observer agreement, and reliability (Horner et al., 2005).

Independent Variable

Quality SSD research requires an independent variable (IV), treatment, practice, or behavioral mechanism under investigation. It is operationally defined (e.g., blocking, as defined by the interference of the researcher's hand when the participant lifts right hand to the mouth), to allow for an observable and measureable effect (Horner et al., 2005).

Baseline Condition

Quality SSD research requires a baseline, or comparison condition, in which the DV is measured without implementation of the IV (e.g., how frequently does the participant hand-mouth void of a blocking procedure within a 10-minute time frame). Measurement of the DV in the baseline phase should occur until the trend, or pattern of responding, is sufficiently consistent (Horner et al., 2005). Once a steady trend is established, the IV is introduced in the treatment or experimental condition.

Experimental Condition

Quality SSD research requires experimental control(s) to limit threats to internal validity; which would show a functional relationship (or lack thereof) between the IV and the DV (Horner et al., 2005). In the experimental condition, the IV may be introduced and withdrawn to show a functional relationship, or the IV may be implemented at different times for different participants, depending on the design. In any SSD design, experimental control is used to describe reliable changes on the DV as influenced by the IV (Johnston & Pennypacker, 2009). According to Maggin et al. (2014), "Providing evidence of a relationship between the DV and IV is a fundamental criterion; this is achieved, within SSD research, by replicating the effect of an intervention on an outcome variable with the same individual at different points in time" (p. 290). Reliability can also be achieved through documentation of effects of an IV across participants or settings with implementation of the IV at different points in time (e.g., multiple baseline across participants, settings).

Social Validity

Quality SSD research requires that the intervention has resulted in some form of a socially valid (SV) and/or societally valued change (Horner et al., 2005). Use of the intervention should produce results deemed beneficial to the individual and/or the family/teacher of the individual, or at the very least, include an SV measure. Horner et al. (2005), additionally requires discussion, regarding IV implementation, by non-researchers.

The seven indicators, discussed above, include 21 subcomponents, used by literature review teams to assess rigor and determine study quality (Moeller et al., 2014). Many researchers have forgone the quality indicator checklist, or often exclude key components, such as social validity, thereby limiting quality of the research. Exclusion of the social validity component from a study prevents high-quality evidence-based practice (EBP) recognition, and high-quality research. EBPs have become a baseline for classroom interventions, indicating a need for high-quality research. Some of the currently used EBPs for maintaining time spent on-task for students with ASD are discussed below.

Current Evidence-Based Practices for Maintaining On-Task Behaviors in the Classroom for Students With Autism

Interventions to maintain time spent on task are implemented in the classroom, however, many do not qualify as a high-quality research, often due to lack of a social validity measure(s) (see Taylor et al., n.d.). This study followed the criteria set forth by Horner et al. (2005), with a social validity measure to ensure high quality. With more research, following the rigorous guidelines set by Horner et al. (2005), implementing noise-cancelling headphones to maintain time spent on-task for students with ASD has the potential to eventually become an EBP.

There are few EBPs currently employed in the classroom to maintain attending and on-task behavior for students with ASD (see Odom et al., 2015; Odom et al., 2010b; Wong et al., 2015). The following EBPs are discussed: (a) functional behavior assessment (FBA) leading to differential reinforcement of alternative (DRA) behavior, (b) self-monitoring, (c) video-modeling (VM)/video-self modeling (VSM), (d) Social Stories, and (e) individual work systems as the primary and currently used EBPs in the classroom to maintain on-task behavior for students with ASD. Also discussed is why the currently used EBPs may be difficult for educators to implement in a classroom.

Functional Behavior Assessment

An FBA is defined by Wong et al. (2015) as a collection of information about a specific behavior designed to identify the functional contingencies that support that specific behavior and by Gresham et al. (2001) as a collection of indirect (e.g., interviews, questionnaires, and observations of behavior) and direct (e.g., experimental manipulation of antecedents and consequences) data collection procedures. An FBA consists of operationally describing the problem behavior, identifying the controlling antecedent/consequent events, and then hypothesizing the behavioral function (Wong et al., 2015). In an educational context, FBA data collection begins with an observational approach, in combination with indirect procedures, leading to experimental manipulation of the antecedent and/or consequence to produce desired effects.

An FBA is derived from operant learning theory, grounded in the functionalism philosophy of science, rejecting the attempts to understand behavior through topography;

as behavioral topographies are descriptive, therefore, explain nothing about behavior (Skinner, 1965). An FBA is not a single experiment, or one observation; it is rather a strategy involving multiple methods of data collection with attention to antecedents, behaviors, and consequences (Gresham et al., 2001). It is also utilized to observe and evaluate effects of environmental influences on students' classroom behaviors (i.e., off-task classroom behavior; Lloyd et al. 2016); therefore, implementing an FBA to determine the function of the off-task classroom behavior is crucial to data collection.

A correlation may exist between lack of on-task behavior and curricular difficulty, leading the student to an escape and/or avoidance response from/of academic tasks (Roberts, 2001). When lack of on-task behavior is present in the classroom, it is necessary to determine the behavioral contingency; an FBA provides direct observation of a behavior, the contingencies of the behavior, and a direct method of testing hypotheses (Cihak et al., 2012). Gresham et al. (2001) state that many classroom interventions are ineffective in eliminating or changing problematic behavior because the intervention is not directly related to the function of the student's behavior. In determining the function of off-task behavior, an effective FBA has the potential to lead to an intervention for off-task behaviors for students with ASD (see Campbell, 2003; Horner et al., 2002). Additionally, Individuals with Disabilities Act (IDEA; 2004) requires an FBA process to assess problematic classroom behavior of publicly educated students receiving services from an individualized education program (IEP; Allday et al., 201l; Gresham et al., 2001; Scott et al., 2004; Shumate & Wills, 2010). Gresham et al. (2001), paraphrasing IDEA, state the IEP team must address, through a behavioral intervention plan, any need for positive behavioral strategies and supports.

The aforementioned interventions are ineffective in the classroom if not based on a specific behavioral function. Accurate data are collected through a properly conducted FBA through direct observations, questionnaires, and/or experimental manipulation of variables. Because of the rigorous requirements, observation, manipulation of variables, and data collection, an FBA may be difficult for a general educator to implement in the classroom setting while attending to other students. For example, Anderson et al. (2015) found in reviews of FBA assessments completed in an isolated or a clinical setting that they demonstrated a lack of classroom generalization. Lloyd et al. (2016) additionally identified time, personnel, and systematic manipulation of variables, multiple conditions, and complex procedures as barriers of classroom FBAs; and finally, Scott et al. (2004) support FBA classroom use, yet also discuss a lack of application practicality into school settings. Additional research needs to be conducted on proper classroom application of an FBA.

An FBA could ultimately be a great method to determine behavioral function in the classroom, including lack of on-task behavior. The process is rigorous and application in a general education setting presents barriers (Scott et al., 2004); however, if completed successfully, the data collected from the FBA have potential to lead to the next step, which may include differential reinforcement of an alternative behavior (DRA).

Differential Reinforcement of Alternative Behavior. According to Odom et al. (2003) differential reinforcement techniques are defined by rewards provided when a skill is used and removal of reward when the skill is not being used. Wong et al. (2015) and Pierce and Cheney (2013), describe differential reinforcement techniques as presentation of positive consequences for target behaviors and extinction of alternative behavior(s) in order to maintain the occurrence of the desired behavior. DRA reinforcement, in an educational context, is provided when the learner is engaged in a specific and immediate task, and void of reinforcement when the learner exhibits behaviors other than those desired. This EBP process, once again, requires constant observation and constant reinforcement for on-task behaviors, further requiring the general education teacher to consistently attend to select students. A DRA can be implemented after the FBA; and, as stated above by Lloyd et al. (2016), the FBA requires time, variable manipulation, and observation, making classroom implementation difficult. Additional classroom EBPs for maintaining time spent on-task are discussed below.

Self-Monitoring in the Classroom

For more than two decades, educational researchers have successfully implemented self-monitoring intervention procedures in special education classrooms to increase time spent on-task (Rock, 2005). A self-monitoring intervention is defined as procedure requiring students to systematically monitor and keep record of his/her own behavior in order to determine if the target behavior has occurred (Odom et al., 2003; Prater et al., 1991; Szwed & Bouck, 2013). Self-monitoring procedures have typically been researched for students with emotional and behavioral disorders and students with learning disabilities, at an average IQ. Currently, self-monitoring research continues for students with ASD (see Holifield et al., 2010); demonstrating EBP generalization across disabilities. Holifield et al. (2010) found that time spent on-task, in mathematics and language arts, for two participants with ASD, immediately increased following introduction to self-monitoring procedures. Self-monitoring requires the student to monitor his/her behavior, relieving the educator of that task, which allows the educator to focus on class-wide instruction. For example, Moore et al. (2001), stated the use of instructional strategies encouraging students to manage and monitor the off-task behavior minimized the instructors' need to discipline off-task behavior. Discussed are two types of self-monitoring procedures considered EBPs: self-monitoring of attention (i.e., instructing students to record whether or not they are attending when cued) and self-monitoring of performance (i.e., instructing students to self-assess an aspect of academic performance; Harris et al., 2005; Holifield et al., 2010; Reid & Harris, 1993). SMA typically involves the student checking in on his/her attentive behavior when cued by the educator or a tone, etc., and SMP involves the student collecting performance data on him/herself during an assignment when cued (Rafferty & Raimondi, 2009).

Self-monitoring procedures have been shown to be effective to maintain time spent on-task for students with ASD; however, one limitation, as discussed by Finn et al. (2015) and Moore et al. (2013) includes a lack of generalization of SMA procedures for maintaining on-task behavior in general education classrooms. Moore et al. (2013) additionally discussed experimenter training and how contact with the experimenter may confound the effects of the SMA intervention and alter students' behavior. This shows that the general education teacher requires procedural training prior to SMA implementation; however, even with proper procedural training, implementation of the SMA may lack fidelity and/or generalization.

Video Modeling and Video Self-Modeling

Modeling has a profound impact on a child's development, and it was concluded that children acquire an array of skills through observation of someone they perceive as competent and resembles them in some way (Bandura**,** 1977, as cited in Bellini &

Akullian, 2007). The researchers also discovered that children would imitate behavior with or without the presence of reinforcement and generalize that behavior to other settings. This shows how modeling of appropriate behavior is not only effective for imitation, but may also generalize to other settings with or without the presence of reinforcement. The two relevant types of video modeling are discussed below.

Video modeling (VM) is a method of teaching using video recording and display equipment to provide a visual representation of the targeted behavior or skill. Basic video modeling involves recording someone, other than the learner, engaging in the target behavior or skill. The learner then views the recorded video at a later time (Franzone & Collett-Klingenberg, 2008). Van Laarhoven et al. (2010) define VM as an instructional approach where the learner views a video with an entire skill sequence; and LaCava (2008) defines VM as an assistive technology able to teach a wide range of skills to an individual with a disability or typically developing peers. It also allows the researcher to edit the displayed undesired behaviors from the final video and solely focus on the desired behaviors. This allows the learner to specifically view the reinforced behavior (Bellini & Akullian, 2007).

Video self-modeling (VSM) is similar to video modeling, but the learner, him/herself is recorded displaying the target skill as opposed to another person (Franzone & Collett-Klingenberg, 2008). VM and VSM require planning, time, equipment, data collection, etc. and these may be difficult for a general educator to implement in an inclusive classroom. As Hitchcock et al. (2003) discuss, the limitations with VM and VSM may derive from access to technology, implementation skills, lack of training, and lack of time required to implement. The lack of classroom VSM usage may be attributed to technology knowledge and the implementation skills for video creation (Buggey & Ogle, 2011). Buggey and Ogle (2011) also highlight the rarity of VSM use outside of a clinical or contained setting; which further demonstrates the implementation difficulty for a general-education teacher.

Social Stories

Social Stories are an additional EBP used to maintain time spent on task for students with ASD. According to Schnieder and Goldstein (2010), a social story is a strategy containing access to visuals with the intention of addressing lack of social skills or a situation that could be considered alarming or problematic to the student with ASD.

According to Schneider and Goldstein (2010), Social Stories have been shown as an effective tool for students with ASD, yet lack proper implementation. Discussed above, ASD symptomology includes lack of appropriate social skills, lack of appropriate responding, aversion and avoidance of sensory input, etc., and Social Stories™ may have a meaningful impact.

Social Stories to maintain time spent on-task in the classroom for students with ASD involve exposure to a depiction describing the desired appropriate on-task behavior (Schneider & Goldstein, 2010). They are considered an effective intervention to maintain on-task behavior; however, Reynhout and Carter (2009) concluded there is a lack of research regarding Social Story™ implementation by practitioners in a school setting. This EBP requires planning, time, equipment, and data collection, making it difficult for a general education teacher to implement in the inclusive classroom.

In conclusion, the aforementioned EBPs are utilized for students with ASD, within the classroom, independently, and some in a clinical setting. Determining the function of off-task behavior and addressing that behavior with an EBP may increase time spent on-task; however, the time and skills each educator needs to dedicate is not practical and may not be feasible. For example, an FBA requires stringent and constant data collection to determine function of behavior. An untrained educator, improperly utilizing an FBA, could produce erroneous data leading to a problematic outcome. VM and VSM both require technical equipment (phone/video recorder, playback device, etc.), which may not be accessible to the educator. VM and VSM, additionally, require a great deal of implementation time (recording, playback), and also require a probe for success and maintenance. VM and VSM require focused attention on a specific individual and may result in neglect of other students' educational needs. Social Stories require individual implementation and additional probing in order to determine success. Self-monitoring of classroom behavior tasks the student with attention to/documentation of his/her own behavior, which may not always be reliable. Use of the aforementioned EBPs, additionally, tasks the educator with maintenance probing for progress. Finding an effective, cost-efficient, easily implemented form of technology is crucial as access to high-tech classroom accommodations available to educators to maintain time spent on-task for students if often limited. Currently used technologies to maintain time spent on-task are discussed below.

Use of Technology to Maintain On-Task Behaviors in the Classroom for Students With Autism Spectrum Disorder

Technology has revolutionized the way society lives, works, communicates, and learns. This technological revolution has lead educators to consider technology over previously used classroom interventions (Knight et al., 2013). For example, traditional lecturing, worksheets, chalkboards, etc. are now outdated. The technology for instruction and intervention of students with ASD has increased drastically (Odom et al., 2015), as has the use of technology for students with other disabilities (see Burton et al., 2013). The shift from traditional classroom lecture settings to a technology-driven academic environment demands more research into the effectiveness of high-quality academic technologies for students with disabilities.

A student's individualized education plan (IEP) may specify the use of assistive technology as an accommodation for a student with ASD; the assistive technology device may be considered high-tech or low-tech depending on accessibility and training requirement. The Technology-Related Assistance for Individuals with Disabilities Act of 1988 (Public Law 100-407) defines assistive technology as equipment, or a product, acquired commercially, or off-the-shelf; it may be modified or customized to increase, maintain, and/or improve the individual's functional capabilities. Knight et al. (2013) state that in an educational environment, through an evidence-based practice (EBP), it's only logical to delve into whether certain technologies may improve learning capabilities for students with ASD. Though both Knight et al. (2013) and Odom et al. (2015) examined the technology for children and adolescents with ASD, limited research has been conducted, specifically, on different high-quality technologies for maintaining on-task behavior in the classroom; further research is necessary to determine if the technology is easily implemented with fidelity. Xu et al. (2002) outlined the need for more classroom research on assistive technologies designed for students with ASD to maintain time spent on-task. Additionally, Bryant-Davis et al. (2012) found that classroom technology application was severely limited even within a classroom with both a general and special educator; demonstrating a need for not only more classroom technology research, but also more research on educator implementation. Because of the limited amount of quality research on technology for maintaining time on-task, the technology currently available for students with disabilities, to maintain on-task classroom behavior, is discussed below.

High-Tech Technology

The definition of high-tech technology, for this paper, established by Odom et al. (2015) is an "electronic item, equipment, application, or virtual network used intentionally to increase, maintain, or improve daily living, work productivity, recreation or leisure activities of a person [with a disability]" (p. 3806). Besides the use of a camera recording device in VM, as discussed above, other technologies exist that may be employed in the classroom to increase time spent on-task. These include, but are not limited to, the use of a speech-generating device (Blischak & Schlosser, 2003), smartphone, iPad (Alzrayer et al., 2014; Neely, 2013; Taylor & Urquhart, 2018), and a tablet device with a specific application or program designed to assist students with ASD in curricular tasks (Taylor & Urquhart, 2018), or to assist in maintenance of on-task behavior. Laptops and computers are additional high-tech devices generally available in many classrooms (Panyan, 1984; Pennington, 2010; Ramdoss et al., 2011).

The current generation of students is among the first to have regular and longitudinal access to computers and the Internet (Odom et al., 2015), demonstrating a dramatic shift in methods of instruction in inclusive classrooms. Odom et al. (2015) discuss several studies involving high-tech technology implemented to assist in maintenance of time spent on task for students with ASD. These technologies include, but are not limited to, a desktop computer for self-monitoring to increase task completion, video recording of choice selection used to reduce task completion time, and video of self-modeling on an iPad to increase completion of an independent academic task. For example, Taylor and Urquhart (2018), discussed iPads and app usage as an effective tool for students with ASD. Unfortunately, many of these high-tech tools are expensive and require high levels of training.

Knight et al. (2013) concluded there is an overall lack in the evidence supporting use of technologies to teach curriculum to students with ASD; prevalent among that research is a large portion of high-quality tech. Furthermore, Taylor and Urquhart (2018) emphasized that many novel tools introduced into education and the classroom (e.g., iPad, apps), lack implementation training prior to product dissemination. This shows the need for further research on novel classroom tool implementation. Specifically, more research needs to be conducted on technology for maintaining classroom time spent on task. In addition to the discussed high-tech technology available in some classrooms, low-tech technologies available to students with ASD are further discussed.

Low-Tech Technology

Low-tech technology is commonly found in most classrooms and generally available to all students. Low tech technologies include, but are not limited to, a magnifying glass, graphic organizers, calculators, visual day schedules, highlighters, pencil grips, specialized paper (lined, ruler, graph), large erasers, etc. Access to low-tech technologies may provide students with ASD the some of the tools necessary to maintain on-task behavior. Specific research needs to be conducted to determine which low-tech tools are effective and easily implemented in promoting classroom time spent on task for students with ASD.

Classroom availability of high-tech technologies may be limited; additionally, they may be available, but underutilized (Taylor & Urquhart, 2018). In a study conducted by Bryant-Davis et al. (2012), one main area of concern within 155 lesson plans, created in collaboration by a general and special educator for a middle school classroom, was the lack and underutilization of classroom technologies. Educators may lack implementation training of the different types of tech discussed above; further demonstrating how implementation, with fidelity may be difficult for a general educator. Bryant-Davis et al. (2012) concluded that most technology observed in their study was greatly limited to low-tech technology. The disproportionate amount of technology available to students of all abilities and socioeconomic statuses should also be considered (Bryant-Davis et al., 2012).

Considering low-tech technologies in the classroom to maintain time spent on task for students with ASD, limited research has been conducted on one specific low-tech technology not readily available in all classrooms, noise-reducing accommodations. Pfeiffer et al. (2019) and Rowe et al. (2011) concluded headphones (or noise-reducing accommodations) provided prolonged, consistent attention to a task and support the use of headphones in a noisy classroom environment to promote on-task behavior. This study explores the use and implementation of noise-cancelling headphones for students with ASD in maintaining time spent on-task.

Use of Noise-Cancelling Headphones in the Classroom for Students With ASD

As discussed above, ambient classroom noise is detrimental to curricula acquisition (Anderson, 2001; Morgan, 1917; Rowe et al., 2011; Smith & Riccomini, 2013), especially for students with ASD with auditory aversion/avoidance. Pfeiffer et al. (2019) hypothesized that in certain settings, the participation of children with ASD, experiencing noise sensitivity, is detrimentally impacted; yet, limited research on treating noise hypersensitivity for children with ASD exists (Fodstad et al., 2020; Neave-DiToro et al., 2021; Pfeiffer et al., 2019).

Implementing modifications to reduce classroom noise is commonly suggested by speech and occupational therapists to maintain/increase time spent on-task for students with ASD (Rowe et al., 2011). Ikuta et al. (2016) and Neave-DiToro et al. (2021) found that ear protection devices (EPDs) such as noise-cancelling headphones, earmuffs, and earplugs were being used to attenuate aversive noise for individuals with ASD. Neave-DiToro et al. (2021) additionally found that the majority of the survey participants (66%; N = 255) had observed individuals with ASD using EPDs; among the participants, 91% reported observation of noise-cancelling headphones. These data show noise-cancelling headphones, are currently implemented and often effective for individuals with ASD. With minimal training and minimal implementation strategies, educators can effectively provide this accommodation for maintenance of time spent on-task for students with ASD. Professionals working with individuals with ASD, observing EPD use, reported positive behavioral changes (e.g., decrease in self-stimulating behavior, and increase in socially meaningful situations; Neave-DiToro et al., 2021).

Pfeiffer et al. (2019) found participants with ASD, using noise-attenuating headphones, had increased involvement in numerous settings, inclusive of school settings. Additionally, it was found the participants began to foresee when he/she required headphone use and would request the accommodation (Pfeiffer et al., 2019), demonstrating preference toward the headphones in certain settings. This surge in headphone research, for children with ASD, indicates a potential increased interest into the effectiveness of the intervention (Fodstad et al., 2020; Ikuta et al., 2016; Neave-DiToro et al., 2021; Pfeiffer et al., 2019; & Rowe et al., 2011). Though the current research presented leans toward noise-cancelling headphones as an effective accommodation to maintain time spent on-task in the classroom for students with ASD, some challenges are also discussed.

Some concerns, regarding use of noise-cancelling headphones, are dependent on the accommodation, and the potential for social implications (Pfeiffer et al., 2019). The initial concern can be minimized through implementation of fading procedures. By gradually increasing the auditory decibel input, the student may develop the ability to habituate to ambient classroom noise. Social stigma was also a concern voiced by the Washoe County School District (J. Hall, personal communication, December 3, 2019). Social stigma of noise-cancelling headphone use may be prevented with use of the teacher introduction script (see Appendix I), or by class-wide student access to the noise-cancelling headphones. Personal classroom observation of noise-cancelling headphone implementation showed that teacher intervention introduction was crucial to reducing social stigma; it also increased desired use from other students. The observed educators introduced the intervention, demonstrated use, and exhibited an affinity toward the headphones; this led to acceptance and desire of the accommodation. An additional concern, documented by Ikuta et al. (2016), is the student's refusal to wear the headphones. This may be a response to other sensory hypersensitiveness (i.e., tactile hypersensitivity), improper implementation, or lack of reinforcement. More research needs to be conducted on the use of EPDs, specifically noise-cancelling headphone use for students with ASD. Additional research is also required on the teacher and parental intervention concerns.

This study, through use of a multiple baseline design across participants and curricula as well as use of a social validity instrument, examines the following research questions:

(1) Does the use of noise-cancelling headphones increase time spent on-task for students with autism, measured by time spent in active listening, active engagement during independent reading tasks?

(2) Does the use of noise-cancelling headphones increase time spent on-task for students with autism, measured by time spent in active listening, active engagement during independent math tasks?

(3) Do the participants view the usage of the noise-cancelling headphones as socially valid and effective?

(4) Do the participants' teachers view the usage of the noise-cancelling headphones as socially valid and effective?

Summary

This chapter provides a description of the prevalence and incidence of ASD as well as the associated behavioral characteristics. Also discussed is the importance of, and legal requirements of, including students with ASD in the least restrictive environment. Furthermore, intervention implementation difficulty for general educators is declared. This chapter also presented the importance of maintaining classroom time spent on-task for academic success for students with ASD, highlighting the current requirements for high-quality EBPs within SSD. Currently used EBPs, to maintain time spent on-task, for students with ASD, are also discussed in detail. These EBPs included: (a) functional behavior assessment leading to a differential reinforcement of alternative behavior, (b) self-monitoring, (c) video modeling and video self-modeling, (d) social stories, and (e) work systems. Also included, is reasoning behind the difficulties of EBP implementation by the general educator in the classroom inclusive of, but not limited to, the importance of social validity measures (see Taylor et al., n.d.). This chapter concludes with currently used high- and low-tech technologies for maintenance of time spent on-task, including the use of noise-cancelling headphones. The current research on, and efficacy of, noise-cancelling headphones for children with ASD is discussed, and finally parental and educator concerns.

Chapter 3

Methodology

Many students in classroom settings struggle with maintaining on-task behavior, specifically students with documented disabilities. Students with autism spectrum disorder (ASD) are included in this population. Students with ASD may struggle with maintaining on-task behaviors in the inclusive classroom leading to lack of academic success. This is discussed in the above chapters.

On-task classroom behaviors, for this study, are defined as active listening (i.e., eyes on the appropriate speaker, body positioned forward, not talking), active engagement (i.e., following the instructor's requests, appropriate responding when solicited, eyes on the appropriate material in front of student, actively engaged in note taking, highlighting, etc.), or ignoring other inappropriate or untimely sources of sensory input (e.g., other students talking out of turn, people entering or leaving the classroom). The aforementioned behaviors, and time dedicated to the classroom curriculum, is essential for academic success. For example, Odell (1923) concluded that for over a century, educators have known that attending school on a consistent basis, as well as engaging in curricular activities, is directly correlated to academic achievement (also see Bleak et al., 2017). This additionally shows the importance of attending to and engaging in school as well as educational curricula. Educators are tasked with teaching curricula as well as implementing behavioral interventions to maintain engagement; this is a reasonable assumption applicable to both general and special educators.

Discussed above, students with ASD are required by law to receive educational access to his/her least restrictive environment (LRE). Current evidence-based practices

(EBPs) are often implemented by a specialist or implemented outside the general education classroom to ensure validity. For this reason, general educators are often unskilled or lack the time required to implement current EBPs in the classroom (Taylor & Urquhart, 2018).

This chapter explores the use of a cost-efficient, often effective, easily implemented in the classroom, intervention for students with ASD.

To analyze the effects of the noise-cancelling headphones, this study employs a multiple baseline design (MBD) across participants. The following sections are included in this chapter: (a) research participants, (b) setting, (c) multiple baseline design across participants (d) independent variable, (e) dependent variables, (f) materials and instruments (g) inter-observer agreement, (h) procedural reliability/treatment fidelity, (i) external validity, (j) social validity, and (k) data analyses. This chapter concludes with a summary. As discussed in the COVID-19 introduction to this dissertation, the participants and data in this chapter are all hypothetical. Due to the COVID-19 pandemic, school buildings were closed and instruction was shifted to online learning for majority of 2020 and 2021.

Research Participants

Three hypothetical students would have participated in the current study. The participants would have come from diverse backgrounds (i.e., racially, economically, gender) (see Table 1), and have documented typical hearing. All participants would have been taught within an inclusive elementary classroom and have been between the ages of 7-12; the participants would not have been in the same classroom(s)/school(s). Finally, all participants would have had a diagnosis of ASD, as documented by the student's individualized education plan (IEP). All three participants would have in both the baseline and the experimental conditions of this study, and served as his/her own control. They would have been recruited to take part in this study by posting research details, electronically, using the recruitment script (see Appendix H) within the teaching community (e.g., Listserve, social media, Washoe County School District forums) and by word of mouth (e.g., asking teachers to recommend students and classrooms, etc.).

Table 1

Hypothetical Participant Demographics

Participant Name	Age	Race	Diagnosis
Jose (M)	7	Columbian	ASD
Nick (M)	8	African American	ASD
Laura (F)	8	Caucasian	ASD

Note. M = participant identifies as male. F = participant identifies as female. ASD = Autism Spectrum Disorder.

Setting

The hypothetical setting would have been within the naturalistic environment of all three participants' individual classrooms. Conducting the research in the classrooms allows for future research and/or future probes to determine reliability of the intervention. It may also determine if a general education teacher is able to easily implement the intervention. Based on personal experience, it was assumed, the classrooms consisted of 10-20 students, and one educator. The classroom arrangements varied, but included tables, desks, and chairs. Stations, or clusters, of tables were set up so the students could move from one content area to the next. The classrooms would be often noisy with talk and highly decorated with academic material and artwork. The educators would have used a microphone for voice projection as well as a smart board, to present class-wide material.

Classroom Background

The lead researcher would have administered a teacher questionnaire (see Appendix F) regarding his/her students with ASD, in his/her inclusive classroom. The questionnaire requested information on which student(s) with ASD exhibited problems maintaining on-task behavior(s) for a specific subject. Additionally, during this time, the researcher would have discussed a typical day in the classroom from beginning to end-of-day to determine when the subject area in which the participant lacked on-task behavior was taught.

This study assumed 30-minute lesson increments, with no longer than 15-minute direct instruction, followed by 15 minutes of independent seatwork. This assumption is based on previous classroom experience in multiple elementary classrooms following this format.

Research Design

Single-Subject Design

A single-subject research design (SSD) would have been utilized for this study. Pierce and Cheney (2013), refer to single-subject research as form of experimental research focusing on the discovery of governing principles and environmental conditions maintaining and influencing the behavior of a single organism. SSD is also used to reference an experimental design in which causal and functional relationships can be seen between an independent (IV) and a dependent variable (DV) (Horner et al., 2005), making it possible to investigate if the exposure to the IV is associated with improved behavior (Maggin et al., 2014), and where the participant serves as his/her own control (Cakiroglu, 2012; Gillis & Butler, 2007; Horner et al., 2005; Tankersley et al., 2008; Wendt & Miller, 2012; Wolery et al., 2011). More specifically, SSD is seen as encompassing a set of design procedures in which the behavior of an individual, or multiple individuals viewed as a single group, is measured repeatedly under different conditions to determine if reliable changes in the dependent variable, as a direct result of the independent variable, exist (Cooper et al., 2007).

Unlike other designs, SSD employs experimental methods, avoiding correlational and/or descriptive methods. The purpose of this experimental method is to demonstrate causal, or functional relationships between the intended IV and DV (Horner et al., 2005). Utilizing experimental procedures, rather than correlational, the IV can be manipulated, thereby demonstrating control or influence, or lack thereof, over the DV (Johnston & Pennypacker, 2009). Use of a single baseline design, within SSD, limits the researcher to "arranging the different conditions one at a time" (Johnston & Pennypacker, 2009, p. 289); therefore, this study would have employed an SSD multiple baseline design. This design would have allowed for the comparison between the control and experimental conditions and would have been strengthened with data from three participants. A functional relationship between the IV and DV could then be observed and analyzed.

Multiple Baseline Design Across Participants

A nonconcurrent multiple baseline design across three participants, over two different curricula areas, would have been utilized to examine the effects of noise-cancelling headphones; this would be implemented in order to maintain on-task, or attending, classroom behavior in both reading and math. Typically, multiple baseline designs are conducted across settings, across subjects (participants), or across behaviors (Hall et al., 1970; Johnston & Pennypacker, 2009; Pierce & Cheney, 2013). Kazdin and Kopel (1975), define multiple baseline design across participants as measuring an effect of an intervention by demonstrating changes across individuals “when, and only when a treatment intervention is introduced” (p. 601). Similarly, Pierce and Cheney (2013) describe multiple baseline design across participants as a research design in which an intervention is introduced at different times, for different participants, who demonstrate similar behaviors. Using this design, experimental control is demonstrated, showing validity by eliminating alternative or confounding variables as explanations of for the behavior change (Christ, 2007). Additionally, within subject data analyses were utilized to compare each participant’s behavioral response in baseline phase to his/her behavioral response in intervention phase. Johnston and Pennypacker (2009) describe within subject design as the comparison of the individual’s responses under a control and intervention condition. This research helped guide the design for this study.

The nonconcurrent component would allow for the data collection to occur across participants in different classrooms, it also would allow for baseline and intervention data collection sessions at different times. The nonconcurrent component also would have provided flexibility for the researcher and the participating educators. As Watson and Workman (1981) discussed, the “nonconcurrent multiple baseline design provides researchers, within applied settings, greater flexibility in determination of a functional relationship between the IV and the DV” (p. 259).

The behaviors (hypothetical data) were graphed and visually analyzed. For each participant, baseline data would have been collected and recorded for no less than four baseline data points over time, for each participant, in both math and reading. Once the baseline data trend demonstrated some stability, the intervention or “B” phase was implemented for each participant. The hypothetical data, which would have been collected using momentary time sampling to represent percentage of time spent on-task, were graphed on the x-axis and the y-axis representing session number. These data were visually analyzed. Additionally, two classroom subjects (math and reading) were also analyzed per participant.

Momentary Time-Sampling

Momentary time sampling (MTS) procedures would have been employed to collect data in both phases of this study. MTS is an intermittent observation method wherein data are collected during an observation interval, resulting in documentation of occurrence of the target behavior (Johnston & Pennypacker, 2009); this would have allowed the researcher to collect data on a response, if the response occurs, or is occurring, exactly at the predetermined moment. The MTS data collection divided time into duration intervals and allowed for coding of the occurrence or nonoccurrence of the target behavior. Harrop and Daniels (1986) concluded MTS provides precise mean time estimates of absolute time duration. Because of this, MTS was the ideal data collection method for this study.

This study was comprised of 15-minute math and reading lessons (15-minute total lesson duration), divided into 15s intervals. As the study by Saudargas and Zanolli (1990) confirmed, “15s MTS closely approximates an actual percentage of time across a range of naturally occurring behaviors" in a natural environment (p. 535). A vibrating timer (see Appendix K), would have alerted after each 15s interval, within the 15-minute time frame. When the vibration occurred, the researcher would have immediately observed the participant for 1s and marked occurrence, or nonoccurrence, of the behavior, with a plus or a minus symbol (+/-), respectively. The data collection method would have continued for both phases every 15s for 15 minutes, for each participant, for no less than four sessions. The percentage of session occurrences was calculated by finding the sum of the plus symbols (+), dividing by number of intervals (60) and multiplying by 100. The percentage of behavior occurrence was plotted on a line graph for each participant. This method of calculation was used for the hypothetical data provided to the researcher. The plotted graph allowed for visual analysis of the data.

Independent Variable

The independent variable was noise-cancelling headphones (see Appendix J).

Dependent Variable

The dependent variable was the percentage of occurrences of on-task/engaged behavior during the 15-minute teacher-recommended subject area(s). Time on-task was operationally defined as active listening (i.e., eyes on the appropriate speaker, body positioned forward, not talking), and active engagement (i.e., following the instructor's requests, appropriate responding when solicited, eyes on the appropriate material in front of student, actively engaged in note taking, highlighting, etc.). Off-task classroom behavior, or nonoccurrence, was operationally defined as inactive listening (i.e., eyes looking anywhere, but the appropriate speaker, body not positioned forward, talking out of turn), inactive engagement (i.e., not following the instructor's requests, inappropriate responding, eyes on inappropriate stimuli, not actively engaged in note taking, highlighting, etc.), or attending to inappropriate sources of sensory input (e.g., other students talking out of turn, people entering or leaving the classroom).

Materials and Instruments

This study requires two different types of materials. These include three sets of children's noise-cancelling headphones (one set per participant). The children's noise-cancelling headphones, with a noise reduction rating (NRR) to 25dB, were ordered and purchased from Amazon.com (see Appendix J). The NRR allows 25dBs of sound input. A student with typical hearing is able to hear face-to-face conversation as well as alarms (e.g., a fire drill) as Ikuta et al. (2016) point out, noise-cancelling headphones reduce ambient noise, but do not block the sound of a human voice or abrupt noise. The vibrating timing device (see Appendix K) was ordered and purchased from Amazon.com, also funded by the researcher.

Eight different instruments would have been used in this study. First, Data Collection Form A is a parental permission form. Data Collection Form B is a teacher participation consent form. Data Collection Form C is a data collection sheet that was used to collect MTS of occurrence or nonoccurrence of target behavior data. Data Collection Form D is a social validity questionnaire, administered to the teachers as well as the participants. The participant recruitment script would have been utilized to recruit participants by explaining the study, the experimental procedures, and also to ensure recruitment reliability. Finally, a teacher intervention introduction script would have been distributed to the participants' classroom teachers to explain and introduce the intervention; this would have helped ensure reliable teacher intervention introduction in the different classrooms.

Data Collection Form A: Parental Permission Form

A parental permission form would have been distributed to all the parents/guardians of the participants to provide consent for his/her child to participate in the study.

Data Collection Form B: Teacher Participation Consent Form

A teacher participation form would have been distributed to participating teachers for consent to conduct the classroom research as well as provide participation consent.

Data Collection Form C: MTS Recording Data Sheets

A MTS recording data sheet was used to calculate baseline and intervention phase data. As discussed above, time sampling is defined by Pierce and Cheney (2013) as the data recording of an observable behavior over a long period of time with observations made throughout the specified times in the determined interval. Each MTS sheet contained enough intervals (60) for 15s MTS for each 15-minute session. A clean data collection form was required, per session, per student, for the duration of all phases. Hypothetical data was provided to the researcher by the researcher's advisor via these sheets.

Data Collection Form D: Social Validity Questionnaires

Quality SSD research requires emphasis on socially valid and societally valued change. This means the intervention must produce results deemed beneficial to the individual, or the family of the individual, by that individual or by someone involved with that individual (see Horner et al., 2005). Horner et al. (2005), additionally describe socially valid SSD as placing emphasis on DV selection as a socially important meaningful context. To determine social validity, two different questionnaires (see Appendices D, E) would have been administered to the participating lead teachers and the participants post data collection.

Data Collection Form E: Teacher Questionnaire for Student Lack of On-Task Behavior Subject-Area Recommendation

The classroom teacher determined the participants' main problematic academic areas through the questionnaire. This helped identify each student's area of off-task behavior and was administered prior to any data collection.

Intervention Introduction Checklist

A checklist (see Appendix G) was utilized for student intervention introduction. According to Pfeiffer et al. (2019), both educators and parents agreed headphone introduction was crucial component in preparing the student for noise-attenuating headphone participation. Therefore, the introduction checklist was followed, step by step, to ensure the student understood the intervention, it's use, and when to properly utilize during the school day. The checklist ensured introduction consistency and direction across participants.

Participant Recruitment Script

Participants were recruited by disseminating the recruitment script (see Appendix H) via email and referral within the parent and teaching communities (e.g., Listserve, Washoe County School District forums) also by word of mouth (e.g., asking teachers to recommend students and classrooms, etc.).

Teacher Intervention Introduction Script

The teacher intervention introduction script (see Appendix I) was disseminated to the participating teachers, which provided specific intervention introduction verbiage for class-wide announcement. This script helped alleviate the novelty of the intervention, limited intervention social stigma, and ensured reliability across the different participant classrooms.

Procedure

Prior to the implementation of the study, permission from the Institutional Review Board (IRB) as well as the Washoe County School District, the principal of the school, participating teachers via consent form (see Appendix B) and the participants' parents via consent form (see Appendix A) was obtained. The researcher was then present in each classroom for three days prior to data collection, subsiding visitor novelty. The lead researcher met with each participant's teacher to obtain consent and administer the teacher questionnaire; which determined the participants' problematic subject area(s). Additionally, the time of day for each student's problematic subject areas were discussed (e.g., math lessons begin at 11am). Following this, baseline or "Phase A" data collection began. Once a steady trend was developed in Phase A, the intervention phase or "Phase B" was implemented.

Phase A: Baseline Phase

The first phase was employed to collect baseline data regarding each participant's occurrences of on-task behavior. A vibrating timing device was used to alert the lead researcher to look up and observe the participant for one second. It alerted every 15s within the 15-minute interval. The occurrence, or nonoccurrence, of on-task behavior was logged on the MTS data collection sheet (see Appendix C) with a plus or minus sign (+/-). This occurred for at least four days, for all participants, in both math and reading. The MTS collection data were calculated and graphed (see Figures 1, 2).

Phase B: Intervention Phase

Prior to the intervention phase, the participant was given the intervention to place over his/her ears comfortably for each session. Additionally, a checklist was utilized to ensure proper introduction and implementation (see Appendix G). Once comfortably in place, the intervention data collection sessions began. The lead researcher then used the same vibrating timing device to alert for a one second behavior observation, vibrating each 15s during the 15-minute interval. The occurrence or nonoccurrence of on-task behavior was again logged on the MTS data collection sheet with a plus or minus sign (+/-). Data collection occurred each day for no less than four days for all participants (see Figures 1, 2).

Inter-Observer Agreement

Horner et al. (2005), state that in order to maintain quality SSDs, the DV reliability should be assessed using inter-observer agreement (IOA). Tankersley et al., (2008) concluded the one method to remedy the inconsistencies with visual data analysis is through IOA, which occurs when two or more researchers collect simultaneous data, blindly, and then compare the data collection results. The percentage of agreement was calculated to provide a level of data collection confidence. A colleague collected IOA for this study, simultaneously, during 20% of the sessions for all participants. IOA was calculated at 95%, demonstrating reliability.

Integrity and Validity

Procedural Integrity

Billingsley et al. (1980) define procedural integrity as the degree to which a procedure or independent variable (IV) is implemented properly and with fidelity. To ensure the intervention was implemented properly and with fidelity, a colleague was trained and briefed to collect IOA data for this study, simultaneously, during 20% of the sessions for all participants.

Experimental Control/Internal Validity

SSD research can show a causal/functional relationship between an IV and a DV (Horner et al., 2005), making it possible to investigate whether exposure to a specific IV is associated with improved target behavior (Maggin et al., 2014), and where the participant serves as his/her own control (Cakiroglu, 2012; Horner et al., 2005; Tankersley et al., 2007; Wendt & Miller, 2012; Wolery et al., 2011). More specifically, SSD is seen as encompassing a set of design procedures in which the behavior of an individual (or multiple individuals viewed as a single group) is measured repeatedly, under different conditions, to determine if reliable changes in the DV are a direct result of the IV (Cooper et al., 2007). In this study, experimental control was demonstrated through a multiple baseline design across participants over two subject areas. Each participant served as his/her own control and was measured repeatedly in each phase.

External Validity

According to Horner et al. (2005), to establish generalizability and external validity, specific participant selection criteria is reported and specific IV conditions are established. Replication across individuals, or settings, or locations, external validity an intervention may be considered as generalizable. This study exhibits external validity through reporting of participant selection criteria, clear delineation of the IV implementation conditions, and data collection on multiple participants.

Social Validity

Quality SSD research requires that an intervention has resulted in a socially valid and/or societally valued change (Horner et al., 2005). This means that the intervention produces results deemed beneficial to the individual, or the family/teacher of the individual. Horner et al. (2005) additionally requires SSD research to place emphasis on DV selection that is deemed socially important and demonstrates that non-professionals, in meaningful contexts, can apply the IV with fidelity. As discussed earlier, many research interventions are implemented without a social validity measure. This, according to Horner et al. (2005), renders the research not of high quality. To prevent this, this study included and administered social validity instruments to both participants and the participants' classroom teacher (see Appendices D, E) to ensure the classification of high quality. This was included with the intention of contribution to evidence-based practice research. These social validity instruments were later expanded to develop the survey that was conducted and can be reviewed in the included article following the dissertation study (see Appendix L).

Data Analyses

Employing the multiple baseline across participants design, the data were graphed and visually analyzed. This study analyzed the data within subject; wherein an individual is exposed to both baseline and experimental conditions and the data are analyzed, void of other participant data (Johnston & Pennypacker, 2009). This study relied heavily on visual analysis; plotted data points were analyzed and conclusions were drawn regarding the data. Using visual data analysis, the effect, or lack thereof, of the independent variable (IV) on the dependent variable (DV) can be seen. Horner et al. (2005) state that evidence of experimental control, within multiple baseline design, requires the presence of a specific data pattern to identify the relationship between the IV and the DV; visual analysis, for this study, allowed for identification of specific data patterns. Parsons and Baer (1986, as cited in Perdices & Tate, 2009), describe visual analysis as the traditional method for data interpretation within SSD, and further note that visual analysis is the only method that should be used, stating statistical analysis is unnecessary if the change [in behavior] is visually obvious in the graphed data. Therefore, this study relied upon visual analyses of the data. "When interpreting and analyzing a single subject graph from data collection, researchers look for a pattern within the data" (Cakiroglu, 2012, p. 22); this pattern includes four dimensions: (a) level, the change in the rate of response from phase or condition (Byiers et al., 2012); (b) trend*,* which Kazdin (1982) and Price et al. (2015) describe as the systematic increase or decrease in the data points within the phase or condition; and (c) variability*,* which refers to the divergence [low, moderate, high] in observed data points within a phase or condition (Cakiroglu, 2012).

For this study, the data trends were determined by drawing a straight line (trend line) through the graphed data in each phase. The trend line allowed for visual analyses of the systematic increase or decrease of the data within a phase (Byiers et al., 2012); and these data were described using the following terms: (a) downward trend (data are decreasing), (b) upward trend (data are increasing), or (c) flat trend (data remain stable). The data levels were determined by calculating the mean percentages in each phase (the average of the data points in a data set); and data variability was determined by calculating the percentage range. Range is defined by Johnston and Pennypacker (2009) as a "variability measure expressed by the lowest and the highest values in a data set" (p. 361). Both the *M* and *R* percentages were then rated using the following parameters: (a) low (0% to 35%), (b) moderate (36% to 65%), or (c) high (66% to 100%).

Summary

This chapter describes the details of the methodology of the study; this included: (a) a demographic table of the hypothetical participants in the study, (b) the hypothetical setting, (c) the research design, (d) the independent variable, (e) the dependent variable, (f) materials and instrumentations, (g) procedure, (h) baseline phase, (i) intervention introduction phase, (j) intervention phase, (k) inter-observer agreement, (l) procedural reliability, (m) experimental control/internal validity, (n) external validity, (o) social validity, and finally, (p) data analyses.

The results of the data levels, trends, and variability, for all three participants, are described in the following results chapter (Chapter 4), and further discussed in Chapter 5.

Chapter 4

Results

Plan of Analysis

The data were graphed and visually analyzed to observe trend, level and variability in the baseline and intervention phases. As stated above, Parsons and Baer (1986; as cited in Perdices & Tate, 2009) explain visual analysis as the traditional method for data interpretation within single-subject design (SSD), and further note that visual analysis is the only method that should be used; stating statistical analysis is unnecessary if the change [in behavior] is visually obvious in graphed data. The data inspection/analysis, for this study, was conducted within subject, for each participant (Jose, Nick, and Laura), in math and reading. Within-subject analysis allowed the researcher to look at the individual data from each participant, void of the other participants, to contrast the differences in behavioral responding from baseline phase to intervention phase (Johnston & Pennypacker, 2009).

As discussed in Chapter 3, the data trends, for this study, were determined by a trend line through the graphed data in each phase; this allowed for visual analyses and data description using the following terms: (a) downward trend (data are decreasing), (b) upward trend (data are increasing), or (c) flat trend (data remain stable). The data levels were determined by calculating the mean percentages in each phase; and the data variability was determined by calculating the percentage range in each phase, for each participant. Both the *M* and *R* percentages were then rated using the following parameters: (a) low (0% to 35%), (b) moderate (36% to 65%), or (c) high (66% to 100%).

Study Results

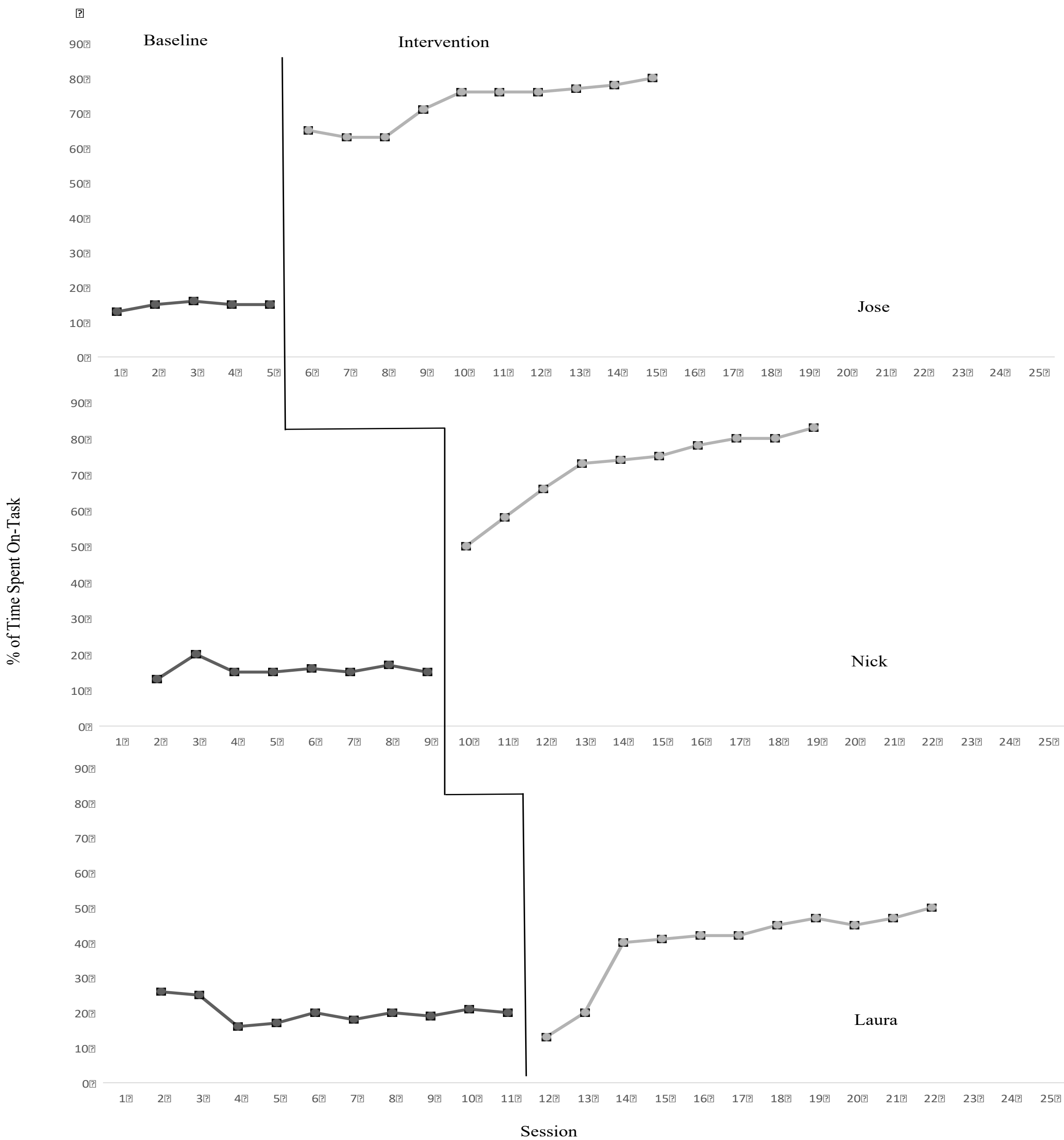
The results show a functional relationship between percentages of time spent on-task and use of the intervention. The differences between baseline and intervention data, though unique to each participant, show an overall positive functional relationship between the independent variable (IV) and dependent variable (DV) in both reading and math. Watson and Workman (1981) state a functional relationship between the intervention and targeted behavior can be determined by a multiple baseline design across participants, when the intervention is implemented during different participant sessions (i.e., the researcher is only concerned with comparing Jose to Jose, Nick to Nick, and Laura to Laura). Applying this foundation, a functional relationship was observed and the individual results are described below.

Jose's Hypothetical Reading Results

The top panel of Figure 1 shows the hypothetical reading baseline and hypothetical intervention data collected for Jose. The baseline data, collected over five classroom sessions, demonstrate a low level, ranging from 13% to 16%, and show a flat trend in percentage of time spent on-task (DV). Once the intervention (noise-cancelling headphones; IV) is introduced, Jose's percentage of time spent on-task improves from a low baseline level ($M = 14\%$), to a high level ($M = 73\%$) in intervention phase (see Table 2). Additionally, low variability exists in both Jose's reading baseline ($R = 3\%$) and intervention ($R = 17\%$) data. The intervention data depict an upward trend in the desired direction; and this, along with the level improvement from baseline phase to intervention phase, as well as low phase variability, shows a functional relationship between the DV and the IV. The IV was implemented over 10 classroom sessions.

Figure 1

Time Spent On-Task in Reading



Note. This nonconcurrent multiple baseline design across participants figure shows the participants' percentage of time spent on-task (y-axis) in reading, by session (x-axis), during the baseline and intervention phases.

Table 2

Jose's Reading and Math Results

Jose	Trend	Level	Variability *R*
Reading Baseline	Flat	Low: 14%	Low: 3%
Reading Intervention	Upward	High: 73%	Low: 17%
Math Baseline	Flat	Low: 15%	Low: 3%
Math Intervention	Upward	High: 88%	Low: 13%

Note. This table shows Jose's reading and math baseline and intervention results in trend, level—represented by the mean (*M*) percentage, and variability—represented by the range (*R)* percentage.

Nick's Hypothetical Reading Results

The middle panel of Figure 1 shows the hypothetical reading baseline and hypothetical intervention data collected for Nick. The baseline data, collected over eight classroom sessions, demonstrate a low level, ranging from 13% to 20%, and show a flat trend in percentage of time spent on-task (DV). Once the IV is introduced, Nick's percentage of time spent on-task improves from a low baseline level (*M* = 16%), to a high level (*M* = 72%) in intervention phase (see Table 3). Additionally, low variability exists in both Nick's reading baseline (*R* = 7%) and intervention (*R* = 33%) data. The intervention data depict an upward trend in the desired direction; and this, along with the level improvement from baseline phase to intervention phase, as well as low phase variability, shows a functional relationship between the DV and the IV. The IV was implemented over 10 classroom sessions.

Table 3

Nick's Reading and Math Results

Nick	Trend	Level	Variability *R*
Reading Baseline	Flat	Low: 16%	Low: 7%
Reading Intervention	Upward	High: 72%	Low: 33%
Math Baseline	Flat	Low: 16%	Low: 1%
Math Intervention	Upward	Moderate: 60%	Moderate: 43%

Note. This table shows Nick's reading and math baseline and intervention results in trend, level—represented by the mean (*M*) percentage, and variability—represented by the range (*R*) percentage.

Laura's Hypothetical Reading Results

The third panel of Figure 1 shows the hypothetical reading baseline and hypothetical intervention data collected for Laura. Laura's baseline data, collected over 10 classroom sessions, demonstrate a low level, ranging from 16% to 26%, and show a flat trend in percentage of time spent on-task (DV). Once the IV is introduced, Laura's percentage of time spent on-task does not initially increase; this is seen in the data points during the initial two intervention Sessions 12 and 13. Her percentage of time spent on-task improves around session 14 to a moderate 40% and continues to improve, peaking at a moderate 50% (Session 22). Baseline level presents as low (M = 10%) and intervention level presents as moderate (M = 39%) and can be seen in Table 4. Additionally, low variability exists in both Laura's reading baseline (R = 10%) and intervention (R = 37%) data. The intervention data depict an upward trend in the desired direction; and this, along with level improvement from baseline phase to intervention phase, as well as low variability, shows a functional relationship between the DV and the IV. The IV was implemented over 11 classroom sessions.

Table 4

Laura's Reading and Math Results

Laura	Trend	Level	Variability *R*
Reading Baseline	Flat	Low: 20%	Low: 10%
Reading Intervention	Upward	Moderate: 39%	Low: 37%
Math Baseline	Flat	Low: 26%	Low: 16%
Math Intervention	Upward	Moderate: 36%	Low: 34%

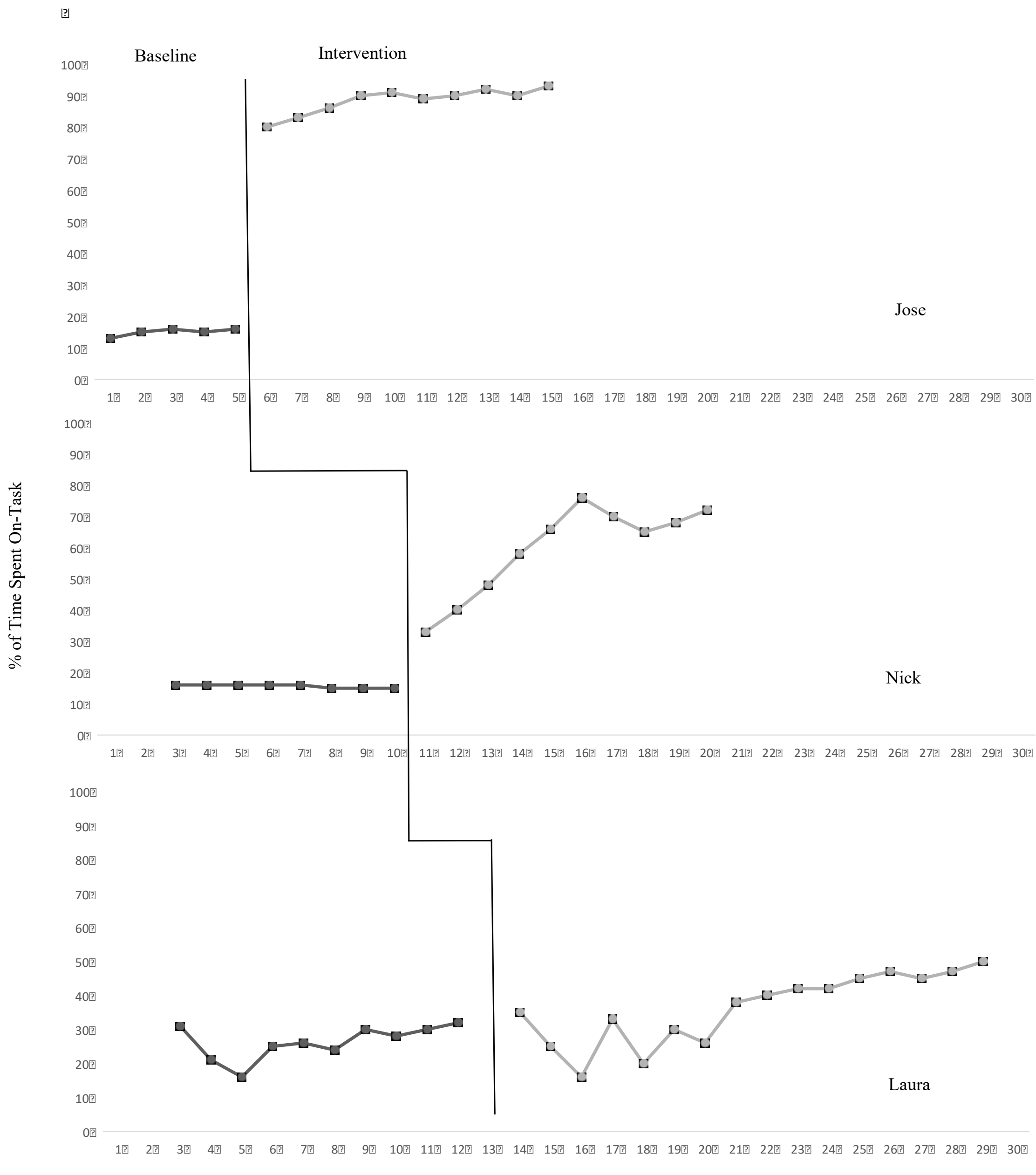
Note. This table shows Laura's reading and math baseline and intervention results in trend, level—represented by the mean (M) percentage, and variability—represented by the range (R) percentage.

Jose's Hypothetical Math Results

The top panel of Figure 2 shows the hypothetical math baseline and hypothetical intervention data collected for Jose. The baseline data, collected over five classroom sessions, demonstrate a low level, ranging from 13% to 16%, and show a flat trend in percentage of time spent on-task. Once the IV is introduced, Jose's percentage of time spent on-task improves from a low baseline level (M = 15%), to a high level (M = 88%) in intervention phase (see Table 2). Additionally, low variability exists in both Jose's math baseline (R = 3%) and intervention (R = 13%) data. The intervention data depict an

Figure 2

Time Spent On-Task in Math



Note. This nonconcurrent multiple baseline design across participants figure shows the participants' percentage of time spent on-task (y-axis) in math, by session (x-axis), during the baseline and intervention phases.

upward trend in the desired direction; and this, along with the level improvement from baseline phase to intervention phase, as well as low variability, shows a functional relationship between the DV and the IV. The IV was implemented over 10 classroom sessions.

Nick's Hypothetical Math Results

The middle panel of Figure 2 shows the hypothetical math baseline and hypothetical intervention data collected for Nick. The baseline data, collected over eight classroom sessions, demonstrate a low level, ranging from 15% to 16%, and show a flat trend in percentage of time spent on-task. Once the IV is introduced, Nick's percentage of time spent on-task improves from a low baseline level (M = 16%), to a moderate level (M = 60%) in intervention phase (see Table 3). Additionally, low variability exists in Nick's math baseline data (R = 1%). Moderate variability exists in Nick's math intervention data (R = 43%). The intervention data depict an upward trend in the desired direction; and this, along with the level improvement from baseline phase to intervention phase, as well as low/moderate variability, shows a functional relationship between the DV and the IV. The IV was implemented over 10 classroom sessions.

Laura's Hypothetical Math Results

The third panel of Figure 2 shows the hypothetical math baseline and intervention data collected for Laura. Laura's baseline data, collected over 10 classroom sessions, demonstrate a low level, ranging from 16% to 32%, and show a flat trend in percentage of time spent on-task (DV). Once the IV is introduced, Laura's percentage of time spent on-task does not initially increase; this is seen in the first intervention data point in Figure 2, Panel 3, Session 14. Laura's intervention percentage of time spent on-task then decreased to below the final baseline data point (Session 12) during intervention Sessions 15, 16, 18, and 20. Her percentage of time spent on-task improved around Session 21 to a moderate 38% and continued to improve, peaking at a moderate 50% (Session 29). Baseline level presents as low (*M* = 26%); and intervention level presents as moderate (*M* = 36%). Additionally, low variability exists in both Laura's math baseline (*R* = 16%) and intervention (*R* = 34%) data. The intervention data depict a slow, but upward trend in the desired direction; and level *M* improved 10% in her intervention phase. Therefore, a functional relationship may exist between the IV and the DV. The IV was implemented over 16 classroom sessions.

Summary

This chapter described the hypothetical baseline and intervention results of the hypothetical data provided for Jose, Nick, and Laura in reading and math. Visual analyses, of the graphed data sets, were used to interpret the effect of the intervention (IV) on percentage of time spent on-task (DV). Level, trend, and variability were examined in both the baseline and intervention phases of this study. Overall, the use of the intervention appears to have had an effect on the percentage of time spent on-task in reading and math for all three participants. These effects, for each participant, will be discussed in the following chapter.

Chapter 5

Discussion

There is limited research on the use of noise-cancelling headphones for students with autism spectrum disorder (ASD) to maintain classroom time spent on-task. One prevalent symptom of ASD is auditory hypersensitivity, which may inhibit an individual's ability to habituate to environmental noise. A classroom has the potential to exceed the recommended decibel level for a typically developing student, which is further amplified for the student with ASD auditory hypersensitivity. This chapter discusses the results of implementing noise-cancelling headphones to increase time spent on-task for three students with ASD.

This study first hypothesized that the participants' percentage of time spent on-task (DV) in reading would increase with use of the noise-cancelling headphones (IV). Overall visual analyses of the reading data in level, trend, and variability revealed the noise-cancelling headphones as an effective classroom tool for students with autism spectrum disorder (ASD); this supports the first hypothesis of this study. As previously discussed, maintaining appropriate classroom behavior is essential for classroom success (Fisher, 2009; Odell, 1923). "If the goal as educators is to encourage thinking and improve academic achievement, we have to create learning environments that facilitate engagement and time on-task" (Fisher, 2009, p. 175).

An upward data trend is seen in all intervention panels of Figures 1 and 2. This upward trend shows all the participants benefitted from use of the noise-cancelling headphones. It was also hypothesized that the participants' time spent on-task (DV) in math would increase with use of the noise-cancelling headphones (IV). Overall, visual analyses of the math data in level, trend, and variability revealed the noise-cancelling headphones as an effective classroom tool for students with ASD; this supports the second hypothesis of this study. Lastly, this study hypothesized the participants and the participants' teachers would view noise-cancelling headphones as socially valid and beneficial as measured by a social validity survey (see Appendices D, E). This survey was not administered to the participants or participants' teachers due to COVID-19 and school restrictions. It is unknown if these hypotheses would have been socially validated. However, a separate study on the current use and social validity of the noise-cancelling headphones in classrooms was conducted and written as an article (see Appendix L).

Though the overall findings of this study are mostly positive, unique data characteristics for each participant were identified. These characteristics lead to further questions about the length of the study and the amount of individual data collection sessions. Perhaps more data collection, in both baseline and intervention, would have established a stronger functional relationship between the IV and the DV.

The researcher would have met with all the participants' teachers to determine the problematic subject area for maintaining time spent on-task. Once the questionnaire (see Appendix F) was completed and the subject area confirmed, the researcher would have been present in each classroom to ensure the researcher's presence novelty subsided. The teacher would have introduced the intervention using the intervention introduction script (see Appendix I) and baseline data collection, utilizing momentary time sampling (MTS) data collection (see Appendix C), would have begun. Once baseline data collection was completed, the intervention introduction checklist (see Appendix G) would have been disseminated to all participants to ensure proper use of the intervention. Following this, the intervention data collection would have begun. Once the data collection concluded, the social validity measures (see Appendices D, E) would have been disseminated to all participants and their teachers. This survey would have shown if the participants and the participants' teachers found the intervention effective. Due to COVID-19, schools closed and research was paused.

Discussion on Jose and Nick in Reading

Jose and Nick's baseline reading data depict low levels and flat trends prior to IV implementation. The flat trends demonstrated baseline data stability and helped to identify the appropriate sessions for intervention implementation. Additionally, the flat baseline trends also allowed for a strong visual representation of the improved level changes. Equally, the low baseline levels helped to definitively identify a positive functional relationship between the IV and DV as a dramatic level improvement was seen immediately, for both participants, with use of the intervention. The reading intervention data, for Jose and Nick, depict upward trends towards the desired outcome, an increase in classroom time spent on-task. Jose and Nick's percentage of classroom time spent on-task is greatly increased with use of the intervention, demonstrating efficacy.

Low variability in both phases, for both participants, demonstrated behavioral consistency and further strengthened the positive IV and DV functional relationship, further supporting the first hypothesis in this study. The first hypothesis, for Jose and Nick, could have supported further with additional data collection, in both phases. However, it is concluded that their data show intervention effectiveness in increasing the time spent on-task in reading; which may positively impact academic success.

Discussion on Laura in Reading

Laura's reading data present differently; her baseline data depict a low level and flat trend, prior to IV implementation. The flat trend demonstrated baseline data stability and helped to identify the appropriate session for intervention implementation. Additionally, the flat baseline trend also allowed for a visual representation of the lack in initial intervention level change. Equally, the low to moderate baseline and intervention levels, respectively, helped determine that a strong positive functional relationship between the IV and DV was not initially present. In Laura's intervention phase, the percentage of time spent on-task gradually increased, as seen with an upward data trend; but it is difficult to determine if the upward trend is directly related to use of the intervention. There are many factors and/or variables that may have confounded Laura's results. While analyzing Laura's reading data, extraneous variables/factors were considered (e.g., changes in classroom dynamics, attention from peers or teachers, lack of sleep or proper nutrition, etc.). These extraneous variables may have affected her time spent on-task, resulting in the lack of initial level change. Additional data collection in baseline may have established a more stable trend, delineating which session was more appropriate for intervention implementation.

Though Laura's intervention data lacked a dramatic initial level improvement, an upward trend in the desired direction is seen. This upward intervention data trend supports the first hypothesis. Additionally, low variability existed in both phases, demonstrating some behavioral consistency. Though it is slow, the gradual upward trend in Laura's time spent on-task, with use of the intervention, may positively affect her academic success. More research needs to be conducted on the effectiveness of the intervention for Laura in reading.

Discussion on Jose in Math

Jose's baseline math data depict a low level and flat trend prior to IV implementation. The flat trend demonstrated baseline data stability, and helped to identify the appropriate session for intervention implementation. Additionally, the flat baseline trend also allowed for a strong visual representation of the improved level change. Equally, the low baseline level helped to definitively identify a positive functional relationship between the IV and DV, as a dramatic level improvement was immediately seen. The math intervention data show an upward trend toward the desired outcome, an increase in classroom time spent on-task.

Low variability, in both phases, demonstrated behavioral consistency and further strengthened the positive IV and DV functional relationship, supporting the second hypothesis in this study. The second hypothesis could have further been supported with additional data collection, in both phases. However, it was concluded that Jose's data show intervention effectiveness in increasing the time spent on-task in math; which may positively impact academic success. Jose's percentage of classroom time spent on-task was greatly increased with use of the intervention, demonstrating efficacy; the noise-cancelling headphones should be considered as an accommodation.

Discussion on Nick in Math

Nick's baseline math data depict a low level and flat trend prior to IV implementation. The flat trend demonstrated baseline data stability and helped to identify the appropriate session for intervention implementation. Additionally, the flat baseline trend allowed for a visual representation of the lack in initial level change. Nick's time spent on-task increased with the intervention (Figure 2, Panel 2, Session 11) and continued to increase with use of the intervention. Equally, the low baseline level, and moderate level improvement, during intervention, may be indicative a positive functional relationship between the IV and DV, but more research needs to be conducted. The math intervention data do show an upward trend in the percentage of classroom time spent on-task, indicating intervention effectiveness.

Moderate variability existed in the intervention phase, which may be an indication that extraneous variables/factors were present (e.g., changes in classroom dynamics, attention from peers or teachers, lack of sleep or proper nutrition, etc.). If the intervention phase data had demonstrated a high level from baseline, a stronger functional relationship would have been established between the IV and DV. Nick's math intervention data do show an upward trend toward the desired outcome, an increase in classroom time spent on-task, therefore it was concluded that Nick's data show intervention effectiveness in increasing the time spent on-task in math. This increase in time spent on-task may positively affect his academic success and should be considered as an accommodation.

Discussion on Laura in Math

Laura's baseline math data depict a low level and flat trend, prior to intervention implementation. The flat trend demonstrated baseline data stability and helped to identify the appropriate session for intervention implementation. Additionally, the flat baseline trend also allowed for a visual representation of the lack in initial intervention level change. Laura's initial math intervention data show a decrease in percentage of time spent on-task, perhaps indicative of confounding variables, which should be considered.

Her intervention data show an increase in time spent on-task around Session 21 (Figure 2, Panel 3), perhaps indicating the novelty had subsided. Low variability is seen in both the baseline and intervention phases, providing a solid foundation for future research. Laura's intervention data show a slow upward trend in the desired direction, demonstrating gradual intervention effectiveness. The gradual increase in time spent on-task may indicate Laura needed more time to adjust to the IV, or may have found the IV socially unacceptable. The social validity survey may have revealed social implications or other confounding variables preventing effective use of the IV (the social validity survey was not completed due to COVID-19). More research needs to be conducted in order to delineate a stronger functional relationship between the IV and the DV for Laura in math.

Social Validity

The social validity survey (see Appendix E) would have provided data regarding the social impact of the IV on the participants. It would have determined if the participants viewed the IV as an effective classroom accommodation for increasing classroom time spent on-task. Social validity measures are a crucial component in determining high quality research (Taylor et al., n.d.).

The teachers' social validity survey (see Appendix D) would have provided data on the effectiveness and ease, or lack thereof, of IV implementation. The teacher survey would have also shown if the teachers would utilize this intervention as an accommodation for students with ASD. Due to COVID-19, these surveys were not administered.

Limitations

This study had the intention to investigate the effects of noise-cancelling headphones on attending behaviors for three students diagnosed with ASD in their individual classroom setting. It sought to look at maintaining time spent on-task as operationally defined above; however, if it was not based on hypothetical data, it would need an instrument to collect data on what curricula was actually acquired with use of the intervention (i.e. a pre/posttest). The researcher understands that time spent on-task does not necessarily equate to learning.

This study was limited to elementary students with ASD ages 7–12. This confines generalization to other age groups and school settings.

It was also limited to the classroom setting. In a clinical setting, the intervention would have been administered to the participants, perhaps void of peers, thereby limiting social stigma. However, administration in a clinical setting would alter the assumption of noise in the classroom setting; additionally, a clinician/researcher, rather than an educator, would have implemented the intervention. Eliminating these two factors would change the course of this study.

It is crucial to collect the average classroom ambient sound during baseline and intervention; this study did not, as it contains hypothetical data. Classroom noise would have been collected with use of an American Recorder sound-level meter as seen in Rowe et al. (2011). Data on the decibel (dB) levels of ambient classroom noise would have provided a noise gauge and shown how much noise is present in the occupied and unoccupied classroom setting.

This study was implemented in only one region of the country, in one school district; this limits the reliability of the intervention. In the additional study, following this dissertation, the use of noise-cancelling headphones, by educators and administrators, for students with ASD, is seen across different states.

Additionally, multiple baseline design across participants design was utilized with hypothetical data; the data presented are not real. This design requires a high reliance on visual analyses. Price et al. (2015), state heavy reliance on visual analysis includes observing plotted data points and drawing conclusions regarding the effect or non-effect of the IV on the DV. Furthermore, the data collected are graphed by the researcher and subject to the researcher’s data interpretation. This study would have included interobserver agreement (IOA) and a social validity measure to help ensure internal fidelity and validity; due to COVID-19, IOA was not conducted.

Finally, this intervention was implemented across two subject areas, at different times, for each participant, perhaps increasing habituation or comfort toward the novel intervention, altering results of the secondary subject area.

Implications for Practice

This study contains many implications for practice. Even though it utilized hypothetical data for analyses, much of the study, up to actual data collection, had been completed prior to COVID-19 school closures. The study was approved and embraced by the Washoe County School District teaching community. Study support is evidenced by the teacher survey data study (see Appendix L), containing actual data. These data show many teachers/administrators ($n = 30$) are currently using, have previously used, or have seen noise-cancelling headphones in the classroom or school for students with ASD;

thereby demonstrating a desired need. This current study identifies the noise-cancelling headphones as a common, cost-efficient, low-tech tool to help students with ASD combat auditory hypersensitivities. Implications from this study could provide valuable information and awareness to educators, parents, etc., about ASD auditory hypersensitivity. There is also the potential to include this tool in classrooms or at home, making it available for discretionary use. The influx of very recent research shows an interest in noise-cancelling headphones among the ASD community (see Fodstad et al., 2020; Neave-DiToro et al., 2021; Pfeiffer et al., 2019; & Rowe et al., 2011).

Noise is detrimental in a learning environment, as it limits curriculum acquisition (Smith & Riccomini, 2013); therefore, it is essential educators limit the amount of classroom auditory stimuli. Furthermore, Bijou and Ghezzi (1999) discuss hypersensitivity as a symptom of ASD leading to avoidance or escape from auditory stimuli causing potential "problems in the development of social-emotional and verbal behavior" (p. 40). This shows that the noisy classrooms may become aversive and detrimental for students with ASD. Students with ASD may lack the ability to habituate to certain classroom noises (e.g., people talking, pens clicking, phones ringing, etc.), leading to time spent off-task and limited curricula acquisition, followed by lack of academic success. Prevention and/or early intervention could limit these deficits. This can be accomplished, for students with auditory hypersensitivity, through use of the noise-cancelling headphones in the classroom. Implications from this study have the potential to assist with early intervention.

Finally, the students' least restrictive environments (LRE) must be considered. The LRE may be an inclusive classroom with same-aged peers and a general educator. It is crucial the general educator has access to easily implemented, cost-efficient tools. The noise-cancelling headphones are classroom-effective, easily implemented, and cost-efficient for students with auditory hypersensitivity. Implementing the noise-cancelling headphones in the students' LRE may help with transitions, free-play, independent seatwork, attendance at school social functions etc. Educators can additionally become the researchers with intervention implementation, limiting the need for clinical settings. With more research, considered of high quality, implementation of noise-cancelling headphones, to maintain time spent on-task for students with ASD, has the potential to become an evidence-based practice; making the accommodation readily available.

Future Directions

All students, in a noisy classroom, may benefit from the option of using noise-cancelling headphones. Limiting the amount of auditory stimuli in the environment may help students of all abilities remain on-task. The increased time spent on-task the great the potential for academic success; auditory stimuli may inhibit this. Utilizing the intervention for all students in the classroom may also increase academic success. Many school districts in Columbus, Ohio currently allocate noise-cancelling headphones to all students, or parents are permitted to purchase the headphones of their choosing; the students have discretionary use (S. Peterson, personal communication, October 10, 2018). More research needs to be conducted with the intervention in general education classrooms for students of all abilities.

It is not ideal for students become so accustomed to the intervention that, when unavailable, are unable to remain on-task. To ensure this doesn't occur, a fading procedure needs to be examined. Fading, as defined by Pierce and Cheney (2013), occurs when stimulus control is transferred from one stimulus to another thereby limiting the response rate to the initial stimulus. This is accomplished by introducing a new contingency with a designated goal (Pierce & Cheney, 2013). To put the fading procedure into context, this can be accomplished by gradually introducing higher input levels of environmental noise thereby slowly habituating the student to auditory classroom stimuli (i.e., slowly raising the decibel level of headphone input). Findings from future studies may show eventual auditory habituation allowing the fading out of headphone use in the classroom.

Finally, alternative research designs should be explored. Implementing a multiple baseline across participants maintains that the student is his/her own control. However, a different design (e.g., ABAB withdrawal, or case study) could potentially strengthen this study further highlighting the functional relationship between the intervention and time spent on-task.

Conclusions

The purpose of the current study was to explore: (1) the use of noise-cancelling headphones to increase time spent on-task for students with ASD, as measured by time spent in active listening, active engagement during independent reading tasks; (2) the use of noise-cancelling headphones to increase time spent on-task for students with ASD, as measured by time spent in active listening, active engagement during independent math tasks; (3) if the noise-cancelling headphones were viewed by the participants as socially valid and effective; and (4) if the noise-cancelling headphones were viewed by the participants' teachers as socially valid and effective. Social validity was a necessary component in this study in order to adhere to the strict SSD EBP guidelines. Due to

COVID-19, the face-to-face components of this study were eliminated; therefore data were created for visual analyses.

This study was partially completed, but lacks the most crucial component of data collection. From the literature, research, personal experience, and analyses of the hypothetical data, it can be concluded the use of noise-cancelling headphones can be an effective classroom tool to maintain time spent on-task for students with ASD. Additionally, it can be concluded that noise-cancelling headphones are easily implemented and cost-efficient, demonstrating how the practitioner can become the researcher.

ASD is a complex diagnosis across a spectrum of symptoms. It is a disability seen across gender, ethnicity, socio-economic status and the cause is unknown. The CDC (2019) has determined, as of 2016, one child out of every 54 (1.85%) eight-year olds have a diagnosis of ASD. This indicates that a high percentage of educators have taught or currently teach a student with ASD. Each student is unique in the etiology of the diagnosis and requires individualized teaching methods. Creating an individualized education plan for students with ASD is challenging, but necessary.

One common symptom of ASD is auditory hypersensitivity leading to aversion or avoidance of auditory stimuli (Baker et al., 2008; Bijou & Ghezzi, 1999; Pfeiffer et al., 2019). Classrooms are a highly distractible, sensory-inducing, moving entity with the potential to create an auditory overload for the students with ASD. Aversion or avoidance to the auditory input may cause academic time spent off-task and eventually lead to lack of academic success, which should be considered a critical outcome for students with ASD. As discussed above, the individuals with disabilities act (IDEA, 2004) requires students with disabilities to receive education in their least restrictive environment. Often, this includes partial or full time education within the general education classroom, tasking educators with providing education for students of all abilities. Because of this, it is important to ensure educators are able to become classroom researchers. An educator as a researcher eliminates the clinical intervention implementation setting and allows implementation in a naturalistic setting. Only with the proper tools, technology, training, and access to easily implemented evidence-based practices can this be accomplished.

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Appendices

Appendix A: Parent/Guardian of Participant Consent Form

University of Nevada, Reno
Parent Permission Form for Educational Research

Title of Study: Noise-Cancelling Headphones as an Intervention for Off-Task Behavior for Students with Autism Spectrum Disorder
Principle Investigator: Shanon Taylor, Ed.D., Associate Professor, 775-682-7864
Co-Investigator: Alicia Nehrkorn M.Ed., Graduate Student, 307-757-6159
Study ID Number:
Sponsor:

Purpose
You are being asked to give permission for your daughter/son to take part in a research study. You are also being asked to answer a brief survey toward the end of the study. The questions on the survey will assess your perception of the study. The purpose of the study is to learn the effects of noise-cancelling headphones to maintain time spent on task.

Participants
You are being asked to permit your child to participate because she/he has been diagnosed with an autism spectrum disorder. Participants in the study will be current elementary school students. There will be 3-5 participants in the study.

Procedures
If you give permission for your child to take part in this research study, she/he will be asked to participate in four phases of the research. The four phases include the baseline/probe phase, the intervention phase, a return to baseline/probe phase, and re-implementation of the intervention phase. All phases will occur in their classroom.

In the baseline/probe phase, the researcher will record data for 3-10 sessions during this phase. The researcher will observe a typical day and collect data during independent seatwork in math as well as independent reading. The intervention phase is the experimental phase. The researcher will record data for 3-10 sessions during this phase. The intervention will be introduced by the lead teacher, and the researcher will observe the intervention during independent seatwork in math as well as independent reading. The intervention will only be available in two phases, the other two phases, no intervention will be used.
The total time commitment for participation in the study is 4-6 weeks. There will be very minimal instruction interruption.

Risk, Discomforts, and Inconveniences
No known risks or discomforts are associated in the study.

Benefits
There will be no direct benefits to your daughter/son as a participant in this study. However, your daughter/son may improve her/his classroom on-task behaviors and retain more instruction with the intervention. By conducting this research, we hope to learn that headphones are a cost effective, easily implemented intervention to combat time spent off-task.

Incentives
Upon the full completion of the study, participants will be allowed to keep the headphones for future classroom use.

Right to Refuse or Withdraw
You may decide you don't want your daughter/son to take part in the study and that is okay. If you say yes at first and change your mind later, you may take your daughter/son out of the study at any time. You may also choose to not answer the survey questions about your perceptions of the study and that is okay. If the researchers change the study design or use of the data, you will be told about the changes and asked to give your permission again. You will be told of any important new information that may change your mind about letting your daughter/son remain in the study.

Confidentiality
Your daughter's/son's identity will be protected to the extent allowed by law. Your child will not be personally identified in any reports or publications that may result from this study.

The Department of Health and Human Service (HHS), other federal agencies as necessary, and the University of Nevada, Reno Social Behavioral Institutional Review Board may inspect your child's study records.

The study records will be securely stored in a locked desk and a password protected computer. The study records will be stored for 5 years after the study has initially occurred. Only the researchers will have access to the locked desk and password-protected computer.

Questions
If you have questions about this study, at any time you may contact Shanon Taylor, Ed.D., Associate Professor at 775-682-7864 or Alicia Nehrkorn Graduate Student at 307-757-6159.

You may ask about your daughter's/son's rights as a research participant or you may report, without giving your name or your child's name, any comments, concerns, or complaints to the University of Nevada, Reno Social Behavioral Institutional Review

Board by calling (775) 327-2368 or by completing the form available on the web at http://www.unr.edu/research-integrity/contact-rio

Closing Statement
Check one: I have read □ this permission form, or it has been read to me□.

__________________ has explained the study to me and all of my questions have been answered. I have been told of the risks or discomforts and possible benefits of the study.

If I do not give permission for my child to take part in this study, my refusal to allow her/him to participate will involve no penalty or loss of rights to which she/he is entitled. I may withdraw my child from this study at any time without penalty.

I have been told my child's rights as a research participant, and I voluntarily give permission for my child to take part in this study. I have been told what the study is about and how and why it is being done. All of my questions have been answered.

I will receive a signed and dated copy of this permission form.

____

Printed name of at least one Parent or at least one Guardian   Date

____

Signature of at least one Parent or at least one Guardian   Date

____

Signature of Person Obtaining Consent   Date

Appendix B: Teacher Consent Form

To Whom it May Concern,

I, the undersigned, grant permission to ____,
a graduate student at ____
to be present in, observe in, and conduct research within my classroom during designated days:
____
____.

I understand the observations and intervention implementation are for research purposes. I also provide consent to participate in a teacher questionnaire prior to the study and a survey post study.

____
Teacher [Name & Signature]

____
Teacher ID and Date

Appendix C: Momentary Time Sampling Recording Form

Target Student: _________________________ School: _______________________ Grade: ______
Teacher: ______________________ Activity: _________________________
Observer: _____________________ Date: __________

Define observed behavior (specific & measurable) Subject area time on-task will be operationally defined as active listening (i.e., eyes on the appropriate speaker, body positioned forward, not talking), active engagement (i.e., following the instructor's requests, appropriate responding when solicited, eyes on the appropriate material in front of student, actively engaged in note taking, highlighting, etc.).
Observation length: __________ Length of each interval: ___________

This form is set up for 60 intervals per observation. For each 15-minute session, each interval is 15s. **At the end of each interval, when the timer vibrates (after each 15s), look to see if the target student is engaging in on-task behavior at that exact moment. Mark + (yes) or – (no). Continue this for each 15s interval for 15 minutes.

Calculate the % by adding the # of +s divided by the number of intervals (60) and multiplying by 100.

Date:	Intervals: (Mark + or -)									
Time:	1	2	3	4	5	6	7	8	9	10
Student										
	11	12	13	14	15	16	17	18	19	20
Student										

	21	22	23	24	25	26	27	28	29	30
Student										
Time:	31	32	33	34	35	36	37	38	39	40
Student										
	41	42	43	44	45	46	47	48	49	50
Student										

	51	52	53	54	55	56	57	58	59	60	+s /60	% of Intervals
Student												

Appendix D: Teacher Social Validity Questions

Instructions: Please circle the number that represents how you feel about using the headphones in your classroom.

1 = Strongly Disagree, 2 = Disagree, 3 = Somewhat Disagree, 4 = Somewhat Agree, 5 = Agree, and 6 = Strongly Agree

1. I enjoyed using the headphones in my classroom.

Strongly Disagree ---- 1 ---- 2 ---- 3 ---- 4 ---- 5 ---- 6 ---- Strongly Agree
☹ ☺

2. It was relatively easy to implement the headphones in my classroom.

Strongly Disagree ---- 1 ---- 2 ---- 3 ---- 4 ---- 5 ---- 6 ---- Strongly Agree
☹ ☺

3. My students enjoyed using the headphones for independent work.

Strongly Disagree ---- 1 ---- 2 ---- 3 ---- 4 ---- 5 ---- 6 ---- Strongly Agree
☹ ☺

4. I noticed an increase in my students' time spent on task.

Strongly Disagree ---- 1 ---- 2 ---- 3 ---- 4 ---- 5 ---- 6 ---- Strongly Agree
☹ ☺

5. I will continue to use the headphones during independent seatwork.

Strongly Disagree ---- 1 ---- 2 ---- 3 ---- 4 ---- 5 ---- 6 ---- Strongly Agree
☹ ☺

6. I am confident that time spent on-task during independent seatwork will continue to increase.

Strongly Disagree ---- 1 ---- 2 ---- 3 ---- 4 ---- 5 ---- 6 ---- Strongly Agree
☹ ☺

Appendix E: Participant Social Validity Questions

Instructions: Please circle the number that represents how you feel about purchasing food/beverage. 1 = Strongly Agree, 2 = Agree, 3 = Somewhat Agree, 4 = Somewhat Disagree, 5 = Disagree, and 6 = Strongly Disagree

1. I enjoyed using the headphones.
   Strongly Disagree ---- 1 ---- 2 ---- 3 ---- 4 ---- 5 ---- 6 ---- Strongly Agree
   ☹ ☺
2. I understood what the headphones were for.
   Strongly Disagree ---- 1 ---- 2 ---- 3 ---- 4 ---- 5 ---- 6 ---- Strongly Agree
   ☹ ☺
3. The headphones allowed me to pay close attention to schoolwork.
   Strongly Disagree ---- 1 ---- 2 ---- 3 ---- 4 ---- 5 ---- 6 ---- Strongly Agree
   ☹ ☺
4. The headphones helped me stay focused on schoolwork.
   Strongly Disagree ---- 1 ---- 2 ---- 3 ---- 4 ---- 5 ---- 6 ---- Strongly Agree
   ☹ ☺
5. I would like to use these headphones in the future.
   Strongly Disagree ---- 1 ---- 2 ---- 3 ---- 4 ---- 5 ---- 6 ---- Strongly Agree
   ☹ ☺
6. Participation in this research study makes a positive impact in my classroom.
   Strongly Disagree ---- 1 ---- 2 ---- 3 ---- 4 ---- 5 ---- 6 ---- Strongly Agree
   ☹ ☺

Appendix F: Teacher Recommended Subject Area Questionnaire

Teacher Name____

Grade Taught__________________

Which student, in which subject area, lacks on-task behavior?

Definition: Lack of on-task behavior or unattending to subject matter is defined by inactive listening (i.e., eyes looking anywhere, but the appropriate speaker, body not positioned forward, talking out of turn), inactive engagement (i.e., not following the instructor's requests, inappropriate responding, eyes on inappropriate stimuli, not actively engaged in note taking, highlighting, etc.), or attending to inappropriate sources of sensory input (e.g., other students talking out of turn, people entering or leaving the classroom).

The problematic subject area must be no less than 15 minutes of independent work (e.g., reading, math).

Student Name____

Subject Area____

Appendix G: Headphone Introduction Checklist

Student Name ______________________________

Researcher Name ______________________________

Date ____________________________

Time ___________________________

Step 1. The student is shown the headphones.

Mark if completed ______

Step 2. The researcher describes that the headphones are noise cancelling, but that they allow one to hear direct conversation; ambient noise is cancelled.

Mark if completed ______

Step 3. The researcher demonstrates proper use of headphones by placing them over ears.

Mark if completed ______

Step 4. The student is asked to demonstrate proper use of the headphones by placing them over ears.

Mark if completed ______

Step 5. The student is asked if he/she has difficulty maintaining attention in (teacher assigned subject specific to student). Yes _____ No ______

Mark if completed ______

Step 6. The student is directed to wear the headphones during teacher-identified subject to help maintain attention.

Mark if completed ______

Step 7. The student is directed during which classroom time of the day to implement the intervention and told the lead researcher will provide the headphones during this time.

Mark if completed ______

Appendix H: Participant Recruitment Script

Dear potential participant,

My name is Alicia Nehrkorn and I am a doctoral student in the education department at University of Nevada, Reno. I am conducting a research study examining the effectiveness of noise-cancelling headphones on maintaining on-task classroom behavior for students with autism spectrum disorder, and you are invited to participate in the study. If you agree, you are invited to participate in a study to help maintain student's time spent on-task in the classroom. This study will be held within the students' classrooms and will not interfere with daily lessons or classroom on-goings. The lead researcher will introduce the headphones to the student and ensure comfort. Data regarding the occurrence or non-occurrence of on-task behavior will be logged for both phase 1 (no headphones use) and phase 2 (headphone use). This will only take place during one teacher-recommended subject area specific to the students. Once completed, the student will be asked to take a very brief survey regarding the headphones use. The noise-cancelling headphones do not completely block out noise, just ambient or background noise. Each student will be able to hear face-to-face conversation and drills or alarms. Additionally, headphones are currently used in many classrooms for independent computer or tablet work (references available upon request). This study is anticipated to take no more than 14 school days and no more than a total of four hours. Participation in this study is voluntary. Your identity as a participant will remain confidential in the write-up of the results. Pseudonyms will be used.

If you have questions or would like to participate, please contact me at
anehrkorn@nevada.unr.edu or (307) 757-6159
Thank you for considering participation,

Alicia Nehrkorn
University of Nevada, Reno
Education Department
Doctoral Student

Appendix I: Teacher Intervention Introduction Script

First day lead researcher is in the classroom:

Hello class, we will continue business as usual, but we have a friend who will be in our classroom for a few days. She is a student just like you and is exploring learning. She will begin with a just a few students in a few days. Her name is ________________. Please say hello on your free time. During classroom time, unless otherwise instructed, let's continue business as usual.

First day of data collection:

Hello class, you remember ______________, she has been in our classroom for a few days. Do you remember what we talked about when she first came in the classroom? She is here as a student just like you and is exploring learning. She will begin with just a few students. You will see these headphones (teacher displays the headphones given to him/her by the lead researcher) used by some of our students during some of our lessons. Please be respectful and continue with business as usual as she works throughout the classroom with some students and these headphones.

Appendix J: Children's Noise-Cancelling Headphones

Appendix K: Vibrating Timer Watch

Appendix L: National Teacher Survey Regarding the Current, or Previous, Classroom Use of Noise-Cancelling Headphones for (a) Student(s) With Autism Spectrum Disorder

By: Alicia Nehrkorn Hellner

College of Education and Human Development, University of Nevada, Reno

Objective

The purpose of this study was to determine if educators across the United States have used, or are currently using, noise-cancelling headphones in the classroom for students with autism spectrum disorder. Noise-cancelling headphones are available to some students as a classroom accommodation, as stated in the student's individual education plan; however, implementing noise-cancelling headphones to maintain time spent on-task for students with autism spectrum disorder is not yet considered to be an evidence-based practice. To be considered an evidence-based practice, numerous studies, conducted on intervention implementation, must be considered high quality and include components of a rigorous checklist, inclusive of social validity measures. The goal of this study was to determine if the noise-cancelling headphones are currently utilized for students with autism spectrum disorder and who, demographically, implements them. Additionally, this survey collected educators' opinion data on the effectiveness, cost-efficiency, and ease of implementation of the noise-cancelling headphones. The results show the majority of participants (n = 30) have used, are using, or have seen noise-cancelling headphones for students with autism spectrum disorder.

Introduction

Children with autism spectrum disorder (ASD) exhibit unique characteristics related to the diagnosis. The Centers for Disease Control (CDC; 2019) defines ASD as a developmental disability affecting one's ability to socialize, communicate, and may include behavioral difficulties. Additionally, the CDC (2019) states children with ASD may learn and acquire information differently than typically developing peers. One common symptom of ASD is a low tolerance of sensory input leading to an overreaction/under reactionary response to sensory information (Suarez, 2012). This low threshold for sensory input may inhibit development of "conditional beneficial social stimuli leading to limited acquisition of functions related to reinforcement, discrimination, and generalization" (Bijou & Ghezzi, 1999, p. 36). These components of the diagnosis may cause social or behavioral problems exhibited at home or in school (Pfeiffer et al., 2019).

The CDC (2019) has determined, as of 2016, an average of 1/54 (1.85%) of 8-year-olds have been diagnosed with ASD. With prevalence and incidence of ASD at such high rates, it can be assumed that nearly all educators have or have had a student with ASD in his/her classroom (Anderson et al., 2018), as dictated by the least restrictive environment (LRE), within the Individuals with Disabilities Act (IDEA, 2004). The federal mandate states:

> To the maximum extent appropriate, children with disabilities, including children in public or private institutions or other care facilities, are educated with children who are not disabled, and special classes, separate schooling, or other removal of children with disabilities from the regular educational environment occurs only

when the nature or severity of the disability of a child is such that education in the regular classes with the use of supplementary aids and services cannot be achieved satisfactorily.

§300.324(d)(2).

Bradley (2016) states the number of students with ASD attending and included in the general education setting has increased. Educating students of all abilities, within one classroom, presents challenges. The educator(s) is tasked with differentiated instruction and maintenance of time spent on-task for all classroom students. Finn et al. (2015) discuss difficulties including students with ASD into the general education classroom due to differences in material acquisition, focus of attention, and educational pacing; however, if the general education classroom is determined to be the student's LRE, the student with ASD must be educated in that classroom. Additionally, educating students of all abilities benefits all students (Odom et al., 2011).

Maintaining time spent on-task has long been linked to academic success (Anderson, 2001; Fisher, 2009; Odell, 1923; Rowe et al., 2011) therefore, it is crucial to ensure students with ASD attend to and remain on-task with curricula (Kinnealy et.al, 2012). Students with ASD may exhibit sensory sensitivities to classroom stimuli, leading to problems in attending to specific curriculum tasks (Anderson, 2001; Kinnealy et.al, 2012); this demonstrates a potential correlation between ASD symptoms and lack of classroom time spent on-task, which may result in lack of academic success. EBPs and assistive technologies are often implemented into the classroom to aid in curricula acquisition. Current EBPs to maintain time spent on-task include but are not limited to: functional behavior assessment (FBA), video modeling (VM), video self-modeling, and

Social Stories™. These require time, different types of technology, and constant data collection, potentially making it difficult for the general-education teacher to implement, with fidelity, in the inclusive classroom (Anderson et al., 2015; Buggey & Ogle, 2011; Finn et al., 2015; Hitchcock et al., 2003; Lloyd et al., 2016; Moore et al., 2013; Reynhout & Carter, 2009); this further demonstrates how critical it is to enable an educator to become the classroom researcher, easily and efficiently, with use of an effective intervention. By optimizing access to tools through assistive technologies (UDL Checkpoint 4.2), the educator can facilitate a class-wide UDL (Universal Design for Learning Guidelines version 2.2, 2018), thereby teaching students of all abilities, effectively in one classroom.

Noise-cancelling headphones are one assistive tool currently utilized in classrooms across the United States. Educators are implementing them, despite lack of research. This study explores the current use of the headphones as well as opinions on the effectiveness.

Methodology

A flyer (see Appendix A), with survey information, was disseminated on various social media platforms: FaceBook, Instagram, and LinkedIn; it was also sent via email to school district contacts. The flyer provided willing participants a link to a Google Survey Form. The survey was completely anonymous and was easily accessed by clicking the available link or by scanning a Quick Response (QR) code included on the flyer. The flyer served as both a recruitment tool and access to the survey. The survey flyer was posted on social media platforms and it was also requested that social media connections ("friends") "share" the flyer. Additionally, it was sent out via email to educator contacts.

Both the link and the QR code led participants to a Google forms survey platform (see Appendix B), where simple demographic/noise-cancelling headphone use information was collected from the following:

- The grade(s) I've taught within the last five years is/are (pre kindergarten-12th grade; check all that apply).
- My current US state of employment is (Alabama-Wyoming, alphabetically).
- The highest degree I hold is a/an (associate's degree, bachelor's degree, master's degree Ph.D., none of the above).
- I have taught students for the following amount of time (six months-20+ years).
- I am licensed in (early childhood, elementary, secondary, special education, administration; check all that apply).
- I have taught in the following types of classroom(s) (general education, gifted and talented, resource classroom, special education-self-contained, special education-push-in, special education/general education-co-taught, and none of the above; check all that apply).
- I have taught at least one student with autism spectrum disorder within the past five years (check yes or no).
- Noise-cancelling headphones have been used in my school and/or classroom by at least one student within the past five years (check yes or no).
- Noise-cancelling headphones have been used in my school and/or classroom by at least one student with ASD within the past five years (check yes or no).

All of the aforementioned questions were mandatory (as indicated by an asterisk) in order to move to the next question.

Further data collection included: (1) in my opinion, noise-cancelling headphones improved time spent on-task during independent seat work for the student(s) with ASD; options included strongly disagree, disagree, agree, strongly agree; (2) in my opinion, noise-cancelling headphones improved time spent on-task during math activities for the student(s) with ASD; options included: strongly disagree, disagree, agree, strongly agree; (3) in my opinion, noise-cancelling headphones improved time spent on-task during English Language Arts (ELA) for the student(s) with ASD; options included: strongly disagree, disagree, agree, strongly agree; (4) in my opinion, noise-cancelling headphones improved time spent on-task during other academic tasks for the student(s) with ASD; options included: strongly disagree, disagree, agree, strongly agree; (5) in my opinion, noise-cancelling headphones can be easily implemented into a classroom; options included strongly disagree, disagree, agree, strongly agree; (6) in my opinion, noise-cancelling headphones are a cost-effective intervention in the school and/or classroom; options included: strongly disagree, disagree, agree, strongly agree; (7) in my opinion, noise-cancelling headphones are a cost-effective intervention to maintain time spent on-task in the school and/or classroom for students with ASD; options included: strongly disagree, disagree, agree, strongly agree; (8) in my opinion, students should use noise-cancelling headphones during academic activities at his/her discretion; options included strongly disagree, disagree, agree, strongly agree; (9) in my opinion, students should use noise-cancelling headphones during academic activities at the discretion of the teacher only; options included: strongly disagree, disagree, agree, strongly agree; and finally (10), an open forum was available for additional comments. A “submit” button was accessible at the end of the survey. This survey was live for three months, and had a total of 47 responses. The participants' anonymous demographic information is discussed below.

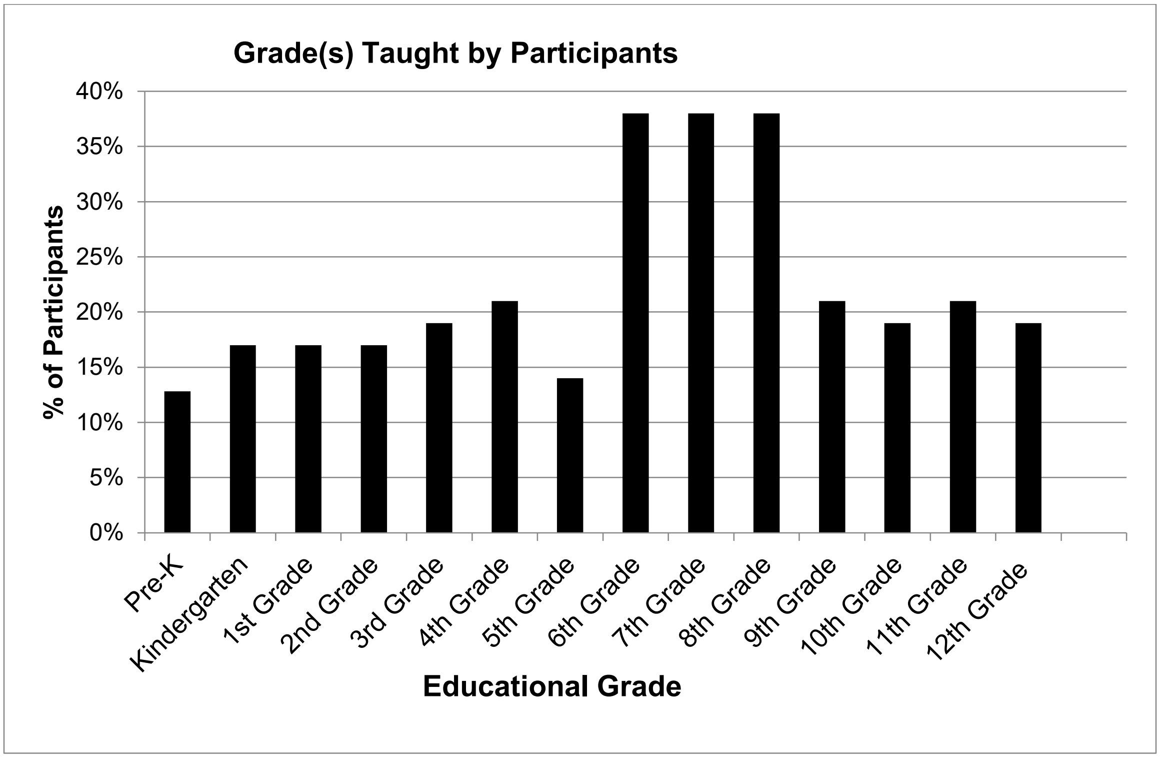
Research Participants

All survey participants were anonymous and no identifying information about the participants' names, email addresses, positions, school districts, ethnicities, race, gender etc., was requested. Information regarding educational grades, currently or previously taught, current state of employment, highest degree held, amount of years in teaching profession, licensure(s) held, type(s) of classroom(s) currently or previously taught was required for survey completion. The demographic data collected is depicted in Figures 1-4.

Figure 1 depicts participants' educational grades, currently or previously taught (N = 47). Majority of participants, 38.3%, are currently teaching, or have taught (within five years) grades six, seven, and eight, followed by 21.3% of participants currently teaching, or previously taught (within five years) grades four, nine, and 11. The data show 19.1% of participants are currently teaching, or have taught (within five years) grades three, 10, and, 12. A total of 17% of participants are currently teaching, or have taught (within five years) grades kindergarten, one, and two, and 14.9% are currently teaching, or have taught (within five years) grade five. Finally, 12.8% of participants are currently teaching, or have taught (within five years) pre-kindergarten (Pre-K).

Figure 1

Grades Taught by Participants Within the Last Five Years

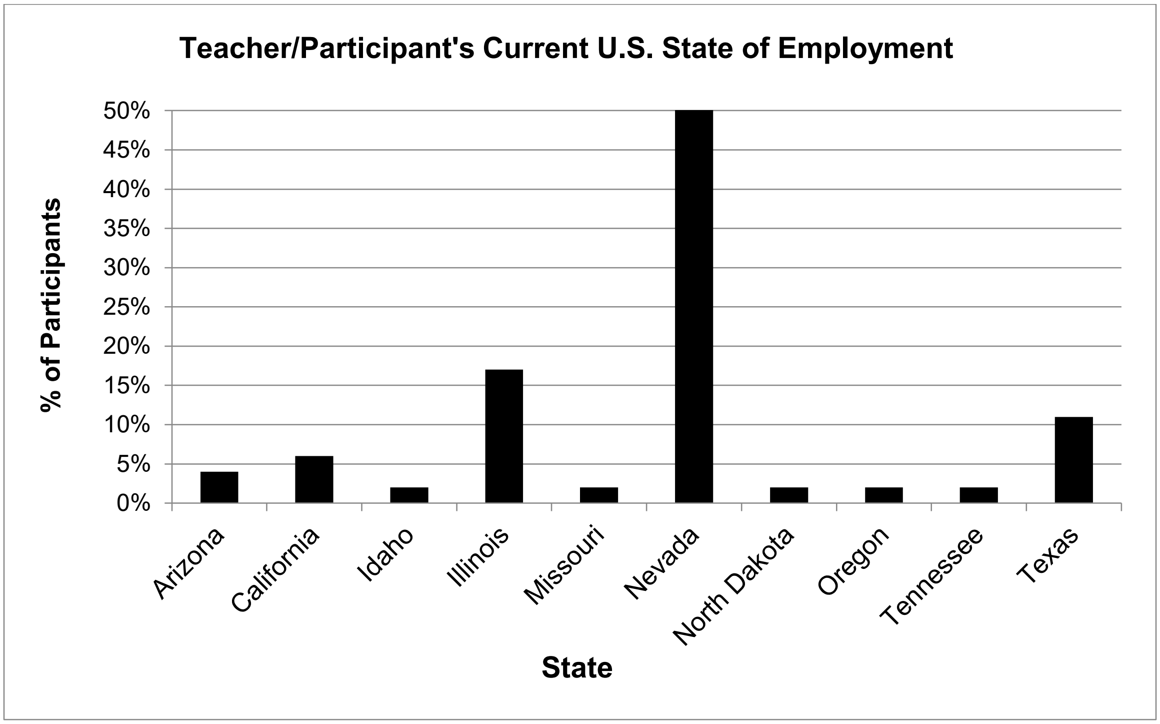


Note. The x-axis represents the grade(s) reportedly taught by survey participants. The y-axis represents the percentage of participants' grade(s) taught.

Figure 2 represents the participants' currently reported U.S. state of employment. The participants were asked in which U.S. state he/she currently holds employment (N = 47). The states represented by the survey participants include: Arizona, California, Idaho, Illinois, Missouri, Nevada, North Dakota, Oregon, Tennessee, and Texas. The other 40 states were not represented in this survey. Nevada had the largest participant rate (51.1%), followed by Illinois (17%), Texas (10.6%), California (6.4%), Arizona (4.1%), and Idaho, Tennessee, North Dakota, Missouri, and Oregon represented at 2.1% participation rate.

Figure 2

Teacher/Participant's Current U.S. State of Employment

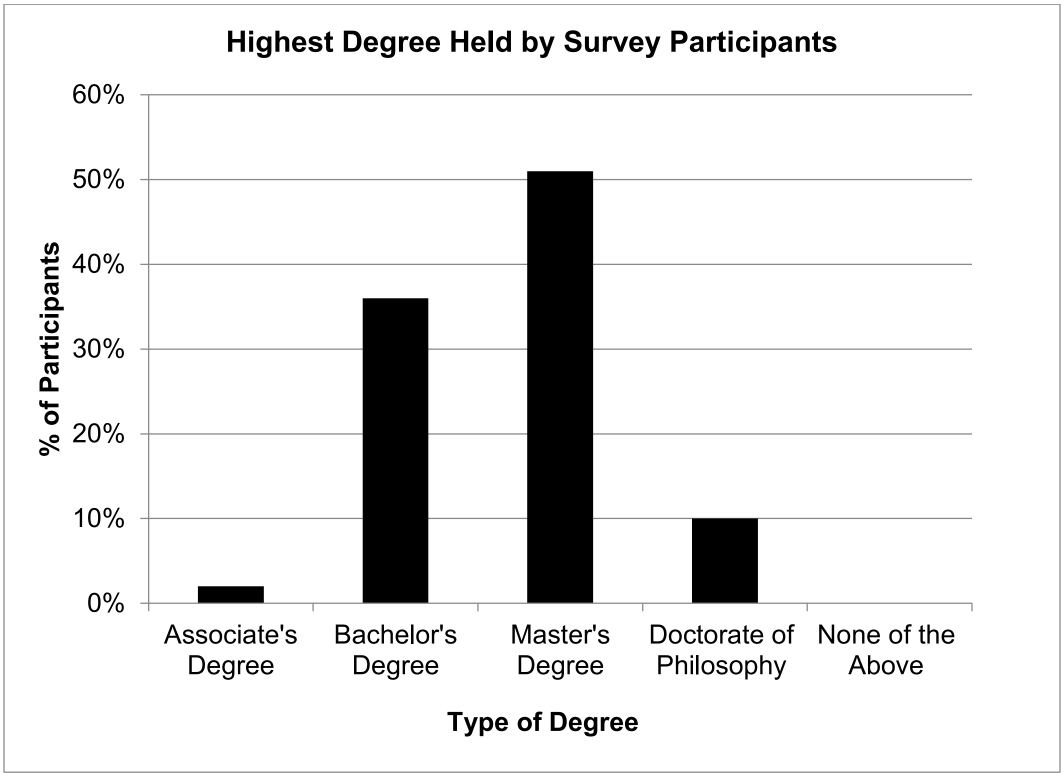


Note. The x-axis represents the state of employment reported by survey participants. The y-axis represents the percentage of participants.

Figure 3 represents survey participants' reported highest degree (N = 47). Majority of the participants, 51.1%, hold a Master's degree, followed by 36.2% with a bachelor's degree, 10.6% hold a Doctorate of Philosophy (Ph.D., or equivalent), and 2.1% hold an associate's degree. None of the participants reported "none of the above" which would indicate no college degree.

Figure 3

Highest Degree Held by Survey Participants



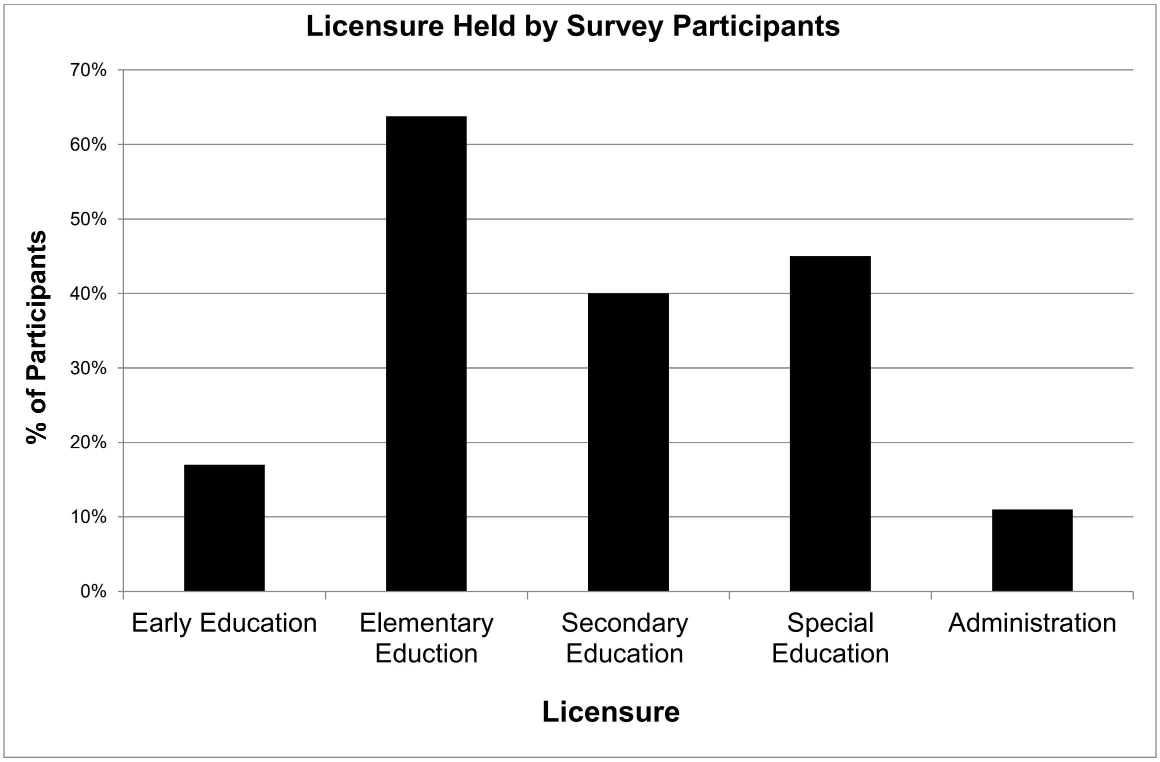
Note. The x-axis represents the degree held by survey participants. The y-axis represents the percentage of participants.

The fourth survey question requested data on the amount of years taught by each participant. Majority of participants have taught for three years (17%), followed by 20+ years (12.8%); 10.6% have taught for nine years, and 8.5% have taught for nine and six years. Subsequent amount of years follow (N = 47).

Figure 4 shows the survey participants' current classroom/educational licensure(s) (n = 47). This figure shows majority of participants are licensed in elementary education (63.8%), followed by 44.7% in special education, 40.4% in secondary education, 17% in early childhood, and finally, 10.6% in administration.

Figure 4

Licensure Held by Survey Participants



Note. The x-axis represents the current licensure reported by survey participants. The y-axis represents the percentage of participants.

After demographic information was collected, Skip Logic was used to either end or continue the survey. The survey continued if the participants checked "have taught students with ASD within his/her classroom," and also if the participants responded with "yes" to utilizing noise-cancelling headphones in his/her school/classroom within the past five years. If the aforementioned survey question response was "no," the survey ended for the participant.

Limitations

This study has limitations. First, this study collected information via social media platforms and over email. Social media platforms are unreliable, and members may not be whom they publish. The information was anonymous and no identifying information was collected, therefore, there was no accountability for the participants. The participants may lack honesty regarding his/her position as an educator and/or his/her implementation of noise-cancelling headphones for students with ASD, also licensure and degree held (see Figures 1, 3, 4). Secondly, Figure 2 shows the participants' reported state of employment. Participants from 10 states (Arizona, California, Idaho, Illinois, Missouri, Nevada, North Dakota, Oregon, Tennessee, and Texas) completed the survey; the other 40 states were not represented. It is unknown if noise-cancelling headphones are currently implemented or have been implemented in the underrepresented 40 states. Additionally, the educators in each reported state are disproportionally represented (see Figure 2), majority claim to teach in Nevada. Finally, the survey lacked a fading procedure question; this question would have inquired about effectiveness of intervention fading.

Instruments

A flyer (see Appendix A) was posted on various social media sites: Facebook, Instagram, and LinkedIn, to recruit survey participants. The flyer was also sent through email addresses to select Washoe County School District (WCSD) employees. Neither email addresses, nor any identifying information were collected. If participants clicked the link on the flyer, or scanned the Quick Response (QR) code, he/she was directed to a Google form (see Appendix B).

Results of the usage of noise-cancelling headphones were collected by Google forms and are described below.

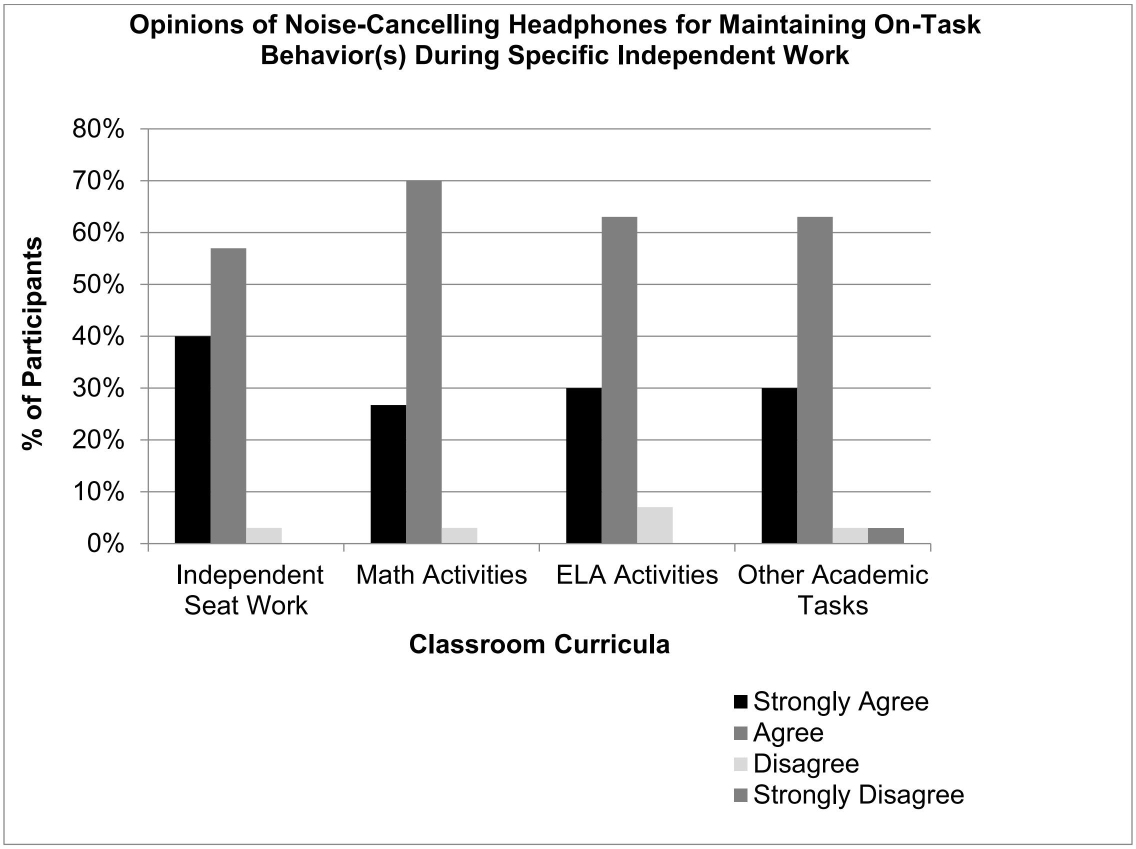
Results

A total of 47 anonymous participants completed the survey (see Figures 5-7). Results show 87.2% (N = 47) of participants have taught at least one student with ASD within five years; 12.8% have not taught a student with ASD within the past five years. The data show 70.2% of participants have utilized noise-cancelling headphones, in his/her classroom or have seen noise-cancelling headphones utilized within his/her school; however, 29.8% have not utilized or seen noise-cancelling headphones utilized in his/her classroom/school. A total of 63.8% of participants have utilized, in his/her classroom, or have seen noise-cancelling headphones utilized for students with ASD within his/her school, within the past five years, 36.2% have not seen the intervention utilized. Participants that responded "no" to the aforementioned question were taken, by Skip Logic, to the end of the survey and thanked for his/her time; 30 participants responded with "yes" to the aforementioned question and were permitted to continue to the next question regarding his/her opinion(s) on noise-cancelling headphone use in the classroom. The data are described below.

Figure 5 shows data collected on participants' opinion(s) regarding the use of noise-cancelling headphones, for students with ASD, in the classroom/school (n = 30). This shows 40% of educators strongly agreed that noise-cancelling headphones improved independent seatwork time spent on-task, in the classroom, 56.7% agreed; 3.3% disagreed. 26.7% of educators strongly agreed that noise-cancelling headphones improved time spent on-task during math activities, 70% agreed; 3.3% disagreed. 30% of educators strongly agreed that noise-cancelling headphones improved time spent on-task during ELA tasks, in the classroom, 63.3% agreed; 3.3% disagreed. 30% of educators strongly agreed that noise-cancelling headphones improved time spent on-task during other academic activities, 63.3% agreed; 3.3% disagreed and 3.3% strongly disagreed.

Figure 5

Opinion(s) on Noise-Cancelling Headphone efficacy, for Maintaining Time spent On-Task

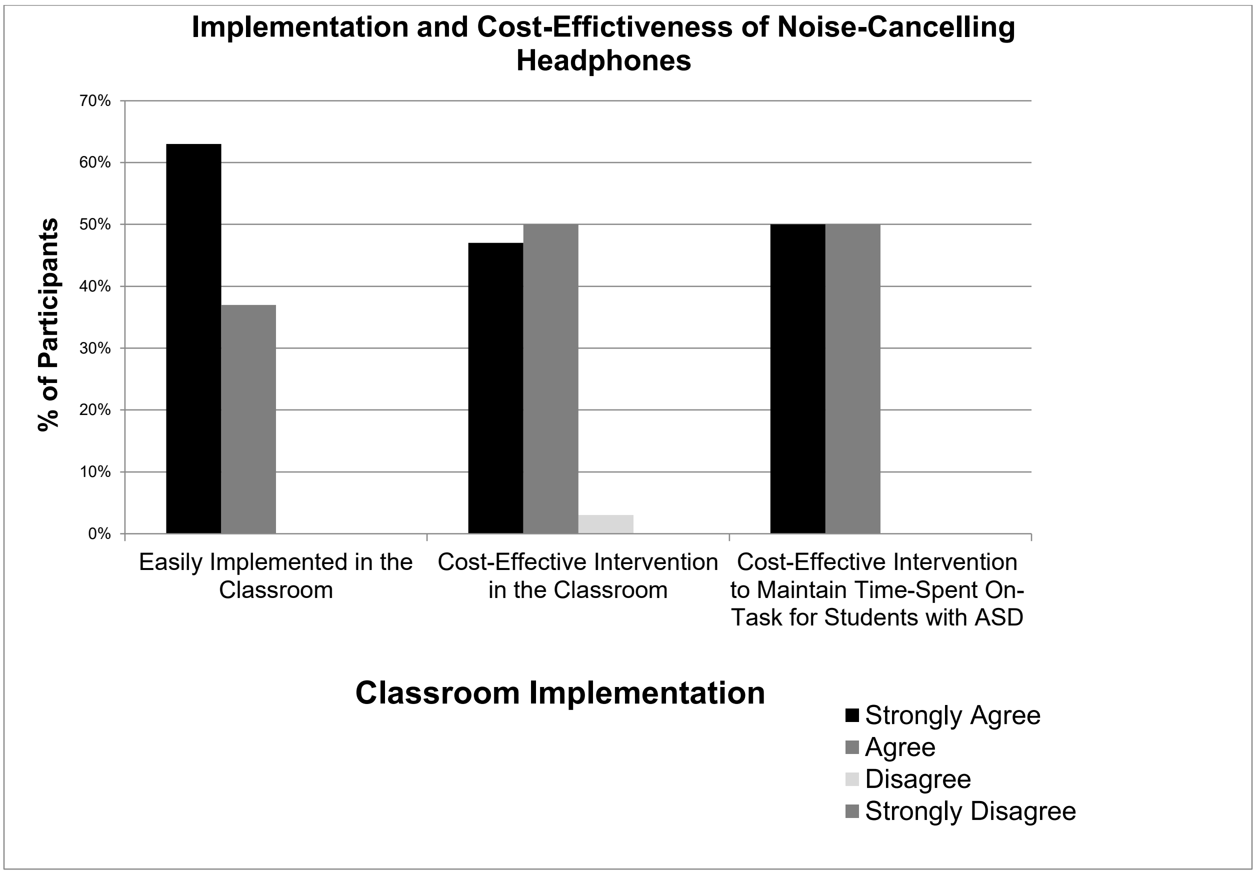


Note. The x-axis represents participants' opinions, on the effectiveness, of noise-cancelling headphone on classroom curricula. The y-axis represents the percentage of participants.

Figure 6 shows the data collected on educators' opinion(s) on implementation and cost-efficiency of noise-cancelling headphones in the participants' classroom/school. Majority of educators strongly agreed (63.3%), that noise-cancelling headphones are easily implemented for students with ASD in the classroom/school; 36.7% agreed that noise-cancelling headphones are easily implemented for students with ASD in the classroom/school. Additionally, 46.7% of educators strongly agreed that noise-cancelling headphones are a cost-efficient intervention for students with ASD, in the classroom/school (50% agreed, 3% disagreed).

Figure 6

Opinion(s) on Implementation Ease/Cost Efficiency of Noise-Cancelling Headphones



Note. The x-axis represents the educators' opinion(s) of implementation and cost-efficiency of noise-cancelling headphone in the classroom/school. The y-axis represents the percentage of participants.

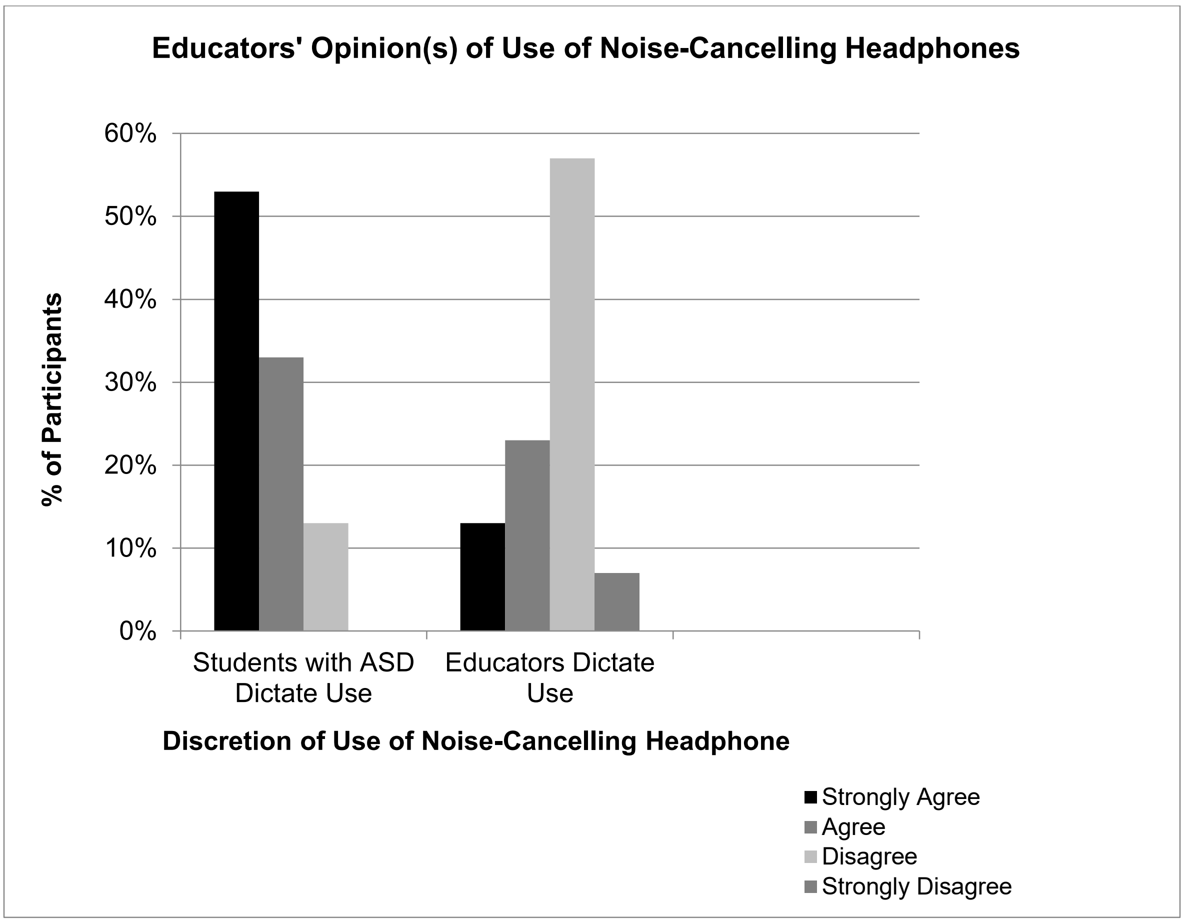
Figure 7 shows data collected on educators'/administrators' opinion(s) of whether students with ASD should have discretion in utilization of noise-cancelling headphones, or if noise-cancelling headphone use should be at the discretion of the educator. Figure 7 shows 53% of participants strongly agreed the students with ASD should use the noise-cancelling headphones at his/her discretion, 33% agreed, and 13% disagreed; no participant strongly disagreed. Additionally, the survey showed 13% of participants strongly agreed usage of noise-cancelling headphones, for students with ASD, should be at the educators' discretion, 23% agreed, 57% disagreed, and 7% strongly disagreed.

The data show majority of educators/administrators believe the student with ASD should have discretionary use of the intervention. Auditory overload is subjective; therefore, it would be difficult for an educator to determine when the intervention is needed for the individual student in order to maintain time spent on-task. As stated in UDL Checkpoint 4.2, it is critical that classroom instructional technologies (e.g., SmartBoard) and academic curricula do not create obstacles to the use of the assistive technologies (Universal Design for Learning Guidelines version 2.2, 2018). This can be interpreted to allow students discretionary noise-cancelling headphone use.

The open dialogue forum at the end of the survey, allowed participants to comment on intervention use. This open dialogue was only available to the 30 participants who have utilized noise-cancelling headphones in his/her classroom/school. Participants who have not utilized noise-cancelling headphones for students with ASD were not privy to the open forum. The forum comments show individual educators/administrators believe: (1) noise-cancelling headphones are only effective when the student is able to make the choice to utilize; (2) guidelines are necessary for implementation; (3) many individual factors may affect noise-cancelling headphone usage; (4) importance of making the intervention student-centered; (5) collaboration with students' parents is crucial for efficacy. Additionally, educators/administrators believe noise-cancelling headphones (6) to be helpful in a self-contained setting; (7) intervention use is effective when students will tolerate them; (8) noise-cancelling headphones may limit social interactions; (9) implementation at the teacher's discretion is best so the students are aware of appropriate time/usage.

Figure 7

Educators'/Administrators' Opinion(s) of Use of Noise-Cancelling Headphone



Note. The x-axis represents participants' opinions on the discretionary use of noise-cancelling headphone during classroom curricula. The y-axis represents the percentage of participants.

Discussion and Future Directions

This survey did not collect any identifying information about survey participants and/or information regarding his/her use of and/or implementation of noise-cancelling headphones; data were anonymously collected. This creates participant ambiguity. It is unknown if the survey participants were educators or administrators and/or if he/she has, in fact, implemented the intervention. Identifying information and credentials would present a different picture of data collection. The study also lacked participants from 40 states. The data collected were highly state disproportionate, as many were located in the researcher's university's school district. Proportionate state representation would show where the intervention is being implemented, providing insight into resources available, in those areas, to students with ASD. More research needs to be conducted on nationwide implementation.

This study does show majority of survey participants view the intervention as an effective, cost-efficient, easily implemented tool, for students with ASD, in his/her classroom/school. The data show majority of participants have seen and/or used the intervention in his/her classroom/school; which shows intervention efficacy. Additionally, educators and administrators are currently utilizing this intervention, as an accommodation, in schools/classrooms despite the lack of research. Therefore, research on the actual intervention, efficacy for multiple populations, cost-efficiency, implementation of fading procedures, social validity, etc., needs to be conducted. This can be done through future experimental classroom research.

The results regarding discretionary use of the intervention are of interest. Majority of participants strongly agreed or agreed the student should decide when to use the intervention. Auditory overload is a common symptom of ASD (Bijou & Ghezzi, 1999), and this survey data show educators/administrators strongly agreed/agreed the student, with ASD, should dictate when environmental noise is overwhelming, and utilize the noise-cancelling headphones, accordingly (see Figure 7). For example, an educator may not be aware of the student's immediate sensory input, so delegating intervention discretion may be beneficial to all parties. As Pfeiffer et al. (2019) discussed, the participants in the study began to foresee needing headphone use. One issue presented, by survey participants, was with the student's discretionary use of the intervention as "he/she may choose to utilize at inappropriate times;" however, "inappropriate time" is subjective. This means that the educator may deem immediate intervention use as inappropriate, but the student may deem immediate intervention use as appropriate and necessary to remain on-task (and vice versa). The survey open forum revealed one educator/administrator participant stated he/she had a bin with the students' noise-cancelling headphones and when use was permitted, he/she would flip an indication card. He/she stated this was effective, but the efficacy for whom needs to be discussed. Should the educator implement the intervention when appropriate, or should the student with ASD dictate appropriate use? More research needs to be conducted on discretionary use of noise-cancelling headphones.

Future research should also include an intervention fading procedure. Pierce and Cheney (2013) define fading procedures as a transfer of stimulus control to another stimulus thereby limiting the rate of response, or attention to, the initial stimulus. This is accomplished by introducing a new contingency with a designated goal (Pierce & Cheney, 2013). Fading classroom noise-cancelling headphone use may increase habituation. Kenzer et al. (2013) describe habituation as attending to a stimulus at occurrence, but through repeated stimulus presentation, less attending occurs. For example, a student may attend to an initial auditory stimulus (e.g., the air conditioner starting), but after repeated stimuli presentation, the student may habituate and not attend to the stimuli. Eventual habituation to classroom stimuli, may limit intervention usage at what is considered inappropriate times, and lead to more time spent on-task. Habituation may also eventually assist in development of appropriate, or socially acceptable, responses to environmental auditory stimuli. Further research needs to be conducted on fading procedures leading to habituation.

The survey also revealed the participants believe use of noise-cancelling headphone requires clear classroom delineations, appropriate usage times, etc. It must be noted, however, that intervention usage should be in the best interest of the student, of which, may not always align with the educators' curricular plan. All these factors must be addressed.

Conclusions

In conclusion, creating a successful, individualized classroom environment for a student with ASD is challenging, yet necessary; there are many factors contributing to the students'/educators' successes. These factors include, but are not limited to, maintaining time spent on-task. As discussed above, maintaining time spent on-task is critical to academic success (see Fisher, 2009; Odell, 1923), demonstrating a need for more research on classroom intervention use, for the general educator, for his/her students with ASD. Academic success, for a student with ASD, is critical to the students' futures and requires attention from both educators and administrators.

Furthermore, additional research must be conducted on all benefits of noise-cancelling headphones, with the intention of making the intervention implementation to maintain time spent on-task for students with ASD, an EBP. Social validity studies will be critical in future research. This study shows the current use and implementation of noise-cancelling headphones in the classroom/school across the US, but more states need representation. This study further requires intervention implementation proportionality across the US; yet, majority of participants viewed noise-cancelling headphones as effective and easily implemented.

It is important to note that despite lack of research on this assistive tool, educators and/or administrators are, in fact, implementing the headphones in classrooms/schools. In a Columbus, Ohio school district, noise-cancelling headphones are allocated to all students for classroom use (S. Peterson, personal communication, October 10, 2018). Additionally, the research on noise-cancelling headphones for students with ASD has dramatically increased (see Fodstad et al., 2020; Neave-DiToro et al., 2021; Pfeiffer et al., 2019; Rowe et al., 2011). This demonstrates a degree of efficacy, which requires further exploration. When the practitioner becomes the researcher, magic happens and effective interventions can be implemented immediately. Easy intervention implementation, cost-effectiveness, and efficacy allow the practitioner to assume the role of researcher, leading to potential academic success for our educators and our students with ASD.

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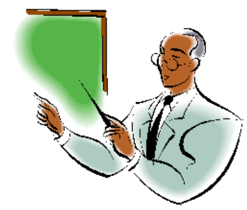
Appendices

Appendix A: Recruitment Flyer/Survey Link

University of Nevada, Reno

Request for Participants: Teacher Survey (3-5 mins)



Teacher and educator participants needed for a survey collecting data on non- invasive classroom Intervention. Will you help support this important research aimed at the needs of our students?!

The survey is pre-approved by the University of Nevada, Reno, completely anonymous and requires only 3-5 minutes to complete.

Please click here to connect to the survey or use your phone to scan the QR code to the Right:

SCAN ME

THANK YOU !!

Partial requirement fulfillment for Completion of a Ph.D. in Special Education at the University of Nevada, Reno

For additional information, please contact:
Alicia Nehrkorn at anehrkorn@nevada.unr.edu or (307) 757-6159

Appendix B: Teacher Survey

The Google Forms survey can be seen through the following hyperlink:

https://docs.google.com/forms/d/1TQQ1717_VLn61J9VEq3bBXLre2HOQoyDVWRDm0ha_T8/edit

Appendix M: iPads as Tools for Students with Autism: A Systematic Review of the Research

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Abstract

Anecdotal evidence often supports the iPad as the perfect tool for working with students with autism, to address everything from communication deficits, content area instruction, and behavior. However, implementation and usage outpaced research on the effectiveness of the iPad. Tincani and Boutot (2005) cautioned about quick embrace of technology for children with autism without research into efficacy of practice and was echoed by Knight et al. (2013) in a review review of technology-based interventions to teach academics to students with autism. This current study replicates Knight et al. (2013); however, we have identified only those studies in which iPads were used as the primary tool to deliver interventions (from 2011-2017) and we did not limit the interventions to academics.

Keywords: students with autism, iPads, evidence-based practices, systematic review

Introduction

Teachers and parents anecdotally report the iPad as the perfect tool for working with students with autism, to address everything from language and communication deficits, content area instruction, and behavioral supports (author, 2018; Yee, 2012). While the iPad was not specifically designed for individuals with autism, these anecdotal reports indicate impressive results that quickly gained momentum within the home and school environments (Yee, 2012; Zelma, 2012). However, educational implementation and usage of the iPad among students with autism has outpaced research on the effectiveness of the iPad as an intervention tool. Thus, educators and parents should not rely on anecdotal evidence alone.

Prior to the release of the iPad, Tincani and Boutot (2005), cautioned about quick embrace of technology for children with autism without research into practice efficacy. Further, Knight et al. (2013) echoed this call for caution in a review of technology-based interventions to teach academic skills to students with autism. The authors stated, "At best, these claims support the need for repeated empirical study of technological interventions to determine if the data support the proclamations of 'miraculous interventions'" (p. 2629).

Reviews Using Quality Indicators

Within the field of special education, it is not uncommon to conduct reviews of existing research on a specific area of study or intervention using quality indicator standards (Haas et al., 2020; Morin et al., 2018; Sweigart et al., 2016; Weston et al., 2018). Most sets of quality indicator standards in special education have been derived from the special issue of *Exceptional Children* on research in which the Horner et al.

(2005) article on single-subject design appeared. Quality indicator reviews provide a checklist of required components that should be included to meet quality criteria.

Since 2005, there have been a variety of organizations that have developed and published quality indicator checklists, based on the 2005 guidelines. The What Works Clearinghouse (WWC; 2017) does not use a checklist, but a flowchart for reviewing research studies, and the process for reviewing single-subject studies was still being piloted in 2017. There are three possible outcomes for reviews using WWC quality indicators: meets standards without reservation, meets standards with reservations, and does not meet standards.

The Council for Exceptional Children also took the work from 2005 and used a working group to take the ongoing work of the WWC to create a more operationalized set of quality indicators that could be used in a dichotomous fashion: do studies meet each standard or do they not meet the standard? Cook et al. (2014) described the development of these standard and presented them for usage; they pointed out that in developing the standards, they eliminated social validity as a separate category of quality indicators but included "aspects" (p. 4) of social validity in outcome measures.

Reviews of Technology for Students with Autism

Previous iPad (or other touchscreen devices) studies, for students with autism, and other developmental disabilities, have revealed beneficial results (Kagohara et al., 2013). Kagohara et al. (2013) categorize usage of the devices over five domains: (a) academic, (b) communication, (c) employment, (d) leisure, and finally, (e) transition across school settings. Kagohara et al. (2013) additionally reviewed study contents but did not examine the research through quality research indicators.

Knight et al. (2013) examined currently available technology-based interventions, which have been employed for teaching academic skills to students with ASD. This included, but was not limited to, iPads. The study reviewed the literature, identified appropriate literature, and then coded appropriate studies using rigorous criteria for SSD and group research, as established by Gersten et al. (2005) and Horner et al. (2005). The studies were evaluated through implementation of quality indicators developed by the National Secondary Transition Technical Assistance Center (NSTTAC, 2010; Test et al., 2009). The NSTTAC checklist, for evaluating quality of SSD research, was based on the criteria set by Horner et al. (2005).

In addition to the NSTTAC, The National Professional Development Center on Autism Spectrum Disorder (NPDC) has conducted reviews, of published studies, on interventions for students with autism over the last decade; this was implemented to identify evidence-based practices (EBPs). For example, the NPDC work, conducted by Wong et al. (2015), iPad intervention research was included in the “technology-aided instruction and intervention” (TAII) category; and previous reviews of iPad use were included in the “computer aided instruction and speech generating devices” category. Wong et al. (2015), defines TAII as “instruction or intervention in which technology is the central feature supporting the acquisition of a learner’s goal” (p. 1960). Additionally, Knight et al. (2013), state that all studies on technology, utilized for students with autism, are included as one category. Because schools and school districts often invest hundreds of thousands of dollars in iPad technology (Price, 2014), a current review of the literature is necessary to determine the quality of research. The review may reveal the iPad as an EBP in academics, communications, behaviors, etc.

The NPDC protocols (see Wong et al., 2014), for evaluating quality research, were extracted from Gersten et al. (2005) and Horner et al (2005); However, the NPDC protocols lacked a social validity component requirement in the study, as Horner et al. (2005) identifies as a key component. This study includes the same methodology employed by Knight et al. (2013); but only considers studies in which iPads were used as an intervention. No studies were excluded for iPad use solely for academic skills.

This study is a systematic review, defined by Harden and Thomas (2010), as "research that uses rigorous and explicit methods to identify and integrate findings from multiple studies," (p. 750). The checklist is revised to maintain the inclusion/exclusion criteria; which limits participants to a diagnosis of autism. Inclusion requirements were implemented in order to review if iPad use, for students with autism, could be considered an EBP.

Methods

Harden and Thomas (2010), state systematic reviews are a method of reviewing studies, intended to encourage the shift towards evidence-informed policy and practice. Synthesizing a large body of literature into a scientific entity enables researchers to determine if a practice or intervention is useful. Harden and Thomas (2010), further describe a systematic review as a research method wherein the literature serves as the participant.

The study begins with a research question, followed by a sampling stage (where literature is reviewed for inclusionary criteria), the data collection stage (where literature is reviewed and data is coded), and finally, a data analysis stage (where results are synthesized). This research review shows that literature, on iPads for students with ASD, may strengthen future studies; adding to the field of evidence-based practices.

Literature Search Procedures

An initial database search was conducted using specific search criteria. Certain terms were utilized in the search to reveal scholarly, recently published, single-subject and group design studies, inclusive of iPad use for children with autism spectrum disorder (ASD). The iPad use could also have been implemented for intervention in behavior or communication, or to teach basic skills, or academic skills across English Language Arts (ELA), mathematics, social studies, and/or science. The terms “autism” and “iPad” were searched using multiple databases.

The iPad was first introduced in 2010, thereby limiting the article search from 2010 to 2018. In order to exhaust the list, these terms were wholly used, truncated, and also put into quotations. The terms were expanded into the title of the article(s), or within the subject terms. The terms were searched within ERIC, Academic Search Premiere, PsychINFO, and Education Full Text, GoogleScholar, and Education Research Premiere databases. Only published articles in peer-reviewed journals were selected; dissertations and theses were not included. This search yielded 64 articles. A visual inspection of the articles revealed relevance and scholarliness; essentially, 59 articles were retained, and four were eliminated from sources of questionable origin (Beall’s, 2016). These were divided into different categories, dependent study type: quantitative, qualitative, or group experimental. Once organized into a spreadsheet, the studies were scored utilizing a revised version of the Quality Indicator Checklist (see Appendix A).

Inclusion/Exclusion Criteria

For articles to remain in the review to be scored, they had to utilize some version of an iPad as an intervention with students with autism. Any version of iPad was acceptable (original iPad, iPad2, and iPad mini were types specified; a version was not always specified, specifically earlier articles). Two articles were excluded because there was not an intervention for children with autism; one examined how families were using iPads at home with their children with autism (Dixon et al., 2015) and the other was examining interactions between sibling pairs (a sibling with autism and a sibling without autism), the iPad was utilized for play (Ozen, 2015). A second inclusion criterion was all participants in the study have some diagnosis of autism. This review focused on determining if iPad use can be categorized as an evidence-based practice for students with autism; studies lacking a diagnosis of autism were excluded. This exclusion resulted in elimination of nine studies. The exclusionary criteria included studies with participants with comorbidity conditions, unrelated to autism. Participant inclusion criteria, following Wong et al. (2015), including all autism spectrum disorders (autism, Asperger's Syndrome, pervasive developmental disorder, etc.) as well as participants with a concurrent intellectual disability. Other co-morbidity conditions (i.e., "Psychotic Disorder" or OCD) were excluded from the study; this eliminated five additional studies. An excluded study included participants with comorbid conditions and included participants with a diagnosis of a disability other than autism. The inclusion criteria left 39 studies to be scored for quality review.

Application of the Quality Indicator Checklist

For this study, the researchers used established quality indicators developed by the National Secondary Transitional Technical Assistance Center (NSTTAC, 2010) and created a checklist with the inclusion/exclusion criteria, discussed above. The quality indicators were employed for studies with a single subject design; this study also includes one randomized control study. The quality indicators on the checklist were adapted from the Horner et al. (2005); components include, but are not limited to, (a) participants, (b) setting, (c) dependent variable and measures, (d) independent variable/intervention, (e) baseline procedures, (f) display of results, and (g) social validity.

Decision-making rules, developed by NSTTAC (2010), for determining overall quality level of research were utilized; therefore, a study must meet all 20 of the quality indicators to be considered of "high quality." If the study met all quality indicators 1-16 and included one of the social validity measures in items 17-20, it was deemed "acceptable quality research." If the study failed to meet any of the indicators, 1-16, it was deemed "not of quality research."

The measure, utilized by Wong et al. (2015), to determine if implementation of iPads for students with autism is an EBP, includes, but is not limited to, (1) two high-quality experimental or quasi-experimental studies conducted by more than one researcher or a research group; (2) at minimum, five high-quality single subject design studies conducted by at least three different researchers or a research group; the studies must include at least 20 participants; and/or (3) a combination of research designs, including at least one high-quality experimental or quasi-experimental design, three high-quality single subject designs, conducted by more than one researcher or a research group.

Inter-rater Reliability and Fidelity Measures

Two researchers scored 18% of the included studies in order to establish fidelity and ensure proper coding of quality indicators; this occurred prior to independent article coding. Inter-rater reliability was established for 36% of the studies. Inter-rater reliability was also completed through an item-by-item methodology; this was calculated by dividing the number of agreements by the total number of agreements plus disagreements, and then divided by 100, as established by Cooper et al. (2007). Using this methodology, inter-rater reliability scored at 95.9%. The coding system included primary coding by the first researcher; the second researcher independently coded 33% of the articles for additional inter-rater reliability. Total reliability came in at 96.6%.

Results

Thirty-nine studies ultimately met the inclusion criteria and were retained for this systematic review. Once the review started, an additional study was excluded, because, while it stated methodology as single subject design, all data reported were qualitative; however, it did not follow an established qualitative design (see Boyd et al., 2015). It could not be reviewed as either a single subject design or a qualitative design; therefore it had to be excluded. This left 38 reviewed and scored studies.

Participants

The included studies have a total of 185 participants. Of these, 82 participated in one randomized control trial (RCT) (see Whitehouse et al., 2017), leaving 103 participants in the remaining reviewed studies. All participants had a diagnosis of ASD;

and a mean age of 7.53 years (ranging from 2-22). Gender identification was included in the participant information for the reviewed studies. 38 participants identified as female (17 females within the RCT). Participants included: M (age) = 7.46 years, (2.3-18), 139 participants identified as male, (63 males within the RCT), M (age) = 8.14 years, range 2 – 22 years. The mean age for both the males and females, in the RCT, was 3.3. Overall, 21% of the participants were female. Race/ethnicity was only identified in only nine of the thirty-eight studies.

Research Design

All studies retained for review, with the exception of one a randomized control study (RCT), utilized single-subject design (SSD). A researcher reviewed the remaining 38 studies to determine the specific type of SSD. The most common design employed was a multiple baseline across participants (n =10), followed by multiple probe across participants (n = 6), and additional multiple baseline designs (e.g., across settings) (n = 6). ABAB reversal design was employed in four of the studies; multiple baseline across behaviors (n = 3), and alternating treatments design (n = 2) was also utilized. The remaining seven SSD studies utilized a variation on SSD, thereby, demonstrating the variability in the descriptions.

Intervention Type

Each study included, implemented a specific iPad intervention for communication, social behavior, and/or academic skills (ELA, math, science, etc.). The interventions were delivered using apps and tools available on any version of an iPad. Intervention details can be seen in Table 3. The most frequent iPad intervention was for verbal behavior and communication (n = 11). The remaining studies focused on social behavioral skills (n = 8), video modeling (n = 7), and academic instruction (n = 4).

Quality of Studies

Of the 38 studies reviewed, three met the quality indicator criteria in order to be considered “high quality research” (see Burckley et al., 2014; Jeffries et al., 2016; Spooner et al., 2014). Nine studies met the criteria for consideration of “acceptable quality research;” categorizing these studies as meeting the first 16 items on the checklist, and at least one of social validity measures; however, not all four of the social validity measures were met (see Table 1). Finally, 18 of the studies did not meet the quality research specifications, as measured by the indicator checklist, discussed above (see Table 2). Of the 18, 10 did not fulfill the quality indicator checklist, as none of the social validity measures were met. The indicators for social validity measures (1) dependent variable is socially important; (2) magnitude of change results from the intervention; (3) implementation of the intervention is described as practical and cost effective; and finally (4) social validity of the intervention is maintained over extended periods of time, by participants, in typical settings, and within typical social contexts. Horner et al. (2005) delineated these social validity measures and is often cited to support single-subject research in special education.

Only three studies met the criteria for “high quality research,” therefore, the use of iPads as an intervention for students with autism could not be declared an evidence-based practice (EBP), as delineated by Wong et al. (2015). Additionally, according to Wong et al. (2015), an EBP requires five high-quality single-subject studies, from at least three different researchers or research groups, including a minimum of 20 participants each.

If the 10 other studies had included social validity measures, or if the nine studies included a social validity measure, the 19 studies would have met the criteria for high quality research consideration; and iPad use, as an intervention for students with autism, would have met the criteria in Wong et al. (2015), as an EBP.

Table 1

Quality Indicators identified in single subject studies in studies that were acceptable or of high quality

	Brodhead et al. (2018)	Burckley et al. (2014)	Cardon (2012)	Dundon et al. (2013)	Genc-Tosun and Kurt (2017)	Jeffries et al. (2016)	Jowett et al. (2012)	King et al. (2014)
Items 1-16 met.	Y	Y	Y	Y	Y	Y	Y	Y
17. The DV is socially important.	Y	Y	N	N	Y	Y	Y	N
18. The magnitude of change in the DV resulting from the intervention is measured as socially important.	N	Y	N	N	Y	Y	Y	N
19. IV Implementation was described as practical and cost effective, by the author.	N	Y	Y	Y	N	Y	N	Y
20. Social validity is enhanced by implementation of the IV over extended time periods, by typical intervention agents, in typical physical and social contexts.	N	Y	Y	Y	Y	Y	Y	N
Total Indicators Met	17/20	20/20	18/20	18/20	19/20	20/20	19/20	17/20
High (H) or Acceptable (A) Quality	A	H	A	A	A	H	A	A

Table 1 continued

	Macpherson et al. (2014)	Murdock et al. (2013)	Spooner et al. (2014)	Vandermeer et al. (2015)	Weng and Bouck (2014)	Yakubova et al. (2017)	Yakubova and Zeleke (2016)
Items 1-16 met.	Y	Y	Y	Y	Y	Y	Y
21. The DV is socially important	Y	Y	Y	N	Y	Y	Y
22. The magnitude of change in the DV resulting from the intervention is measured as socially important	Y	N	Y	N	N	Y	N
23. IV Implementation was described as practical and cost effective, by author	N	Y	Y	Y	Y	N	Y
24. Social validity is enhanced by implementation of the IV over extended time periods, by typical intervention agents, in typical physical and social contexts	Y	N	Y	N	N	N	Y
Total Indicators Met	19/20	18/20	20/20	17/20	18/20	18/20	19/20
High (H) or Acceptable (A) Quality	A	A	H	A	A	A	A

Table 2

Indicators in Single Subject Design Studies as Not Meeting High Quality Research

	Alexander et al. (2013)	Barnett et al. (2014)	Browder et al. (2015)	Doenyas et al. (2014)	Gevarter et al. (2017)	Gevarter et al. (2014)	Kim and Clarke (2015)	Lee et al. (2015)	Lorah (2016)	Lorah et al. (2014)
1. Participant selection process described in detail	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Participant selection process described in detail	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Features of the physical setting are described in detail	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
4. Dependent variables described with optimal precision	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5. Each dependent variable measured by a quantifiable index procedure	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
6. Measurement process described in detail	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
7. Dependent variables measured repeatedly over time	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
8. Data collected on reliability or IOA and met with minimal standards	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
9. Independent variable described in detail	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

10. Independent variable systematically manipulated under experimental control	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
11. Overt measurement of fidelity of implementation for the independent variable	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
12. Baseline phase provided repeated measurement of a dependent variable and established a pattern	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
13. Baseline phase conditions described in detail	Y	Y	Y	Y	N	Y	Y	N	Y	Y
14. Three or more demonstrations of experimental effect at different points in time	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
15. The design controls for threats to internal validity	Y	Y	Y	N	N	Y	Y	Y	Y	Y
16. Experimental effects replicated across participants, settings, or materials	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Items 17–20 met (Y=Yes, N=No)	N	17-18	N	N	17	N	17, 19	N	N	N
Total indicators met	16	17	16	12	16	16	17	14	16	16

Table 2 continued

	Lorah et al. (2013)	Lorah and Parnell (2017)	Lorah et al. (2015)	Neely et al. (2013)	Sigafoos et al. (2013)	Waddington et al. (2014)	Xin and Leonard (2015)	Xin et al. (2017)	Ying Sng et al. (2016)	Zein et al. (2016)
1. Participants described in detail	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Participant selection process described in detail	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Features of the physical setting are described in detail	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
4. Dependent variables described with optimal precision	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5. Each dependent variable measured by a quantifiable index procedure	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
6. Measurement process described in detail	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
7. Dependent variables measured repeatedly over time	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
8. Data collected on reliability or IOA and met with minimal standards	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
9. Independent variable described in detail	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

10. Independent variable systematically manipulated under experimental control	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
11. Overt measurement of fidelity of implementation for the independent variable	Y	Y	Y	Y	Y	Y	N	N	Y	Y
12. Baseline phase provided repeated measurement of a dependent variable and established a pattern	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
13. Baseline phase conditions described in detail	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
14. Three or more demonstrations of experimental effect at different points in time	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
15. The design controls for threats to internal validity	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
16. Experimental effects replicated across participants, settings, or materials	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
Items 17–20 met	N	N	N	N	N	N	19	Y	N	N
Total indicators met	16	16	16	16	16	16	15	19	15	13

Discussion

The results of this systematic review indicate majority of the included studies met most quality indicators, but did not include social validity measures. Majority of the studies reviewed (see Appendix A for all reviewed studies) lacked reporting of: (a) use of a social validity interview/questionnaire to determine importance, (b) demonstration of a magnitude of change, deeming the intervention as socially important, (c) intervention practicality and cost effectiveness, or (d) implementation of the intervention, over time, in different settings. This reverberates results of the computer-aided instruction review conducted by Knight et al. (2013), noting lack of social validity measures in the SSD studies. The previous review results, and the current review, show the need to reiterate the importance of social validity as a key component of quality SSD research, as delineated by Horner et al. (2005). Further, Callahan et al. (2015) reviewed the existing identified EBPs in autism to determine which had evidence of social validity. Social validity was discussed as an expected component in behavioral change research based on the seminal work done by Kazdin (1977) and Wolf (1978).

Social validity, more often than not, has been overlooked. In the aforementioned studies, it was found that only 26% of studies on autism interventions included social validity measures; however, additionally discussed, was the importance to note that inclusion of a social validity measure is not a substitution for a complete and rigorous use of research design and methodology.

Barry et al. (2020) cited a lack of social validity measures in autism research, when examining identified barriers in implementing EBPs for autism, in the classroom;

they stated many effective interventions, under research conditions, do not transfer to classroom and teacher use.

Consideration of a social validity measure in the research design, allows researchers to clearly identify the effective interventions designed to support academic, communicative, and social behavioral interventions through iPad use. It is also important to note collected participant data. In the reviewed studies, participant age and gender is reported, however, race/ethnicity or primary familial language is not reported; ensuring interventions are applicable to and reliable for a diverse student population is critical. It would be beneficial to have all relevant participant data.

Cook and Cook (2011) discuss the importance of identifying EBPs, and why it is essential for special educators to understand EBP implementation. Increased use of iPads, as an intervention for students with autism, and the growth of research into these interventions, as EBPs, requires further research. Thoughtful implementation of social validity measures, when conducting iPad studies for individuals with autism, will assist in iPad use as a tool becoming an EBP.

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Appendices

Appendix A: Study Descriptors

Table 3

Reviewed Study Descriptors

Study	Description of Participants		Race/Ethnicity of Participants (NI if not identified)				Type of Design	iPad apps used and/or skills taught	Dependent Variables	Results
	Age/Gender									
	M	F	White	Black	Latinx	Other				
Alexander, Ayres, Shepley, & Mataras (2013)	18.7 17.6 15.1 17.8 17.1 17.6	17.2	NI	NI	NI	NI	Two multiple probes across 3 and 4 participants	Video modeling; sorting mail	Percentage or correctly matched mail to mailboxes	Three participants learned target sets & generalized to untrained sets, two required error correction procedures, two did not achieve mastery
Barnett, Colcord, & Zucker (2014)	9		NI	NI	NI	NI	ABAB reversal	Video self-modeling highlighting desired behaviors	Attending behaviors, such as looking at instructor, attending to content, transitioning	Positive treatment effects, increasing attending & on-task behavior during intervention & maintenance

Brodhead, Courtney, & Thaxton (2018)	4 9	6	NI	NI	NI	NI	Nonconcurrent multiple baseline	Keynote presentation software; activity schedules	Percentage of correct responses to the activity schedules	Percentage of correct & independent responses to the activity schedule improved to above 80% for all participants
Browder, Root, Wood, & Allison (2015)	8 9	10	2	0	1	0	Multiple probe across participants	Story map using SMART notebook application; comprehension skills related to story elements	1. Independent number of correct pairings of story element words to definitions 2. Labeling of the electronic touch-based story map 3. Number of comprehension questions answered independently and correctly	Each of the participants showed increase in level after instruction on the definition of story elements began using constant time delay. Students also maintained skills.
Burckley, Tincani, & Guld Fisher (2014)		18	1	0	0	0	Multiple probe across settings	Book Creator; shopping skills	Percentage of steps in the shopping task analysis completed independently without prompting	The participant independently executed 88% of steps in second location, 88% of steps in the third location.
Cardon (2012)	4.2 2	3.8 2.3	NI	NI	NI	NI	Multiple baseline across participants	Video Modeling Imitation Training; imitation skills	Correctly copying the target action within 10 seconds with an action that looks	All four caregivers were able to successfully create videos on the iPad

							through video modeling	distinctly like the action being modeled. The imitation must occur before any other action occurs.	with minimal training and implement the VMIT with fidelity; all four children made substantial gains in imitation skills; expressive language skills increased to varying degrees
Doenyas, Simdi, Ozcan, Cataltepe, & Birkin (2014)	4 11 15	0	0	0	3	ABA across participants	Turkish app; sequencing skills	Ability to place cards in the correct sequence; used a points system to track	One participant's sequencing skills increased; one participant made slight gains; one participant scored highly on the baseline and therefore did not make any increases in skills
Dundon, McLaughlin, Neyman, & Clark (2013)	5	NI	NI	NI	NI	Multiple baseline	My Choice Board and Go Talk Now; communication skills	Correct requests with each iPad application	Increased correct requesting when model, lead, and test were employed; after model, lead, and test error correction was no longer in effect, participant continued to accurately use both applications on his iPad touch

Genc-Tosun & Kurt (2017)	4.11 4.8 4.1		NI	NI	NI	NI	Multiple probe across participants	Turkish app called Dokun Konus ("touch and speak"); speech skills	Percentage of correct multistep requests	All showed improvement; Tau-U effect sizes of 1.00, 1.00, and .9 (high improvement)
Gevarter, O'Reilly, Kuhn, Watkins, Ferguson, Sammarco …Sigafoos (2017)	4.6 8.8 6.3	3.1 4.4	NI	NI	NI	NI	Multielement design	AutisMate; speech skills	Correct responses; percentage of correct trials per session	Three participants mastered requesting preferred items in a field of four; 1 mastered requesting in a field of two; 5th participant did not master
Gevarter, O'Reilly, Rojeski, Sammarco, Sigafoos, Lancioni, & Lang (2014)	3.1 3.11 3.6	2	1	0	0	0	Multielement design	Go Talk, Scene and Heard; communication skills	Percentage of correct responses: independently pressing the correct location on the screen to produce the speech output within 6 s of the iPad placed in front of him	AAC display and design elements may influence mand acquisition: 2 showed more rapid acquisition with Scene and Heard than Go Talk, one reached mastery criterion in all three conditions
Jeffries, Crosland, & Miltenberger (2016)	3.8 3.7 5.11		NI	NI	NI	NI	Nonconcurrent multiple baseline	Look In My Eyes Steam Train; eye contact skills	Percentage correct of matching numbers to those in the eyes on the person on the application, differential reinforcement:	The tablet app did not increase eye contact for any of the participants; differential reinforcement increased eye contact

								looking in the eyes of the therapist while manding	for all participants across all assessment conditions
Jowett, Moore, & Anderson (2012)	5.6	NI	NI	NI	NI	Multiple baseline across target behaviors	Video modeling with Angry Birds; math skills	Indicators of participant's ability to identify, write and comprehend the quantity of number 1-7	Clear gains were evident in the participant’s ability to identify and write the Arabic numerals 1–7 and comprehend the quantity each numeral represents in association with the lagged intervention. Generalization and maintenance data demonstrated the robustness of the treatment effects
Kim & Clarke (2015)	4.6 4.6	NI	NI	NI	NI	Multiple baseline across participants	PowerPoint slides; turn-taking skills	Frequency of appropriate turn taking behaviors during play activities	The percentage of nonoverlapping data indicated that the intervention was fairly effective for 1 child but not reliable for the other child. It is suggested that iPads or tablet devices can be effective tools to support socialization, more particularly, turn-taking behaviors

										in children with autism
King, Takeguchi, Barry, Rehfeldt, Boyer, & Mathews (2014)	3	4 5	NI	NI	NI	NI	Multiple probe across participants	Proloquo2go; requesting skills	Percent of independent requesting, frequency of vocal requests: any instance of vocal requesting	Results support that a child diagnosed with ASD can acquire skills needed to request preferred items using the iPad and Proloquo2go app with training on a picture-based communication system
Lee, Lang, Davenport, Moore, Rispoli, van der Meer… Chung (2015)	4 2		NI	NI	NI	NI	ABAB reversal	Photos, See.Touch. Learn; behavior skills	Percentage of 10s whole intervals with on-task behavior, percentage of 10 s partial intervals with challenging behavior, percentage of independent correct responses out of total number of responses, duration of intervention sessions in minutes and seconds	The iPad was associated with shorter intervention sessions, more time on-task and less challenging behavior for one participant. There was no difference between conditions for the second participant. Both participants selected the iPad when given the choice and, although the effect of choice was modest, choosing was associated with more time on-task

										and less challenging behavior
Lorah (2016)	4	3.2 3.8	NI	NI	NI	NI	Multiple baseline across participants	Proloquo2go; communication skills	Percent of independent (manding within 5s) and accurate (the picture-symbol selected on the screen of the device matched the item used for the training trial) manding	For all three participants the acquired repertoires maintained following the discontinuation of training, provides continued support for the use of handheld computing devises as SGD for children with autism
Lorah, Crouser, Gilroy, Tincani, & Hantula (2014)	5.5 4.3 5.0 6.2		3	1	0	0	Multiple probe with changing criteria	Proloquo2go; picture symbol discrimination skills	Rate of independent (manding within 5s) and accurate (the picture-symbol selected on the screen of the device matched the item used for the training trial) manding	Results provide tentative support for a procedure to teach children with autism to discriminate between picture symbols while manding using a handheld SGD
Lorah, Tincani, Dodge, Gilroy, Hickey, & Hantula (2013)	5.5 4.3 4.1 3.10 5.11		NI	NI	NI	NI	Alternating treatment	Proloquo2go; manding skills	Frequency of independent and prompted mands converted to percentage of independent mands	Four participants demonstrated a clear preference for the SGD device and one for PE.
Lorah &	3.6	4.2	NI	NI	NI	NI	Multiple	Proloquo2go;	Probe data: Yes/no	Two participants

Parnell (2017)		4.2					baseline across participants	speech skills	responses if participant selected the correct icon that corresponded with the book	were able to tact both icons relatively quickly and maintained the skill; one participant was only able to tact one icon but never learned the other and no maintenance data was collected due to preschool year ending
Lorah, Karnes, & Speight (2015)	8.7	12.2	NI	NI	NI	NI	Multiple baseline across target behaviors	Proloquo2go; intraverbal responding	Probe data over three trials, per target, per response- correct response correct if participant selected and pressed the accurate picture symbol corresponding to the intraverbal statement	Both children acquired the ability to respond to three different intraverbal statements, additional support to the use of the iPad as an SGD for individuals with autism
Macpherson, Charlop, & Miltenberger (2014)	11.2 9.5 11.11 10.3	10.1	NI	NI	NI	NI	Multiple baseline across participants	Video modeling; social skills	Verbal compliment and compliment gestures	Viewing the video rapidly increased the verbal compliments participants gave to peers. Participants also demonstrated more response variation after watching the videos.
Meeks (2017)	4		2	0	0	0	Multiple	Go Talk Now;	Frequency of	Increased responding

	5					baseline across settings	requesting skills	independent responses, incorrect responses.	across settings for both participants
Murdock, Ganz, & Crittendon (2013)	4.1 4.10 4.6 4.4	NI	NI	NI	NI	Multiple baseline across participants			
Neely, Rispoli, Camargo, Davis, & Boles (2013)	7 3	NI	NI	NI	NI	ABAB reversal	WritePad and Little Matchups; challenging behavior and academic engagement	Percentage of intervals with challenging behavior using 10 s partial interval recording; academic engagement was recoded using 10 s whole interval recording	Both participants demonstrated lower levels of challenging behavior with higher levels of academic in the iPad condition and higher levels of challenging behavior with lower levels of academic engagements in the traditional materials condition
Sigafoos, Lancioni, O'Reilly, Achmadi, Stevens, Roche… Green (2013)	5 4	NI	NI	NI	NI	Multiple baseline across participants	Proloquo2go with a Toy Play symbol; requesting skills	Requesting opportunities - a request was considered a correct if it occurred with no physical guidance and within 10 s of interruption, reaching - child moving one or both hands toward the toy being held by	Both boys learned to use the SGD to request and also maintained the skill void of prompting and acquisition of the SGD based requesting was associated with decreases in reaching and aggressive

									the trainer within 10 s, hitting - the child hit the trainer within 10 s from the start of interruption	behavior
Spooner, Ahlgrim-Delzell, Kemp-Inman, & Wood (2014)	12 8 11 8		2	1	1	0	Multiple probe across participants	AAC program, GoTalk Now, and embedded text-to-speech; literacy skills	Each student's independent correct responses for items on task analysis, number of correct unprompted responses to listening comprehension questions	The participants were able to increase the number of independent correct responses on the task analysis from baseline to intervention
Vandermeer, Beamish, Milford, & Lang (2015)	4.11 4.3	4.1	NI	NI	NI	NI	Multiple baseline across participants	Stories2Learn (21); on-task behavior skills	Appropriate and typical on-task behavior exhibited by the child while seated in the classroom	The combination of the social story and the iPad proved to be an effective intervention for one of the three participants
Waddington, Sigafoos, Lancioni, O'Reilly, van der Meer, Carnett… Marschik (2014)	7 8 10		NI	NI	NI	NI	Multiple baseline across participants	Proloquo2go; communication skills	Independently activating the correct icon on the iPad screen at each of the three steps in the communication sequence	All three participants showed improvement in performing the communication sequence
Weng &	17		2	0	1	0	Multi-probe	Video clips,	Mean percent of the	Two of the

Bouck (2014)	15 15						multiple baseline across participants	iMovie; math and basic skills	lowest-priced grocery item independently selected per session	participants benefited from video prompting presented on iPad to complete the price comparison tasks during in class simulation and grocery store settings
Whitehouse, Granich, Alvares, Busacca, Cooper, Dass …Anderson (2017)	n=63 (Total data M=3.3, SD =8.41)	n=17 (Total data M=3.3, SD =8.41)	NI	NI	NI	NI	Randomized controlled trial	Therapy Outcomes By You (TOBY); speech and social skills	Autism Treatment Evaluation Checklist; Mullen Scales of Early Learning; Vineland Adaptive Behavior Scales-2nd Edition; Words and Gestures form from MacCarthur-Bates Communication Development Inventory; Communication and Symbolic Behavior Scales Developmental Profile Caregiver Questionnaire	No difference between groups on ATEC, but TOBY group had greater improvement than control group on MCDI, MSEL, and VABS
Xin & Leonard (2015)	10 10	10	NI	NI	NI	NI	Multiple baseline with AB phases	SonoFlex; communication skills	Total number, mean scores and standard deviations of requests, responses, and social comments	With least-to-most prompting hierarchy, all students increased initiating requests, responding to questions and making

										social comment in both class and recess settings
Xin, Sheppard, & Brown (2017)	12	11 10 10	NI	NI	NI	NI	ABAB reversal	Choiceworks; self-monitoring skills	On-task behavior, academic achievement and student satisfaction	The participating students' on-task behaviors were increased when an iPad was used for self-monitoring
Yakubova, Zehner, & Aladsani (2017)	22		1	0	0	0	Multiple probe across goals	Voice Thread; career development skills	Rate of initiating a conversation in a 10 minute period, rate of initiating a verbal greeting in a 10 minute period, number of questions answered correctly about job exploration	Improved in each area; strong effect size
Yakubova & Zeleke (2016)	18 18 17		3	0	0	0	Multiple probe across participants	Video modeling; problem solving skills	Each student’s ability to complete a series of steps for solving problems during transition-related tasks and measured as percentage of problem solving steps completed accurately	Following a multicomponent intervention utilizing point-of-view video modeling paired with practice sessions and a self-operated cue sheet, all students were able to improve their problem-solving performance. Additionally, students generalized the skills

									to a second untrained setting.
Ying Sng, Carter, & Stephenson (2016)	7.11	NI	NI	NI	NI	Multiple baseline with probe	Conversation Coach; social skills	Correct responses during intervention probes and generalization probes to paraphrased scripts using the iPad	Cannot solely attribute results it the iPad, efficacy of delivery by the teacher is unknown, generalization
Zein, Gevarter, Bryant, Son, Bryant, Kim, & Solis (2016)	9.5 9.11 10.11	1	0	2	0	Alternating treatment	Space voyage; reading skills	Probes for reading comprehension, frequency counts of vocal protest, physical task refusal or task refusal without either	The multicomponent intervention implemented during both conditions was associated with improved performance on curriculum-based measure probes during Tdi and IAI with indication that Tdi was more effective in increasing accuracy of responding on CBM probes