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Clinical Focus

Using Visual Supports to Facilitate Audiological Testing for Children With Autism Spectrum Disorder

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Purpose: One in 59 children is diagnosed with autism spectrum disorder (ASD). Due to overlapping symptoms between hearing loss and ASD, children who are suspected of having ASD require an audiological evaluation to determine their hearing status for the purpose of differential diagnosis. The purpose of this article is twofold: (a) to increase audiologists' knowledge of ASD by discussing the challenges associated with testing and interpreting clinical data for children with ASD or suspected ASD and (b) to provide visual supports that can be used to facilitate audiological assessment.
Method: Eight children (ages 4–12 years) were recruited as video model participants. Videos were filmed using scripts that used concise and concrete language while portraying common clinical procedures. Using the video models, corresponding visual schedules were also created.
Conclusion: Although obtaining reliable hearing data from children with ASD is challenging, incorporating visual supports may facilitate testing. Video models and visual schedules have been created and made freely available for download online under a Creative Commons License (Creative Commons–Attribution-NonCommercial-ShareAlike 4.0 International License). Incorporating visual supports during clinical testing has the potential to reduce the child's and family's stress, as well as to increase the probability of obtaining a reliable and comprehensive audiological evaluation. Future research is warranted to determine the effectiveness and feasibility of implementing these tools in audiology clinics.
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The current incident rate for autism spectrum disorder (ASD) is one per 59 children in the United States (Centers for Disease Control and Prevention, 2018a). ASD is a neurodevelopmental disorder that emerges in early childhood with varying degrees of deficits in social interaction and communication (Centers for Disease Control and Prevention, 2018b). Individuals with ASD also typically display restricted interests, as well as repetitive behaviors (American Psychiatric Association [APA], 2013). Due to overlapping symptoms between hearing loss and ASD—such as language delays and not responding to their name—children who are suspected of having ASD require testing to determine their hearing status for the purpose of differential diagnosis (Johnson & Myers, 2007). Moreover, although there is not a consensus in the literature (reviewed by Beers, McBoyle, Kakande, Dar Santos, & Kozak, 2014), Rosenhall, Nordin, Sandström, Ahlsen, and Gillberg (1999) reported that, in their prospective study of children with ASD (n = 199), the incidence rate of bilateral hearing loss was 3.5%, 10 times higher than in the general population. For these reasons, audiologists play a critical role in the differential diagnosis of children with suspected ASD and unknown hearing status. In order to ensure an appropriate diagnosis and prompt access to intervention services, audiologists must obtain accurate results and do so in a timely manner.

However, audiologists can encounter a variety of challenges when testing or interpreting results of children with suspected ASD. Testing challenges may arise because children with ASD often have difficulty when asked to perform tasks with unfamiliar individuals, and they potentially have social communication and/or language deficits. These challenges may be exacerbated if an audiologist or testing assistant is not experienced in working with individuals with developmental differences. Even when audiological data are collected, unique features associated with ASD

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can make the data difficult to interpret. Specifically, studies suggest that both behavioral and physiological clinical tests may have different results for children with ASD compared to children that are neurotypical (Bennetto, Keith, Allen, & Luebke, 2017; Kwon, Kim, Choe, Ko, & Park, 2007; Roth, Muchnik, Shabtai, Hildesheimer, & Henkin, 2012; Tharpe et al., 2006). It appears that these differences are not a result of peripheral hearing loss but rather are due to potential underlying differences in auditory functioning and/or structural differences in the brain (e.g., Hyde, Samson, Evans, & Mottron, 2010; Kulesza, Lukose, & Stevens, 2011; Kulesza & Mangunay, 2008; Kwon et al., 2007; Roth et al., 2012).

The purpose of the current paper is twofold: (a) to increase clinical audiologists' knowledge and awareness of the challenges associated with testing and interpreting clinical data for children with ASD or suspected ASD and (b) to provide free access to visual supports that can be used to facilitate audiological assessments (McTee et al., 2019). The development of these tools was motivated by the success that other professional fields (e.g., education, speech-language pathology) have observed when introducing video models and visual schedules to children with ASD to promote transitions and the establishment of new routines (for a review, see Lequia, Machalicek, & Rispoli, 2012). Video models are videos of an individual performing an activity or task. Visual schedules are composed of pictures and/or words that indicate the sequence of steps involved in an activity. Implementing visual supports in an audiology clinic may facilitate improved compliance with audiological testing procedures for children with ASD or suspected ASD, which, in turn, may result in obtaining reliable results in a limited number of visits (Davis & Stiegler, 2005). Additionally, as argued by others (e.g., Blackstone & Pressman, 2016; Thunberg, Buchholz, & Nilsson, 2016), visual supports are an effective strategy that medical providers can use to address the basic communication rights of individuals with communication disabilities as declared by the United Nations (2006).

Differential Diagnosis: The Importance of Audiology During Developmental Evaluations

For children undergoing a developmental evaluation, determining their hearing status is a critical component of their evaluation because there are some overlapping behavioral characteristics between hearing loss and ASD (e.g., Johnson & Myers, 2007). Similar to children with undiagnosed hearing loss, children with ASD may not respond to their name and demonstrate delayed or abnormal social and communication skills, including delayed language development (Johnson & Myers, 2007; Mitchell et al., 2006; Moeller, 2000, 2007; Simonsmeier & Nelson, 2014; Szarkowski, Mood, Shield, Wiley, & Yoshinaga-Itano, 2014; Szymanski & Brice, 2008; Tager-Flusberg, Joseph, & Folstein, 2001; Wetherby, Watt, Morgan, & Shumway, 2007; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998). Although developmental concerns can overlap between the two diagnoses, children with ASD typically demonstrate atypical patterns and delays in the domains of language, speech, and social skills (APA, 2013; Meinzen-Derr et al., 2014; Mitchell et al., 2006; Simonsmeier & Nelson, 2014; Tager-Flusberg et al., 2001; Wetherby et al., 2007). For example, children with ASD may display atypical language patterns such as echolalia, perseverance on a single word, and reduced eye contact (APA, 2013; Johnson & Myers, 2007; Szarkowski et al., 2014). Thus, careful differential diagnosis with skilled clinicians is critical to determine if communication and social delays are the result of hearing loss or ASD.

A hearing screening is often the first step in determining whether hearing differences underlie observed developmental concerns and is specifically recommended by both the American Speech-Language-Hearing Association (ASHA) and the American Academy of Pediatrics when there are developmental concerns that impact communication (ASHA, n.d.; Johnson & Myers, 2007; Schaefer & Mendelson, 2013). However, a speech-language pathologist or nurse may not be able to obtain and/or interpret hearing screening results from children suspected of ASD because of complex or challenging behavior. Therefore, children with suspected ASD are often referred to an audiologist for a comprehensive audiological evaluation. According to pediatric assessment guidelines published by ASHA (2004), audiologists must test children's hearing using both physiological and behavioral methods to ensure agreement of results. Physiologic measures do not depend on the child providing a response and include tympanometry, otoacoustic emissions (OAEs), and auditory brainstem response (ABR) testing. Tympanometry assesses the status of the middle ear and can detect middle ear pathologies that may contribute to hearing loss. OAEs are a preneural measurement that assesses the outer hair cell function within the cochlea. ABR testing is a means to measure the integrity of the auditory pathway from the cochlea to the brainstem. These physiologic measures serve as a cross-check when behavioral results are unreliable or inconclusive (Jerger & Hayes, 1976). Furthermore, the ASHA guidelines (2004) recommend using ABR on children that are less than 6 months of age or if behavioral thresholds are not obtained and/or are unreliable after two appointments within a 2-month time period.

Although physiologic measures are an important aspect of the audiologic testing battery, behavioral testing is the gold standard assessment. Behavioral testing is the gold standard because it tests the entire auditory system, requires the listener to provide a response, and determines the type and severity of hearing loss across a range of frequencies. For children with suspected ASD, developmental concerns are commonly first reported during the preschool years (Baio et al., 2018); thus, either visual reinforcement audiometry (VRA) or conditioned play audiometry (CPA) are often used. VRA requires the child to make a head-turn response toward a reinforcer (e.g., mechanical toy), whereas CPA requires a child to make a play-based motor response when the signal is detected. These procedures correspond to a developmental age of 6–24 months and 2–5 years for

VRA and CPA, respectively (ASHA, 2004). For children on the cusp of being able to perform CPA, tangible reinforcement operant conditioning audiometry or visually reinforced operant conditioning audiometry may be appropriate (e.g., Lloyd, Spradlin, & Reid, 1968; Thompson, Thompson, & Vethivelu, 1989). These methods require the child to press a lever when the signal is heard; if correct, the child receives a tangible or visual reinforcement, respectively. Older children are tested with conventional audiometry methods that are also used when testing adults (e.g., push a button or raise your hand when the signal is heard; ASHA, 2004; Eagles & Wishik, 1961). The ultimate goal of behavioral testing is to obtain a complete audiogram. Because behavioral testing is dependent on the child's behavior, it can be challenging for an audiologist to successfully complete testing in one visit. Therefore, the family may need to return for multiple visits, which can be a burden on the family and the clinic and, ultimately, prolong the diagnostic process.

Challenges Associated With Testing and Interpreting Audiological Data From Children With ASD

Audiologists, especially those with limited experience in testing children with ASD, may rely on physiological measures over behavioral assessment procedures in order to determine hearing status for children with suspected ASD (e.g., Davis & Stiegler, 2005; Diefendorf, Corbin, Trepcos-Klinger, & Weinzierl, 2017; Dittman & Brueggeman, 2003). However, relying predominately on physiological data provides an incomplete picture of the child's hearing (e.g., Jerger & Hayes, 1976). Moreover, there is a growing debate in the literature about whether physiological data are clinically different for children with ASD. Compared to children who are neurotypical, children with ASD may have longer ABR latencies (Kwon et al., 2007; Roth et al., 2012; for contradictory findings, see Courchesne, Courchesne, Courchesne, & Lincoln, 1985; Dunn, Gomes, & Gravel, 2008; Tharpe et al., 2006) and reduced responses for OAEs (Bennetto et al., 2017; Danesh & Kaf, 2012; for contradictory findings, see Gravel, Dunn, Lee, & Ellis, 2006; Tharpe et al., 2006). Although the underlying mechanisms for abnormal findings are not clear, it has been suggested that differences may be attributed to overall structural brain differences (Hyde et al., 2010; Kulesza & Mangunay, 2008; Kulesza et al., 2011; Kwon et al., 2007; Roth et al., 2012). Further research is needed to better understand how potential structural differences for children with ASD may affect performance on these procedures and how clinical findings should be interpreted. In the meantime, audiologists should remain cautious about solely using physiological data to determine peripheral hearing status of children with ASD.

Contrary to the common perception among clinical audiologists that children with ASD are unable to perform behavioral hearing procedures, research findings indicate that the majority of children with confirmed or suspected ASD can be successfully tested (e.g., Downs, Schmidt, & Stephens, 2005; Rosenhall et al., 1999; Tharpe et al., 2006). For example, Downs et al. (2005) reported that, for a sample of children diagnosed with ASD ($n = 87$), 83% were able to complete behavioral audiological testing at the time of their ASD evaluation. Although behavioral thresholds can be obtained from children with ASD, questions remain about the reliability of the threshold estimates. Tharpe et al. (2006) reported audiological findings for 3- to 10-year-old children with ASD ($n = 22$) or who were neurotypical ($n = 22$). All children demonstrated clinically normal results on physiological auditory evaluations (i.e., OAEs, acoustic reflexes, and ABR). However, for the behavioral hearing evaluation, 41% of the children with ASD had pure-tone thresholds that were elevated (> 20 dB HL). Moreover, 64% of children with ASD had test–retest threshold estimates that varied by ≥ 15 dB between their two visits. In contrast, all children who were neurotypical had thresholds that were within normal clinical limits (≤ 20 dB HL), and all but one child demonstrated high test–retest reliability (≤ 10 dB). Because all children had clinically normal physiological results, Tharpe et al. interpreted elevated behavioral thresholds in the ASD group to reflect inconsistent responses to auditory stimuli in the environment. This idea is supported by a growing body of literature that suggests that children with ASD respond to and/or process auditory stimuli differently than children who are neurotypical (for a review, see O'Connor, 2012). For example, some children with ASD appear to experience hypersensitivity and discomfort with loud sounds, whereas others do not have a physical response to loud stimuli (Gomes, Rotta, Pedroso, Sleifer, & Danesi, 2004). These inconsistencies and/or potentially abnormal auditory processing may explain why auditory thresholds are elevated and/or variable for children with ASD.

Although underlying differences in auditory functioning may affect thresholds obtained during a clinical evaluation, there are three additional factors—the audiologist, the test procedure, and the child—that could also contribute to elevated behavioral thresholds. One challenge is that many audiologists have limited training and/or experience testing children with ASD (e.g., Dittman & Brueggeman, 2003). Audiologists with limited experience may choose a task or reinforcers that are developmentally inappropriate for the child. Given the variability and complexity of behaviors in children with ASD, audiologists unfamiliar with this population may be inconsistent or unreliable in their ability to judge the auditory behavior of children with ASD. Also, it may be difficult to train the child to perform the task, especially if the clinician fails to use simple and concrete language, does not incorporate visual models, or is overly reliant on using social reinforcement to keep the child engaged during testing.

Another factor that may be contributing to elevated thresholds is that the underlying assumptions of VRA and CPA methods may not be appropriate for children with ASD, as they were developed based on the behavior of children who are typically developing. For example, VRA is based on the observation that typically developing infants will make a reflexive head-turn response when a sound is heard in their environment (Muir, Clifton, & Clarkson, 1989; Widen, 1993). However, preschool children with ASD are less likely than neurotypical, mental age–matched peers to orient to sounds (e.g., Dawson et al., 2004). Additionally, CPA is an abstract task that requires the child to "surrender" a toy when the signal is heard. This task may be difficult for children with intense interests in particular objects or who have difficulty transitioning to a new object. VRA and CPA may also be challenging for children with ASD because it requires frequent shifts in attention, an area of concern for many children with ASD (Liss, Saulnier, Fein, & Kinsbourne, 2006). Additionally, because children with ASD tend to have restricted interests (Richler, Bishop, Kleinke, & Lord, 2007), reinforcers commonly used in the clinic may not be effective. Thus, it is possible that elevated or unreliable thresholds may be a result of the behavioral methods being dependent on skills that are difficult for many children with ASD.

The third factor that may result in elevated or unreliable thresholds are those characteristics that are specific to the child. For example, children with ASD may have sensory sensitivities and perceive aspects of the testing to be aversive. For example, it may be challenging to place and/or maintain the placement of the headphones on the child. Children with ASD may have self-stimulating behaviors (e.g., repetitive hand movements), which make it difficult to observe the child's behavior that is in response to the auditory stimulus. Children with ASD may also exhibit challenges transitioning either into the testing environment or between test assessments, making it difficult to switch tasks and collect data. Also, the high prevalence of anxiety as a secondary diagnosis in children with ASD (for a review, see White, Oswald, Ollendick, & Scahill, 2009) may affect the child's performance. For example, it is possible that the child will become anxious because he or she is working with an unfamiliar adult(s) in an unfamiliar setting. This anxiety may be compounded if the child has had a previous negative experience with a medical provider or procedure. Finally, a child with ASD may become distracted or overwhelmed by other sensory inputs or items in the booth (e.g., lighting, extra toys, electronic equipment, or the smell of cleaning agents).

In summary, factors related to the audiologist, the testing procedure, and the child may contribute to obtaining elevated or unreliable behavioral thresholds. However, many of these concerns can be addressed through training audiologists to improve testing techniques, thoughtfully designing the test space and structure of the test session, and implementing visual supports to prepare the child for the appointment.

Facilitating Evaluations With Video Models and Visual Schedules

Visual supports can be used to address some of the child-related factors that may make testing challenging for children with ASD or suspected ASD (e.g., difficulty transitioning, wariness of the unknown, unwillingness to wear headphones, and anxiety). Of particular interest in the current paper are two strategies—video models and visual schedules—that are particularly effective for helping children with ASD transition and generalize desirable behaviors to new activities (e.g., MacDuff, Krantz, & McClannahan, 1993; McCoy & Hermansen, 2007; Spriggs, Knight, & Sherrow, 2015). Video models are videos of a child or adult performing an activity. Visual schedules are composed of pictures that show the sequence of steps involved in an activity.[1] Other medical and educational professions have successfully employed these tools when working with children with ASD. Research has demonstrated that visual supports prepare children for transitions, facilitate behavioral expectations, establish an understanding of the unknown, and reduce anxiety in a variety of settings (Hume & Odom, 2007; Knight, Sartini, & Spriggs, 2015; MacDuff et al., 1993; Rao & Gagie, 2006; Spriggs et al., 2015; Stoner, Angell, House, & Bock, 2007).

Because there is substantial evidence indicating that video models and visual schedules are effective tools in children's everyday environments, visual supports have been recommended for use in medical settings to reduce the anxiety experienced by children with ASD during medical evaluations and procedures (ASHA, n.d.; Shellenbarger, 2004; Thorne, 2007). There are a limited number of studies that have examined the benefit of visual supports in medical settings, although results support their usage. Chebuhar, McCarthy, Bosch, and Baker (2013) evaluated the use of visual schedules that were designed for nurses to use during medical assessment of children with ASD (n = 17). In that study, 77.8% of the parents reported that their child's anxiety was reduced, improving the family's overall experience. Thunberg, Törnhage, and Nilsson (2016) provided visual schedules to 25 children with known communication challenges to prepare them for surgery. Results from this exploratory study suggest that visual schedules reduced children's stress levels. Furthermore, results from Benjaminsson, Thunberg, and Nilsson (2015) suggest that providing visual supports can reduce the severity of pain reported by pediatric patients during needle-related procedures for sedation. These findings are broadly consistent with the positive outcomes observed for visual supports in home and educational settings.

Development of Visual Support Materials

The primary purpose of this article was to make freely available video models and visual schedules that can be used in a clinical setting to facilitate the successful completion of an audiological evaluation for children with ASD or suspected ASD (McTee et al., 2019). Video models and visual schedules were produced that followed the ASHA (2004) recommended testing battery with either CPA or standard audiometry. Although these tools have not yet been validated in a clinical setting, it is our expectation that

[1]There are several examples of visual schedules available from Autism Speaks (e.g., Loring & Hamilton, 2011).

these tools will facilitate audiological testing for children with ASD or suspected ASD, therefore promoting an accurate and timely assessment of hearing status.

Participants

Eight children (ages 4–12 years) were recruited as model participants. Efforts were made to recruit children who were diverse in terms of their age, race/ethnicity, and disability status. Table 1 provides an overview of each child, including age, demographics, and diagnoses, based on parental report. All video models include otoscopy, tympanometry, and OAEs except for Video Model 2, which demonstrates real-ear measurements and aided testing instead. Also described in Table 1 is the type of behavioral testing (i.e., CPA or conventional) and speech audiometry testing performed, as this varied across models. Parents signed a photo/video release allowing us to use photographs and video recordings of their children on websites and in publications, promotional flyers, educational materials, derivative works, and for any other similar purpose. A photo/video release was also signed by any parent that was captured in the videos and by the audiologist model. Families were compensated for their time.

Video Models

Creation of Scripts

Scripts were written in English for the audiologist to use during the recording process. Scripts were reviewed by all authors, as well as an additional six external reviewers. Four of the authors and all external reviewers had ≥ 10 years of experience in either clinical and/or research settings working with children, including children with ASD. Script reviewers represented a variety of professional backgrounds: audiology (n = 7), speech-language pathology (n = 1), developmental psychology (n = 1), and early childhood education (n = 1). Reviewers were specifically asked to (a) provide feedback on the language of the script to verify that it was developmentally appropriate and (b) verify that the test battery portrayed was common to clinical sites. The use of concrete and concise language within the scripts was of particular focus. We also removed any language that was inconsistent with maintaining appropriate social and body boundaries (e.g., the otoscope or probe tip "kissing" or "tickling" the ear). In order to address the children's potential discomfort due to tactile sensitivities, we described the transducer as "it's soft" or "it's squishy." In the videos, we elected not to say "it won't hurt" when describing the tasks to avoid making an assumption about the child's physiological experience. If an audiologist wants to address potential pain, phrases such as "most children say it doesn't hurt" or "you can handle it" are recommended. Older child model participants were also asked to follow a simple script and were encouraged to ask simple questions. Video Models 4 and 6 display children that ask questions. Sample scripts used in the videos can be found in Supplemental Materials S1 and S2 for CPA and conventional audiometry, respectively. Scripts demonstrating VRA, tangible reinforcement operant conditioning audiometry, or visually reinforced operant conditioning audiometry were not created. The rationale for this choice is that, in order to benefit from visual supports, children need to have symbolic representation,

Table 1. Description of the video model participant and the clinical procedures depicted in each video model.

Video model	Age (years)	Gender	Race & ethnicity	Disability	Tests demonstrated
Video Model 1	4	Male	Asian, not Hispanic or Latino	Neurotypical, speech and language delays	Picture-pointing SRT, CPA with headphones
Video Model 2	4	Male	White, not Hispanic or Latino	Mild-to-severe sensorineural hearing loss, autism spectrum disorder	Real-ear measurement (RECD), aided picture-pointing SRT, aided CPA, no OAEs performed
Video Model 3	7	Male	White, Hispanic	Autism spectrum disorder	Picture-pointing SRT, CPA with headphones
Video Model 4*	8	Male	African American, not Hispanic or Latino	Neurotypical	Standard SRT, standard audiometry with insert earphones and bone conduction vibrator
Video Model 5	10	Female	White, not Hispanic or Latina	Down syndrome	Picture-pointing SRT, CPA with insert earphones
Video Model 6*	10	Male	White, Hispanic	Autism spectrum disorder	Standard SRT, standard audiometry with insert earphones
Video Model 7	10	Male	White, not Hispanic or Latino	Autism spectrum disorder, somatodyspraxia	Standard SRT, standard audiometry with insert earphones and bone conduction vibrator
Video Model 8	12	Male	White, not Hispanic or Latino	Autism spectrum disorder	Standard SRT, standard audiometry with headphones

Note. The following demographics, based on parental report, are provided for the video model participants: age, gender, race, ethnicity, and disability. For all video models, otoscopy, tympanometry, and otoacoustic emissions (OAEs) were included. The one exception is Video Model 2, which did not demonstrate OAEs. Other additional audiological procedures performed are specified in the far right-hand column. Children that modelled asking questions (e.g., "Will it be loud?") are indicated with an asterisk. SRT = speech recognition threshold; CPA = conditioned play audiometry; RECD = real-ear-to-coupler difference.

which corresponds to a developmental age of around two years (Ganea, Allen, Butler, Carey, & DeLoache, 2009). Thus, children who are most likely to benefit from visual supports will likely be able to perform either CPA or standard audiometry.

Recording and Editing of Videos

In order to promote sustained attention to the child and clinician in the video, filming was completed in front of a plain wall (Cloppert & Williams, 2005). The videos were filmed using a Zoom Q8 video camera with audio input via a wireless microphone (Shure BLX4R) that was worn by the audiologist. Audiological equipment used to demonstrate the testing procedure included TDH 49 supra-aural headphones, ER3 insert earphones, GSI TympStar Pro tympanometer, GSI Corti otoacoustic (OAE) screener, and a Biologic Navigator Pro OAE probe. None of the audiological equipment was functional at the time of video recording. Speech audiometry was either modeled by repeating words or using a picture-pointing spondee board.

Recordings were compiled and edited in Adobe Premiere Pro to create the final videos in .mp4 format. In the editing process, a 500-ms, 1000-Hz warble tone was superimposed to demonstrate the stimulus during behavioral testing. In order to introduce each step of the test battery in the video, a picture of that task was displayed with a child-appropriate title (e.g., "Ear Light" for otoscopy). These images are identical to the photos used in the visual schedules. Videos are approximately 3 min in duration. Two versions of each video were created: one with captions and one without captions.

Visual Schedules

The visual schedules were created to mirror the video models. Specifically, images were captured from the video models at points in the video that demonstrated the general concept of each procedure. Using PowerPoint, the images were arranged from top to bottom (first step to last step in the sequence) on the left-hand side of the page. Each image was labelled with a child-appropriate title to explain each step in the procedure in a concrete, friendly, and age-appropriate manner (Davis & Stiegler, 2005). A visual schedule was created to pair with each video model.

In order to provide clinicians versatility and flexibility, the visual schedules can be used in one of two ways. First, the audiologist can simply print the visual schedule and either have the child physically check off each box with a pencil when the step is completed, or if the schedule is laminated, a dry-erase marker can be used, allowing the schedules to be reused. Second, visual schedules are often created to include an action of moving the step in a sequence to indicate its completion. To do this, the visual schedule will first be printed and then laminated. The images in the sequence can be separated/cut out and then attached to the schedule with Velcro. Boxes were illustrated on the right side of the page. Velcro can be attached to these boxes so that the child can physically move each image to the right when they have reached that step in the process. Refer to Supplemental Material S3 for an example of a visual schedule.

Online Access to Visual Support Materials

The video models and visual schedules are freely available for access and download under a Creative Commons–Attribution-NonCommercial-ShareAlike 4.0 International License. The materials are available on the Open Science Framework website (McTee et al., 2019).

Implementing Visual Supports in a Clinical Setting

Although there is no research to date examining the most effective strategies for implementing visual supports in audiology clinics, there is a large body of literature evaluating video models and visual schedules in home and school environments (Buggey, 2005; Rao & Gagie, 2006; Wong et al., 2015). Drawing on this research, video models are most effective when viewed (a) before the behavioral task is attempted (Buggey, 2005; Cox & AFIRM Team, 2018; National Professional Development Center on Autism Spectrum Disorders, 2010) and (b) repeatedly until the clinician/teacher is confident that the child will attempt the targeted behavior (Cox & AFIRM Team, 2018; National Professional Development Center on Autism Spectrum Disorders, 2010). Visual schedules are most effective if the child is shown the image of the first step of the procedure, followed by a brief description of what will occur next using a "first/then" approach (Meadan, Ostrosky, Triplett, Michna, & Fettig, 2011).[2] An example of a first/then approach would be, "First you listen for the beep, then you put the toy in the box."

In order to prepare a child for the audiological evaluation, we recommended that the video model is shown at home prior to the appointment. It is recommended that the child is provided multiple viewings at home (Davis & Stiegler, 2005) and in the audiological office prior to starting the appointment. During this process, it is also recommended that the caregiver explains potential differences between the video and the child's expected experience (e.g., the clinician and room will be different), as children with ASD may perseverate on these details (Cloppert & Williams, 2005). The audiologist should also describe any changes in testing order from what was depicted in the video. If the video was not viewed at home prior to the appointment, it is still recommended that the video be watched in the clinic.

In contrast to the recommendation that the video model be shared with the child before the appointment, the visual schedule may be introduced for the first time at the appointment. Because our visual schedules have been designed with flexibility in mind, the audiologist can rearrange

[2]For a review on the evidence-based practice for using visual supports, and instruction on how to use and create visual supports, refer to the AFIRM modules: video modeling (Cox & AFIRM Team, 2018) and visual schedules (Sam & AFIRM Team, 2015).

the visual schedule to reflect that particular test sequence desired. After completing the case history, the audiologist can show the child the schedule and introduce the first step of the sequence by pointing to the step and explaining the task using concise language (Chebuhar et al., 2013). Examples of concise and concrete language to describe testing procedures can be found in Supplementals S1 and S2. Once the task is completed, the child or audiologist can remove the photo and move it to the right-hand side (or check off the box on the right-hand side). The audiologist will then point to the next step in the procedure. The audiologist and child will continue through this process until each step is completed or testing is terminated.

Despite preparing the child for testing by using the visual supports, it is possible that additional visit(s) will be needed in order to complete testing. At the end of the first appointment, the audiologist should provide the family strategies to further prepare and desensitize the child prior to the next appointment. One recommended strategy is for the audiologist to either provide our website or send the visual supports home with the child's family. Additionally, if the child did not tolerate the transducer, caregivers can desensitize the child to headphones by wearing headphones at home (Cloppert & Williams, 2005). Ultimately, it is vital that the audiologist and family remain persistent in testing, as multiple visits to the audiologist will help familiarize the child to the environment, the equipment, and the task (Davis & Stiegler, 2005). By remaining persistent and continuing to use visual supports to facilitate testing, a comprehensive audiological evaluation can be completed for most children.

Discussion

It is recommended that children with suspected ASD receive a hearing assessment in order to determine if a potential hearing loss is contributing to their delays. The goals of this article were (a) to review the challenges associated with obtaining reliable hearing data from children with ASD and (b) to provide freely available visual supports—video models and visual schedules—that can be used by clinical audiologists. The implementation of visual supports in audiology clinics may have the potential to improve the health care provided to children with ASD and their families.

Benefits for Implementing Visual Supports in Clinical Settings

There are several likely benefits for implementing video models and visual schedules in audiology clinics. One potential benefit is that visual supports may facilitate the audiologist's ability to collect accurate and reliable clinical data from children with ASD or suspected ASD. Visual supports encourage smoother transitions, facilitate behavioral expectations, establish an understanding of the previously unknown, and reduce anxiety (Hume & Odom, 2007; Knight et al., 2015; MacDuff et al., 1993; Rao & Gagie, 2006; Spriggs et al., 2015; Stoner et al., 2007). A second and related benefit of using visual supports is that it may reduce the number of audiological visits required to complete a comprehensive audiological evaluation.

If visual supports lead to completing audiological testing in fewer visits, the result will be an expedited introduction to the child's ASD diagnostic process. This is beneficial, as parent reports reveal that, when the ASD diagnosis is delayed, their stress is exacerbated (Elder, Kreider, Brasher, & Ansell, 2017). Therefore, an earlier diagnosis is essential, as an accelerated introduction to early intervention services has not only been shown to improve the prognosis of language and outcomes in several other domains (Fenske, Zalenski, Krantz, & McClannahan, 1985; Vivanti, Dissanayake, & Victorian ASELCC Team, 2016) but has also the potential to mitigate the stress upon the family during this process (Crane, Chester, Goddard, Henry, & Hill, 2016; Hayes & Watson, 2013; Horlin, Falkmer, Parsons, Albrecht, & Falkmer, 2014). These findings illustrate the importance of achieving an early diagnosis for a child who has ASD because the reduction of parental stress is determined by the success of early intervention services (Elder et al., 2017; Horlin et al., 2014).

Another benefit of these tools is that they can be used for a diverse pediatric population beyond children with ASD or suspected ASD. Pediatric audiologists work with a wide variety of different children with unique disabilities and needs. Furthermore, 40% of children with permanent hearing loss also have an additional disability such as learning disabilities, developmental delays, cognitive impairments, behavioral-emotional disabilities, and visual impairments (Cupples et al., 2014; Gallaudet Research Institute, 2011). Based on the success of other studies using visual supports with individuals with a variety of disabilities (e.g., Down syndrome, developmental disabilities, and language delays), it is likely that visual supports can facilitate audiological testing in a broader population of children with developmental delays (for a review, see Koyama & Wang, 2011). Providing visual supports for a diverse population not only facilitates audiological testing but may also meet the communicative needs of some children in the medical setting (Blackstone & Pressman, 2016; Thunberg, Buchholz, et al., 2016).

Another potential benefit of these materials is that they provide a template for future development of other visual supports for hearing health care. Of particular interest is to develop visual supports that would benefit children with dual diagnoses of hearing loss and ASD. The most recent prevalence rate estimates that one in 59 children with hearing loss also has a diagnosis of ASD (Szymanski, Brice, Lam, & Hotto, 2012). In order to promote child compliance and reduce anxiety during amplification fitting and verification, audiologists may find that visual supports benefit children with a dual diagnosis of hearing loss and ASD. Of the children we recruited as video model participants, one child (Video Model 2) had both sensorineural hearing loss and ASD. For this reason, this video model portrays a real-ear measurement and aided testing. In the future, additional visual supports should be created that are specifically designed for children that use amplification.

Limitations of Visual Supports

Although the research base supports the idea that there are many benefits to using visual supports in the audiological setting, the efficacy of our visual supports has not been verified, nor has our recommended implementation procedure been evaluated in audiology clinics. Future research is needed to determine how and if the usage of these tools reduces a child's anxiety, improves test–retest reliability, and increases productivity and efficiency within the audiological clinic.

An additional challenge of using visual supports is that audiologists may not know that they are seeing a child for an ASD differential diagnosis appointment until they are encountering the child and family. Without appropriate notification, many audiologists will not be able to incorporate visual supports into the appointment. This process could be improved at the level of the clinical scheduling staff by means of a brief screener at the time of scheduling to identify children who may benefit from these tools. Additionally, if the audiologist elects to exclude some tests or modify testing procedures from what is presented in the visual supports, the visual supports may not align with their intended protocol/testing sequence. However, the visual schedules can be easily modified by the audiologist.

Another limitation is that not all children with ASD will benefit from visual supports. Because children with ASD exhibit varying symptoms that lie on a spectrum, children who are more impacted by ASD (e.g., extreme perseverance, echolalia, or self-stimulating behavior) may not benefit from the visual supports because of limited sustained attention abilities (Buggey, 2007). Additionally, in order to benefit from these tools, children need to have the developmental skill of symbolic representation to understand that the pictures of the visual supports represent real objects and/or concepts, which corresponds to a developmental age of around 2 years (Ganea et al., 2009).

Conclusion

Audiologists are often one of the first medical providers to evaluate a child with suspected ASD. Therefore, it is essential that the audiologist obtains accurate results to determine if the child's developmental delays could be due to hearing loss. This clinical focus article reviewed (a) the challenges audiologists may encounter when evaluating children with known or suspected ASD and (b) how the use of visual supports, including video models and visual schedules, may be one effective strategy to facilitate audiological testing. We also provided video models and corresponding visual schedules portraying a diverse population of children for audiologists and families to use to facilitate completing an audiological evaluation. These visual supports are free and accessible online (McTee et al., 2019). Incorporating visual supports during clinical testing has the potential to reduce the child and family's stress as well as to increase the probability of obtaining a reliable and comprehensive audiological evaluation. Furthermore, the use of these visual supports may, at least in part, address the communicative needs of children with ASD in a medical setting (e.g., Blackstone & Pressman, 2016; Thunberg, Buchholz, et al., 2016), promoting a basic human right to access and communication (United Nations, 2006). As we did not measure the effectiveness or feasibility of these tools in the clinic, future research is warranted.

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