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Impact of Noise-Attenuating Headphones on Participation in the Home, Community, and School for Children with Autism Spectrum Disorder

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ABSTRACT

Aim: The purpose of this study was to conceptualize the benefits and limitations of using noise-attenuating headphones for children with autism spectrum disorder (ASD) on participation in home, community, and school environments from the perspective of parents and teachers. *Methods*: Grounded theory methodology was used to guide data collection and analysis. Ten parents and five teachers of children with ASD and auditory hypersensitivity aged 6–12 completed recorded interviews. Interviews were transcribed and crosschecked prior to analysis by two or more researchers. Constant comparison was used during open and axial coding followed by theoretical integration. *Results*: Participants identified that the use of noise-attenuating headphones increased participation in home, community, and school settings. Barriers and benefits were identified for both around-ear and in-ear headphones. Preparation for use was an identified strategy that reduced the barriers and increased use of the headphones. Additionally, many of the children learned to predict when they needed the headphones and requested their use. *Conclusion*: Results of the study identified parental and teacher support for the use of noise-attenuating headphones to increase participation in natural environments for children with ASD, as well as suggestions to facilitate use for practicing physical and occupational therapists.

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Autism spectrum disorders; barriers; benefits; headphones; noise-attenuation; participation

Introduction

Many children with autism spectrum disorders (ASDs) demonstrate atypical responses to auditory stimuli in the environment (Baranek, 2002; Stiegler & Davis, 2010). Research has demonstrated significantly more self-reported auditory-related behaviors (Jones et al., 2009; Stiegler & Davis, 2010) including fearful and anxious reactions to noise in children with ASD. A few studies identified that there was a difference in auditory discrimination in a subset of children with ASD, although in other studies no actual physiological differences were found in response to noise thresholds when children with and without ASD were compared (Gravel et al., 2006). There are consistent differences in parental and self-reports (Gravel et al., 2006) identifying that individuals

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with ASD have significantly higher rates of noise hyperacusis than those without ASD. The term hyperacusis is used to describe an unusual intolerance of ordinary environmental stimuli (American Speech-Language-Hearing Association, 2016). Some research has suggested that certain individuals with ASD may have a psychological bias rather than an abnormality in their actual auditory system. Whether there is a physiological or psychological basis, the behavioral responses can impact school performance, social interactions, and overall quality of life for children with ASD and their families (Grinker, 2007; Rowe et al., 2011; Smith & Riccomini, 2013).

There are a number of methods to create more optimal auditory environments including reducing noise emission, blocking sound transmission from the source, and blocking sound transmission to the ears (Rowe et al., 2011). Reducing and blocking sound transmission from the source often involves environment adaptations such as noise absorbing walls, adding carpets, or designating "quiet" areas. It is often impossible to implement these types of accommodations in all the environments in which children and their families commonly engage in daily routines due to the community nature of some environments (i.e., sporting event, shopping in a store) or due to the nature of the activity (i.e., attending a family party, the general classroom). Families of children with ASD have reported that they avoid common activities that are not considered essential (i.e., child party, vacations) and therefore experience a reduced quality of life (Pfeiffer et al., in press). It is important to determine the impact of interventions whose implementation is feasible in all environments. One such option is noise-attenuating headphones. Although this is a low-cost and easily implemented intervention, there is minimal research documenting its impact on important outcomes such as physiological responses, attention, and most importantly participation. One prior study used a single case design with a child with ASD. Results showed that use of noise-attenuating headphones increased this child's ability to attend to task while wearing the headphones (Rowe et al., 2011). A second study showed that students with a wide range of learning disabilities benefitted from use of noise-attenuating headphones as evidenced by an increase in test scores (Smith & Riccomini, 2013). The current study expands prior work to a wider range of children on the autism spectrum to explore participation in home, community, and school environments.

Due to the scarcity of extant research, it is important to first understand the perceived benefits, feasibility, and limitations of using noise-attenuating headphones in natural environments from the perspective of key stakeholders such as the family/caregivers and teachers of children with ASD. This knowledge can provide the foundation to implement a well-designed study focused on the effectiveness of interventions using noise-attenuating headphones and help clearly define the targeted outcomes. Therefore, the purpose of this research was to implement a grounded theory study with data collected from families and teachers of children with ASD, all of whom have auditory hypersensitivity and have piloted the use of noise-attenuating headphones. We hypothesized that noise sensitivity in children with ASDs impacts participation in the natural environments of children with ASD. Related to this, we intended to answer the question, "What are the perceived benefits and limitations of using noise-attenuating headphones for a child with ASD on participation in home, community, and school environments from the perspective of parents/caregivers and teachers?"

Methodology

Participants

We interviewed 10 parents and 5 teachers of children between the ages of 6 and 12 (mean =8.3, $SD = 3.1$) diagnosed with ASD based on the DSM-IV or DSM-V guidelines. There were 13 male children/students and 2 females representing a range of diagnoses on the spectrum of autism. Since data collection occurred shortly after the change from the DSM-IV to DSM-V diagnostic criteria, diagnoses ranged from the DSM-IV (American Psychiatric Association, 2000) diagnoses of Autism ($n = 11$) and Pervasive Developmental Disorder Not Otherwise Specified ($n = 1$) to the DSM-V (American Psychiatric Association, 2013) diagnoses of Levels 1 ($n = 1$), Level 2 ($n = 1$), and Level 3 ($n = 1$) ASD. All of the children scored in the range of "Very Likely" on the Gilliam Autism Rating Scale (Gilliam, 2014), which indicates that the child demonstrates behaviors consistent with a diagnosis of ASD. For inclusion, the children had to have an identified auditory hypersensitivity determined by a score in the range of probable or definite difference on the Sensory Profile (Dunn, 2014) or Adolescent Sensory Profile (Brown & Dunn, 2002). Five of the children were in regular education classrooms, 6 in special education classrooms, and 4 in a mix of special and regular education classrooms. Thirteen of the children and students were Caucasian and 2 were African American. Demographics for the parents and teachers are provided in Table 1.

Recruitment occurred through social media, school programs for children with ASD, private therapy practices, and organizations supporting individuals with ASD. Information about the study was posted on social media sites (e.g., Facebook) and fliers were provided to administrators at schools, private therapy practices, and ASD organizations. If participants were interested, they contacted the research coordinator directly. Two of the teachers learned about the study through school administrators who received the study information from the researchers and three of the teachers learned of the study through a parent participant. Recruitment continued until there were enough interviews to saturate the data.

Design

A grounded theory approach was used to develop a conceptual theory through the analysis of interviews with parents and teachers. This approach allowed the researchers to collect data from a group of participants with diverse experiences and use a systematic method of analysis to identify related concepts and categories providing a theoretical explanation (Corbin & Strauss, 2008) of the benefits and limitations of noise-attenuating headphones on participation in natural environments for children with ASD.

Procedures

IRB approval was obtained prior to the start of the study. Prior to determining inclusion and conducting the interviews, researchers obtained informed consent and consent to audiotape from each parent and teacher participant. Parents provided consent for their child to trial the headphones for all 15 children. Assent was obtained from all

Table 1. Parent ($n = 10$) and teacher demographics ($n = 5$).

Demographics of parents ($n = 10$)	*n* (%)
Gender and relationship	
Mother	(80)
Father	2 (20)
Age	
30–39 years	5 (50)
40–49 years	4 (40)
50–59 years	1 (10)
Ethnicity	
African-American	1 (10)
Caucasian	9 (90)
Living environment	
Rural/small town	3 (30)
Suburban	6 (60)
Urban	1 (10)
Country of residence	
United States	10 (100)
State of residence	
Pennsylvania	9 (90)
New Jersey	1 (10)
Education	
Some college or technical school	2 (20)
College graduate	7 (70)
Graduate school	1 (10)
Demographics of parents ($n = 5$)	*n* (%)
Age	
20–29 years	3 (60)
30–39 years	1 (20)
40–49 years	1 (20)
Ethnicity	
Caucasian	5 (100)
Living environment	
Rural/small town	0 (0)
Suburban	5 (100)
Urban	0 (0)
Country of residence	
United States	5 (100)
State of residence	
Arizona	1 (20)
Pennsylvania	4 (80)
Education	
College graduate	4 (80)
Graduate School	1 (20)

children/students to trial the headphone through verbal (i.e., "yes," "OK") or nonverbal communication methods (i.e., nodding of head). Parent participants completed the Sensory Profile and teacher participants the Sensory Profile School Companion to assess the sensory processing patterns of the child or student. Both of these tools are report measures that assess "children's behavior in relationship to sensory processing" (Dunn, 2006a, p. 7) in the natural environment (i.e., home or school), and include subscales specific to the processing of auditory stimuli in the environment (Dunn, 2006b). Participants also completed the Gilliam Autism Rating Scale—3rd edition (GARS) for their child to ensure behaviors consistent with an ASD diagnosis.

All participants completed a demographic form through Qualtrics survey software providing information on age, gender, employment status, education, income, ethnicity, country/state of residence, and relationship to the child. Demographic information for

Table 2. Guiding questions.

(1) Can you describe how your child/student reacts to noise in the environment?
(2) Can you describe the (environment) setting(s) that your child/student wears headphones to block out noise?
(3) What are the activities that your child/student participates in when wearing the headphones? How does the use of the headphones impact participation in those activities?
(4) What do you percive as the benefits to your child/student wearing the headphones to block out noise?
(5) What do you perceive as the limitations to your child/student wearing the headphones to block out noise?
(6) Are there any things/barriers that impact the ability of your child/student to wear the headphones?
(7) Can you describe a few examples of when and where your child/student wears the headphones and how the use of the headphones impacts the child?

children or students of the participants was also collected including age, gender, ethnicity, diagnosis, and classroom placement.

The children were provided and trialed two different types of noise-attenuating headphones, around-ear or in-ear. The around-ear headphones were Bose QuietComfort 15 Acoustic Noise Canceling Headphones and the in-ear were Bose QuietComfort 20i Acoustic Noise Canceling Headphones. The in-ear headphones had "aware mode" technology that allowed the child to switch the processing applied to microphones on the outside of each earbud to create an auditory approximation to removing the headphones. The around-ear device did not have this mode and continually blocked out noise in the environment. During the trial, the children/students wore the headphones during activities that had either large amounts of auditory stimuli or those that had auditory stimuli perceived as aversive by the child.

The number of weeks the headphones were trialed for each participant was tracked by researchers. The trials ranged from 2 to 4 weeks in length with a mean trial time of 3.6 weeks. There was no identifiable literature that provided recommended wearing times for trialing the headphones. Therefore, 2–4 weeks was deemed an adequate amount of time for children to trial both of the headphones at multiple times across targeted environments per parent report. Although the total trial time varied between children/students from 2 to 4 weeks, each child/student trialed the two different headphones for equal amounts of time. For example, when the total time was a period of 2 weeks, the child trialed each type of headphone for 1 week. Although the amount of time the child actually wore each headphone type within each week was not controlled in the study, parents and teachers were instructed to have the child wear both types of headphones in the same environment. The children of parents ($n = 10$) interviewed trialed both headphones in the home setting and students of the teachers interviewed trialed both headphones in the school setting ($n = 5$). The parents or teachers determined the order of the headphones trialed based on child preferences. The headphone type that was perceived as more acceptable or familiar to the child was trialed first with the other headphone type trialed second. This was recommended by research staff to reduce the potential negative responses during initial exposure to a new interventional device. Of the 15 children who participated in the study, 11 children trialed the over ear headphones first and the in-ear headphones second.

Following the trials with both types of headphones, recorded interviews were completed with parents and teachers of children with ASD over a 1–2 hour period of time in a convenient location for participants. One researcher trained in qualitative interview methods completed all of the interviews. Guiding questions were developed prior to data collection and used during the interview process (see Table 2). As data analysis was on-going and conducted as each interview was completed, the guiding questions

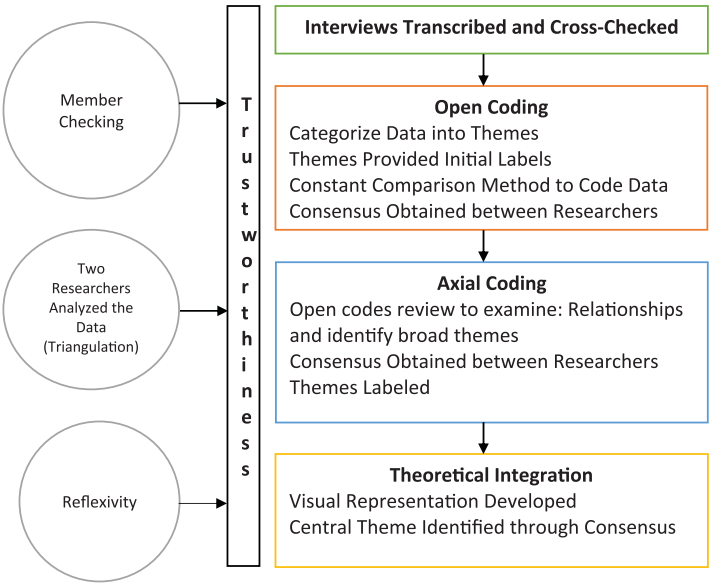

Figure 1. Data analysis process.

were expanded based on concepts and themes discovered during data collection. For example, additional questions were asked about the child' behaviors observed when there was noise in the environment and behaviors observed when wearing the headphones when there was noise in the environment. Additionally, the interviewer asked probing follow-up questions during the interview (e.g., "what do you mean by …?" or "Can you provide an example?") to obtain more in-depth and specific information.

Data analysis

Each interview was transcribed and then cross checked by a researcher separate from the transcription process (see Figure 1). Two researchers independent of the interview process analyzed interviews throughout all stages of data analysis. In the first open coding stage of analysis, researchers completed an indexing of text of each separate interview. Data were divided into segments of information that appeared related and then analyzed for commonalities that were categorized into themes. These themes were provided with initial labels to reflect the content. The technique of constant comparisons was used to code data that seemed similar and also to code data more accurately in multiple themes versus just within its initial label. At this point, the two researchers met to discuss open coding results and established agreement in coding through consensus. Data was analyzed for each interview as it became available and interviews were completed until there was data saturation in the open coding process. Following the completion of open coding, axial coding was completed by the two researchers during numerous meetings. During axial coding, the open codes initially were reviewed independently by the two researchers to examine the relationship between themes and identify broader themes. Each researcher analyzed the open codes and identified primary

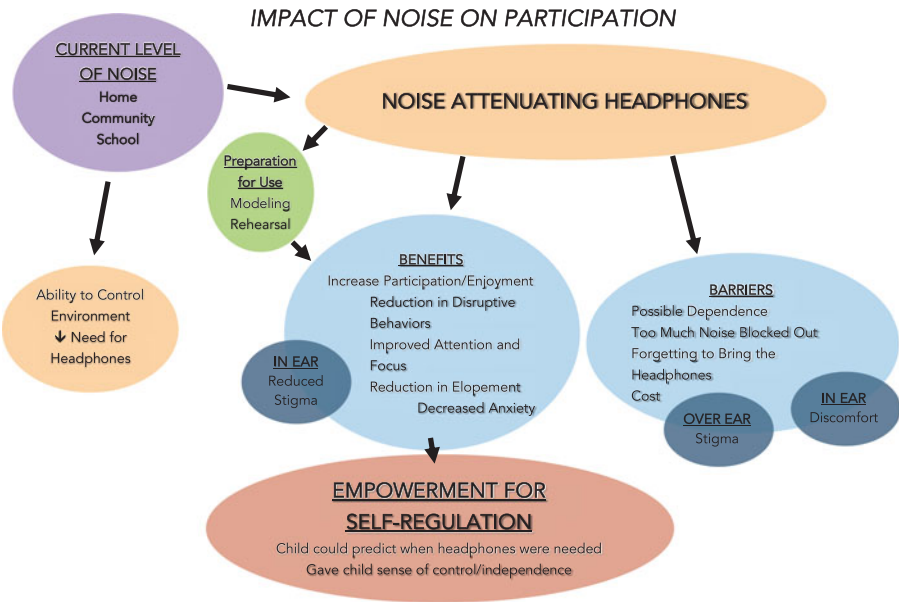

Figure 2. Impact of noise on participation.

themes and subthemes. Researchers met to discuss and obtain consensus on the primary themes, their subthemes, and the relationships between themes. Themes were provided with identifying labels. Once all themes were identified, a visual representation of the themes and their relationships to each other was refined over the course of two 3-hour meetings with both researchers present. These visual results were used by researchers to complete the process of "theoretical integration" where a main theme representing all of the themes was identified and then systematically linked to these themes. This resulted in the central theme of *Impact of Noise on Participation*. An integrative diagram was used throughout data analysis to aid in the process, which provided a final visual theoretical representation (Corbin & Strauss, 2008) (see Figure 2).

Researchers instituted methodological processes including member checking, triangulation, and reflexivity (Lysack et al., 2006) to strengthen trustworthiness and rigor of the data analysis process. There were informal member checks completed during the data collection and analyses process with three parents and two teachers who were not participants in the study, but who met inclusion criteria (i.e., parent or teacher of a child with ASD who have used noise-attenuating headphones to block out noise perceived as loud or aversive). These were completed in person and over the phone based on the preference of the participant. Any additional data collected during this time was documented in notes and integrated in the data analysis process. This primarily occurred during the open and axial coding process to check themes identified in the data. Multiple researchers analyzed the data for investigator triangulation in order to ensure validity of the results. Researchers then completed a validation process in which they compared their analyses and obtained consensus.

Researchers also used reflexivity, a critical and honest reflection on the research process (Lysack et al., 2006), during data analysis through bracketing. Although the

definition of bracketing is inconsistent within the literature (Tufford & Newman, 2010), for the purpose of this study, bracketing refers to the researcher acknowledging prior beliefs about content related to the research and temporarily setting aside those beliefs during the data analysis process (Creswell & Miller, 2000). This was done to reduce bias that can occur due to a specific set of prior assumptions or beliefs when analyzing new information. For example, specific beliefs and biases identified for bracketing included the past training of the researchers in sensory integration principles, previous research findings of the team from other studies, and specific experiences in clinical practice and research related to auditory hypersensitivity in children with ASD. It is important to note that the primary researcher is an occupational therapist who engages in clinical research and practice using principles of sensory integration. The primary researcher did not complete the initial interviews, but did analyze the data. Additionally, multiple members of the research team have years of experience working with children with ASD and reported assumptions that auditory hypersensitivities impact participation. This was identified specifically in past studies completed by the research team. These assumptions and related experiences were bracketed for the data analysis process. In addition to the methodological actions to ensure trustworthiness, we attempted to ensure credibility and quality of this research through data saturation.

Results

Impact of noise on participation

A central theme of *Impact of Noise on Participation* emerged from the data. Figure 2 identifies the central theme, related sub-themes, and the relationship among themes. Parents and caregivers reported both (1) specific activities that noise sensitivity negatively impacted and (2) how the use of noise-attenuating headphones supported participation in these same activities. Parents and teachers described three main environments in which noise impacted on participation including the home, community, and school.

In the home environment, examples of specific activities included engaging in occupations with parents, quiet time, and social activities in the home. Participant 5 reported, "For as much as he likes to [make] smoothies and help in the kitchen, without the headphones, he would choose not to. And he would lose all of the skills that he and I are working on as we're doing that. Some of the reading, some of the sequencing, and some of the processing things." Participant 9 reported that her son would not be able to participate in his preferred quiet time activities without the help of headphones. She stated, "my purpose of wanting to, introducing the headphones is just so that he can focus just on the game and not have to like be so concerned with other conversations going on."

In the community, examples of specific activities included appointments, eating at a restaurant, celebrating family events, traveling, and going shopping. Several participants discussed their experiences eating out at restaurants. Participant 3 talked about needing to keep both of her kids at the table for a few more minutes so others could finish their meal. "I actually managed to get him and [his brother] to have a good little banter back and forth … while the rest of us were eating, while [the child] wore the headphones." Participant 13 described an experience at a restaurant in which the noise made the child

so uncomfortable that the father had to take him out of the environment. They retrieved a pair of headphones from their car and the family was able to proceed with their meal reporting, "It blocked out enough that he could sit down … and focus, he was able to eat."

Participants provided examples of using the headphones in a variety of different activities and community settings. Participant 14 shared specific examples of how headphones had helped her child attend and enjoy a family wedding stating, "He wore his headphones the whole service because he just wasn't sure that there might be some loud music." The use of headphones allowed Participant 4 to participate in a family vacation that required travel by train. The father reported, "The trains were pretty loud and she was having issues with them coming and going, the brakes and everything and we put them on and they worked fine. Before we put the headphones on, she started tensing up and she said 'loud, loud, too loud, too loud, too loud'." Participant 6 identified that her son has trouble when in a store, as the cash registers are loud. During these times, he would ordinarily use his hands to cover his ears the entire time, but with the "headphones he didn't have his hands up, and there was just no problem with him walking through the store with the earplugs in." She reported similar results in the grocery store and at the mall.

Examples of specific activities in the school environment include attending assemblies, participating in fire drills, eating lunch in the cafeteria, and participating in the general education classroom. Many of the teachers identified assemblies as a school environment where the headphones helped the children participate. Participant 15 noted that headphones not only helped the student to remain calm and quiet during an assembly, they allowed him to engage and participate in the learning experience saying, "He can definitely pay attention."

A number of teachers commented on the effects on participation during fire drills. For instance, Participant 8 spoke of one student whom he had never observed during a fire drill without headphones, but suspects that "if he didn't have the headphones on, I think they would be much more upsetting to him." With them, "he walks calmly with our group to go out." For another student, it was enough to have the headphones just in case he needed them. Participant 11 noted "A lot of times he'll wear them, and then kind of take off one ear and see if it's ok and if it's too loud he'll put it back on."

Teachers mentioned students being able to participate more fully at lunch, during recess and in other specials as well. At lunch, Participant 15 commented that "it helps him [her student] sit there quietly rather than having any behaviors," when he might otherwise speak rudely and swat at those around him. At recess, Participant 11 shared that her student was terribly afraid of the noise of motorcycles. She encouraged him to use the headphones until he acclimated to the outside noises and then "he was playing just like all the other children." This teacher also mentioned that this child has had several times where he just needs the headphones to get started on something and then "once he realizes that it is ok and he feels comfortable, he'll take them off and hand them to us."

Teachers noticed that headphones supported participation in the classroom. Participant 7 used headphones to help her preschool student participate in circle time. She shared that she "would even give him a warning ahead of time saying, 'this song

might be a little loud, you might want to put your phones on,' and he would put them on and … make it through the song without any kind of discomfort." This teacher went on to say the headphones allowed this child to "stay in the classroom and participate in all the activities … in a general education classroom, if he was having a meltdown, he would need to be removed." Participant 8 remarked that one of his students is able "stay in the general education room with that support in place," for his science class.

Noise control

A common theme among participants was that there was a greater ability to control the noise in the home environment resulting in a reduced need for using noise-attenuating headphones. Both parents and teachers reported that the child did not need the headphones if he or she had control of the noise in the environment. Parents noted that they were able to control and reduce noise for their children more easily in their home environment. Participant 1 shared that "at home it's kind of controlled. There's not much that really bothers her here." Participant 10 shared something similar, saying "and at home the noise is not overwhelming for him, and he's comfortable there so I don't ever see a problem with noise at our house." In contrast, noise in the community and school environments was often unpredictable or uncontrollable resulting in an increased use of noise-attenuating headphones.

In the school environment, there were teachers who reported that use of routines helped to control noise levels and that the noise-attenuating devices were relied on more heavily during activities that were out of routine. Participant 7 had a student that liked to take his headphones to music with him because "if the routine was going the way that he liked it, then he was good with the sound and he wasn't bothered by it. But if the routine was out of what he was expecting, then the sound would start bothering him."

In general, both parents and teachers reported that there were many school-related activities and internal school environments for which it was hard to reduce noise levels due to the large number of students, type of activity (i.e., assembly, gym class), and unique needs of other children in the classroom (e.g., child making noises as a self-soothing or stimulatory behavior). Participant 2 noted, "We have other students in the classroom who scream, or have other behaviors and those loud noises can affect this specific child."

Barriers and benefits of noise-attenuating headphones

Barriers to use

Parents and teachers identified specific barriers of using the noise-attenuating headphones which included: (1) concern for dependence on the headphones; (2) discomfort of the headphones (in-ear); (3) stigma attached with using the headphones (around-ear); (4) remembering to bring the headphones into community settings; (5) amount of noise blocked out by the headphones (around-ear); and (6) costs of the headphones (see Table 3). A number of participants were concerned that the child would become dependent on using headphones, and would not desensitize to noise or learn

Table 3. Perceived barriers and benefits of noise-attenuating headphones.

Barriers to use	Benefits of use
Concern for dependence on the headphone	Increased participation
Discomfort of the headphonesb	Enjoyment in the task
Stigma attached to the wearing of the headphones[a]	Reduction in behavioral responses
Remembering to bring the headphones into Community settings	Decreased observed anxiety
	Improved attention and focus
Amount of noise blocked out by the headphones[a]	Increased ability to stay calm
Costs to obtain the headphones	Reduced elopement
	Normalization of childb

[a]Around-ear headphones only.
[b]In-ear headphones only.

how to engage in certain activities or situations without using the headphones. Participant 4 stated "We've used [the headphones] very rarely … we don't want her to have to rely on headphones because she's got a number of other things she's got to overcome to fit in."

Barriers specific to the use of the in-ear headphones among some users included discomfort or not liking the feel in one's ear. A few children reportedly refused to wear the headphones as they associated it with other past experiences that were perceived as uncomfortable and resulted in anxious responses. For example, participants 5 and 12 mentioned they believed their child associated the headphones with swimming earplugs.

A number of participants reported that the headphones made the child "look different" and made it known that the child has a disability. This was a specific concern reported for the around-ear headphones. Participants identified that the headphones would make the child "stick out" due to the size and the "overall look." Participant 5 stated, when referring to her child, that "He doesn't want to use [the headphones] because there's a growing awareness that to him, 'my friend isn't using [them] and I don't want to be different', so at school, he's refused [them]."

Parents and teachers reported that at times it was difficult to remember to bring the headphones with them into noisy environments. Participant 14 stated that "… if I would forget [the headphones], his anxiety would go up high if he knew that he didn't have them or if he couldn't use them."

Additionally, a few of the parents and teachers reported that the amount of noise that was blocked out by the around-ear headphones caused the child to lose attention to the task at hand, or prevented them from being able to hear and engage in conversations and activities. This was not reported as a concern with the in-ear headphones, as the noise attenuation of the in-ear type of headphone provided could be disabled by activating "aware mode." Some school personnel expressed concerns that the child would not learn how to self-regulate and that the student was not able to hear the teacher when wearing the headphones. For example, participant 15 stated "I think it's harder for him to completely listen to the teacher and learn what we're trying to teach because he doesn't have the full ability to hear."

Finally, participants 7 and 8 reported that the school districts would not always provide financial support to obtain the headphones and that either the parent or the teacher would need to purchase them. Participant 7 stated that "… the district was not willing to provide [headphones] because they didn't have any funds to get them, so I had to go out and purchase my own."

Benefits of noise-attenuating headphones

There were a number of benefits reported for using the noise-attenuating headphones in the home, community, and school environments. These included: (1) increased participation and enjoyment in the task; (2) reduction in disruptive behavioral responses; (3) decreased observed anxiety; (4) improved attention and focus; and (5) reduction in elopement. Participants reported overall benefits for use of both types of headphones including an increase in participation and a reduction in the behavioral responses to noise when wearing headphones. Participation included initiating the task, participating for longer periods of time, and completing the task. Participant 13 reported that "[The headphones] allow him to participate in certain activities that he couldn't participate in because they are too overwhelming for him." Participants reported that they also enabled the child to enjoy the task in which they were participating. Other overall benefits included a decrease in observed anxiety and an increase in calming behaviors. Participant 15 mentioned that, " … for Autism, [the headphones have] been very beneficial because they have so many other things that bother them and so many anxiety issues, and [the headphones] help relieve their anxiety." All participants identified that the headphones helped the children improve attention and focus and helped them remain calm in stimulating environments. Participant 9 noted that her child was "able to focus on the task at hand and was able to relax his brain and not be so hyperfocused on all the other environmental factors." Many participants reported that their children or students have an adverse reaction to unwanted noise in the environment resulting in elopement. Wearing the headphones decreased this elopement, which allowed the child to remain in the environment resulting in increased safety. Participant 15 shared that one student now requests headphones when his space get noisy instead of "screaming, swatting and trying to avoid environments." Before the school provided access to headphones for Participant 14's son, he would "elope, he would run out of the building," every time he was taken to the cafeteria. The same thing would happen at recess, "he would run off the playground to get away from the noise."

The benefits identified were consistent across both types of headphones, although there was one specific benefit identified for the in-ear headphones. Participants reported that they were not as noticeable and helped to "normalize" the child, especially when compared to the around-ear headphones. Participant 6 reported that the in-ear headphones are " … neat, they kind of blend in with everyone because everyone's wearing [them] … [so people] just see him as another kid … "

Preparation for use

A common theme related to both the barriers and benefits to use of noise-attenuating headphones was preparation. Participants described preparation as a variety of strategies and processes to prepare the child to wear and use the headphones in noisy environments. Preparation both increased the use of the headphones and reduced some of the barriers of use including: (1) the initial resistance to wearing the headphones and (2) a lack of understanding of the purpose of the headphones. Participants reported that the child was initially resistant, but when provided with time and opportunities to wear them, as well as additional strategies, resistance was eliminated and the child would use them consistently to support participation. Strategies implemented to support

preparation for use including modeling by the parents and explaining the purpose of the headphones. For example, participant 13 stated "… if dad was willing to wear [the headphones] or do the same thing, then he was comfortable because he wanted to be like dad". Participant 13 also reported that the child would wear the headphones when provided with an explanation of how they work and the possible benefits. Teachers identified preparatory strategies such as teaching about acceptance of differences in the classroom including using headphones, as well as having more than one set of headphones in the classroom for use by any of the children in order to decrease stigma associated with wearing the headphones. Participant 7 stated, "I had a few sets [of headphones] so that other friends, if they needed them, could use them."

Empowerment for self-regulation

A primary theme of using the headphones was empowerment for self-regulation. For some children, parents and teachers reported that the child learned to predict when he or she would need the headphones and initiate or request their use. They reported that the child had a sense of control and independence in self-managing the headphones, with participant 10 stating that "[My child] can independently manage [the headphones] without relying on somebody else or needing somebody else." Participant 13 reported that the child had a new "freedom." Children used various methods for requesting the headphones when they were not freely accessible to the child including verbally asking for the headphones when possible, using a communication device, or making a specific noise for those children who were nonverbal. When the child did not self-initiate use, some parents reported that their child would accept wearing the headphones when put on by the parents.

Discussion

Results of the study provided a conceptual model (see Figure 2) describing the impact of noise on participation for children with ASD in home, community, and school environments and the use of noise-attenuating devices to improve participation. Additionally, the perceived benefits and barriers of using noise-attenuating devices, as well as the feasibility of using the device from the perspective of the child's parent and teachers are core themes in the conceptual model.

Results are consistent with previous research identifying the impact of noise on participation for children with ASD. Parents and caregivers consistently report oversensitivity and unusual responses to auditory sensory stimuli in their children with ASD resulting in distress, difficulties processing the social environment, and an inability to adapt to the demands of the environment (Baranek et al., 2006; Kern et al., 2006; Kientz & Dunn, 1997; Tomchek & Dunn, 2007; Watling et al., 2001). Anecdotal descriptions have identified hypersensitive reactions to auditory stimuli of individuals with ASD not only impact the individual, but also limit family outings and impact classmates (Grinker, 2007). Additionally, previous research has identified a negative impact of auditory distractions on learning and school performance including reduced reading

comprehension, memory, task completion, attention, and test completion (Hughes et al., 2007; Shield & Dockerell, 2008).

Noise-attenuating headphones are one option to reduce the impact of hyperacusis and auditory hypersensitivity on performance and participation in home and community settings. Participants in the current study reported that attention to relevant tasks improved in all environments, but both parents and teachers emphasized this benefit most often on school related tasks. Similarly, Smith and Riccomini (2013) reported that students with learning disabilities performed better on comprehension tasks when wearing noise reduction headphones. In another study (Rowe et al., 2011) using a single case design, researchers identified improvements in attention to task in a child with ASD.

In contrast, one of the barriers identified with the use of the noise-attenuating headphones was about becoming dependent on their use. There is preliminary research using cognitive behavioral therapies to reduce negative behaviors associated with noise and increase participation (Koegel et al., 2004). Researchers conceptualized that pairing a positive experience with the negative exposure to noise deemed aversive in the specific environment reduced the negative response and increased participation in the activity for the individuals with ASD. Using this approach, noise-attenuating headphones may serve an important purpose of providing initial experiences to relearn that the noise associated with the activity does not warrant an anxious or distressed response subsequently leading to improved participation after multiple positive exposures. A gradual reduction of the use of the headphones would follow, as the individual demonstrates a decrease in behaviors associated with noise hypersensitivity when in the specific environment and activity. Although further research is necessary, the use of noise-attenuating headphones in combination with cognitive behavioral therapy with a fading approach may provide an important clinical option in reducing negative behaviors associated with noise hypersensitivity.

Stigma was identified as another barrier of wearing noise-attenuating headphones. There were concerns that the child was perceived as different or that the headphones accentuated that the child had a disability. In-ear headphones do not have the same visibility as around-ear headphones and are often worn in typical situations when listening to music and playing videogames, which has the potential of reducing the perceived stigma. This is important information to guide decision-making processes and recommendations for use (e.g., type of headphones; preparation) for therapists providing school-based services, as well as those working directly with families.

There were a number of strategies identified by both parents and teachers to prepare the child to use noise-attenuating headphones. Although there were many perceived benefits for the use of the headphones, children often needed preparation prior to using them to support participation and attention. Occupational and physical therapists have unique expertise to identify strategies and consult with teachers and families to support preparation and implementation of noise-attenuating headphones. Therapists have a responsibility of presenting families with the potential benefits and limitations of using noise-attenuating headphones and providing support to make informed decisions about if and how to use the headphones. Family-centered practice is central to this process, as decisions are based on the unique needs of each child and their family.

Limitations

There are a number of limitations to the current study. Grounded theory methodology was used to conceptualize the impact of noise-attenuating headphones on participation for children with ASD. Due to this, it is not intended to be generalized but only provides a limited conceptual model to suggest benefits, barriers, and potential outcomes in future research studies. Although data was collected to saturation, the study only represents parents and teachers of children with ASD between 6 and 12 years of age. Results may differ significantly if an older or younger population is considered. Additionally, qualitative questions from the research and a self-report measure completed by the parents or teachers were used to determine if the child demonstrated behaviors associated with auditory hypersensitivity. The child needed to score in the range of probable to definite difference. Although this is a well-used tool, it was based on proxy and could represent a variety of levels of auditory hypersensitivity.

Conclusion

Children with ASD used noise-attenuating headphones in the home, community, and school environments to reduce noise and increase participation. The headphones were most often used in community and school environments, although they were also used in home environments during out of routine or unusually noisy activities that were not in control by the child or the parent. Participants identified barriers and benefits for both around-ear and in-ear headphones, and overall headphone use. Preparation for use was an identified strategy that reduced the barriers and increased use of the headphones to increase participation. Additionally, many of the children using the noise-attenuating headphones learned to predict when they needed the headphones and requested their use resulting in an ability to better self-regulate. Occupational and physical therapists have a unique expertise to support decision-making processes (e.g., if and how to use noise-attenuating headphones) and guide implementation of use of noise-attenuating headphones when working with families and teachers of children with ASD who have auditory hypersensitivity.

Declaration of interest

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References

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Arlington, VA: Author.

American Psychiatric Association. (2013). *The diagnostic and statistical manual of mental disorders: DSM 5* (5th ed.). Arlington, VA: Author.

American Speech-Language-Hearing Association. (2016). *Hyperacusis*. Retrieved from http://www.asha.org/uploadedFiles/AIS-Hyperacusis.pdf#search=%22hyperacusis%22

Baranek, G. (2002). Efficacy of sensory and motor interventions for children with autism. *Journal of Autism and Developmental Disorders*, *32*(5), 397–422.

Baranek, G. T., David, F. J., Poe, M. D., Stone, W. L., & Watson, L. R. (2006). Sensory experiences questionnaire: Discriminating sensory features in young children with autism, developmental delays, and typical development. *Journal of Child Psychology and Psychiatry*, *47*(6), 591–601.

Brown, C., & Dunn, W. (2002). *Adolescent/adult sensory profile: User's manual*. San Antonio, TX: Psychological Corporation.

Corbin, J., & Strauss, A. (2008). *Basics of qualitative research* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Creswell, J., & Miller, D. (2000). Determining validity in qualitative inquiry. *Theory into Practice*, *39*(3), 124–130.

Dunn, W. (2006a). *Sensory profile supplement*. San Antonio, TX: Pearson.

Dunn, W. (2006b). *Sensory profile school companion*. San Antonio, TX: Pearson.

Dunn, W. (2014). *Sensory profile 2*. Bloomington, MN: PsychCorp.

Gilliam, J. E. (2014). *Gilliam autism rating scale – Third edition (GARS-3)*. Austin, TX: Pro-Ed.

Gravel, J., Dunn, M., Lee, W., & Ellis, M. (2006). Peripheral audition of children on the autistic spectrum. *Ear and Hearing*, *27*(3), 299–312.

Grinker, R. (2007). *Unstrange minds: Remapping the world of autism*. New York: Basic Books.

Hughes, R. W., Vachon, F., & Jones, D. M. (2007). Disruption of short-term memory by changing and deviant sounds: Support for duplex mechanism account of auditory distraction. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*(6), 1050–1061.

Jones, C. R. G., Happé, F., Baird, G., Simonoff, E., Marsden, A. J. S., Tregay, J., … Charman, T. (2009). Auditory discrimination and auditory sensory behaviors in autism spectrum disorders. *Neuropsychologia*, *47*(13), 2850–2858.

Kern, J. K., Trivedi, M. H., Garver, C. R., Grannemann, B. D., Andrews, A. A., Savla, J. S., … Schroeder, J. L. (2006). The pattern of sensory processing abnormalities in autism. *Autism*, *10*(5), 480–494.

Koegel, R., Openden, D., & Koegel, L. (2004). A systematic desensitization paradigm to treat hypersensitivity to auditory stimuli in children with autism in family contexts. *Research & Practice for Persons with Severe Disabilities*, *29*, 122–134.

Lysack, C., Luborsky, M. R., & Dillaway, H. (2006). Gathering qualitative data. In G. Kielhofner (Ed.), *Research in occupational therapy* (pp. 341–347). Philadelphia, PA: F. A. Davis.

Pfeiffer, B., Coster, W., Snethen, G., Piller, A., Derstine, M., & Tucker, C. (in press). Perspectives on the impact of the sensory environment and participation in daily activities for children with autism spectrum disorders. *American Journal of Occupational Therapy*, *71*, 7104220020. doi:10.5014/ajot.2017.021360

Rowe, C., Candler, C., & Neville, M. (2011). Noise reduction headphones and autism: A single case study. *Journal of Occupational Therapy, Schools, & Early Intervention*, *4*(3–4), 229–235.

Schaaf, R. C., Benevides, T., Leiby, B. E., & Sendecki, J. A. (2015). Autonomic dysregulation during sensory stimuli in children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *45*(2), 461–472.

Shield, B. M., & Dockrell, J. E. (2008). The effects of environmental and classroom noise on the academic attainments of primary school children. *Journal of the Acoustical Society of America*, *123*(1), 133–144.

Smith, G. W., & Riccomini, P. J. (2013). The effect of a noise reducing test accommodation on elementary students with learning disabilities. *Learning Disabilities Research & Practice*, *28*(2), 89–95.

Stiegler, L. N., & Davis, R. (2010). Understanding sound sensitivity in individuals with autism spectrum disorders. *Focus on Autism and Other Developmental Disabilities*, *25*(2), 67–75.

Tomchek, S. D., & Dunn, W. (2007). Sensory processing in children with and without autism: A comparative study using the short sensory profile. *American Journal of Occupational Therapy*, *61*(2), 190–200.

Tufford, L., & Newman, P. (2010). Bracketing in qualitative research. *Qualitative Social Work*, *11*, 80–96.

Watling, R. L., Deitz, J., & White, O. (2001). Comparison of sensory profile scores of young children with and without autism spectrum disorders. *American Journal of Occupational Therapy*, *55*(4), 416–423.