

Pediatric Focus 1

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Considering directional microphone use in pediatric hearing aid fittings

Introduction

Hearing aid prescription and fitting in early infancy is becoming increasingly common due to the implementation of early hearing identification and intervention (EHDI) programs. Although the primary goal of early fitting is to improve access to speech to support communication development, children's listening needs change with age. Their world expands, giving children exposure to different listening environments and talkers. The combination of multiple sound sources and the impact of real-world acoustics can make it challenging for the developing child to have clear access to speech.

Communication generally takes place in complex environments where acoustic conditions can negatively impact the audibility of the speech signal. A considerable body of research has documented that the speech understanding of children with normal hearing is more negatively affected by adverse acoustic conditions compared to adults (e.g., McCreery et al., 2010; Neuman, et al., 2010; Wroblewski et al., 2012; Yang & Bradley, 2009). Poor acoustic conditions also affect children's performance in

areas that impact academic success (e.g., Dockrell & Shield, 2006; Klatt, Hellbrück, et al., 2010; also see Anderson, 2001, for a review). The deleterious effects of adverse acoustics are greater for children with hearing loss when compared to their peers with normal hearing (e.g., Crandell & Smaldino, 2000; Hicks & Tharpe, 2002; Stelmachowicz et al., 2001).

Remote microphone hearing assistance technologies have been shown to improve the signal-to-noise ratio (SNR) for children with hearing loss in conditions where noise, distance and reverberation interact to reduce the audibility of a talker's speech (Anderson & Goldstein, 2004; Anderson et al., 2005; Hawkins, 1984; Pittman et al., 1999; Thibodeau, 2010; Wolfe et al., 2013). These technologies provide considerable improvement in SNR, but they might not be an appropriate solution in all cases due to the need for a separate microphone/transmitter. Noise management technology is readily available in pediatric hearing aids in the form of adaptive noise reduction (ANR) and directional microphones.

Currently, the American Academy of Audiology (AAA) Pediatric Amplification Guidelines (2013) recommends routine consideration of these technologies. Recently, additional guidance has been provided for considering the application and verification of ANR technology in pediatric hearing aid fittings (Scollie et al., 2016). Less guidance is available for the use of directional microphones for children.

The purpose of this summary document for hearing healthcare professionals is to review the current evidence related to directional microphone use for children (*What we know*), describe further information needed to guide our clinical recommendations (*What we need to learn more about*), and provide considerations for moving forward with the available evidence (*What we should consider in the meantime*). This document also includes a summary of information that can be shared with professionals who work with children who have hearing loss or with their caregivers (*Summary information for professionals and caregivers*). It ends with a section of *References and readings* for professionals that provides more detailed information for the topics addressed here.

What we know

The research examining the benefits of directional microphones for children with hearing loss has been limited. The following references include studies from the 1990s through the time of this publication, although individual studies are not reported unless they were published after the aggregate reports. The reader is referred to the end of this document for references for those individual studies. It is important to note that studies directly examining the use of directional microphones in infants/toddlers currently are not available.

McCreery, R., Venediktov, R., Coleman, J., & Leech, H. (2012). An evidence-based systematic review of directional microphones and digital noise reduction hearing aids in school-age children with hearing loss. *American Journal of Audiology*, 21, 295–312

McCreery and colleagues (2012) completed an evidence-based systematic review that included qualified studies examining the efficacy of directional microphones for school-aged children with hearing loss. Evidence-based systematic reviews utilize strict criteria for including studies in the body of evidence (see the original paper for those criteria). The authors reported results from seven studies published between 1981 and 2011 that met the criteria for

the systematic review. From those studies, they reported the following outcomes:

- Speech recognition
 - Directional microphones were more effective than omnidirectional microphones when speech was directly in front and noise directly behind listeners.
 - Omnidirectional microphones were more effective when speech was not directly in front of listeners.
- Self- or parent-report
 - Children preferred directional microphones over omnidirectional microphones for the majority of situations in one study, but there were no differences between the two microphone types in another study, as reported by children or their parents.

Following their evidence-based review, the authors concluded: "Given the number of potential acoustic environments that a school-age child might experience in home, academic, and social situations, directional microphones may be beneficial in some situations and equivocal or detrimental in others." (p. 309)

American Academy of Audiology. (2013). Clinical practice guidelines on pediatric amplification. Retrieved from www.audiology.org/resources/documentlibrary/Documents/PediatricAmplificationGuidelines.pdf

The AAA guidelines (2013) provide an evidence base that can be used by clinicians to make decisions related to amplification for the pediatric population. In these guidelines, both research evidence and clinical expertise were used to develop recommendations. Directional microphones are addressed in the section on hearing aid audio signal processing. The references in the evidence base include studies of adults as well as children. From those studies, the following outcomes are reported:

- Adults (12 references)
 - Directional microphones improved speech understanding in many, but not all, noisy environments.
 - Adaptive directional microphones provided small additional directional benefit over traditional directional microphones with no negative consequences.

- Children (4 references)
 - Directional microphones provided benefit when a school environment was simulated if the child faced the target signal but resulted in greater difficulty when the target signal was behind the listener.
 - The benefits from a directional microphone were smaller than those obtained with FM remote microphone hearing assistance technology.

Based on review of the evidence, the following recommendations were made:

- Do not use directional microphones full-time.
 - Directional microphones may be recommended for children for some environments, with the understanding that they may reduce the audibility of off-axis talkers.
 - Technology that automatically switches the microphone between directional and omnidirectional modes of operation should be considered, with the caveat that the professional is responsible for understanding how the adaptive program functions as well as environments where it will be appropriate. In addition, omnidirectional mode might be preferred over automatic switching in some cases.
- Remote microphone systems will provide SNR improvements equal to or greater than directional microphones in hearing aids when those systems are prescribed/used appropriately.

Protocol for the Provision of Amplification within the Ontario Infant Hearing Program (MCYS, 2014; <http://www.dslio.com/wp-content/uploads/2015/05/DSL5-Pediatric-Protocol.2014.01.pdf>)

This protocol was developed by the Ontario Infant Hearing Program (IHP, Ontario Ministry of Children and Youth Services, 2014) specifically to address amplification for infants and pre-school children with hearing loss. The protocol aligns with AAA Guidelines (2013), and additionally provides specific details about how to operationalize the recommendations. In the section on noise management, the use of directional microphones for infants and pre-school children is addressed. The IHP protocol states:

Directional microphones can be beneficial if the listener faces the target talker and background noise is from other directions. However, accurate head orientation toward talkers is low in this age range. In addition, over-hearing and

incidental learning require this population to hear talkers from a variety of directions other than the front.

- Currently, the evidence base for directional microphone use, spatial hearing, and benefit in real-world environments for this population is lacking.
- Training on correct directional microphone use might be needed to ensure appropriate use.

Based on a review of the evidence, the following recommendations were made:

- Full-time use of directional microphones is not recommended for this population.
- Part-time use of directional microphones can be considered on a case by case basis with appropriate monitoring.

What we need to learn more about

Further knowledge about the characteristics of directional microphones and how they interact with young listeners' needs is necessary. Directional microphones work best when the most sensitive area of the microphone is directed toward the signal of interest. Based on the available research from school-aged children, it appears that their looking behaviors impact the benefit offered by directional microphones, and they are often not facing the target talker. Additionally, there is a need for young listeners to have access to sounds from all directions to promote incidental learning and awareness of sounds from different locations, thus, supporting the recommendation of part-time directional microphone use.

Directional microphones with fixed sensitivity points (e.g., polar plots) are available and can be accessed either manually or automatically within hearing aids. Manually-activated directional microphones would be appropriate for children or caregivers who are aware of the situations where the technology would be helpful and the child can orient appropriately to the signal of interest. Automatically-activated directional microphones would reduce user error; however, the interaction of the hearing aid's choice of sensitivity point compared to the listener's needs is not well-understood. Furthermore, directional microphones with roving sensitivity points might offer a solution to varying listening needs, but they have not been well-validated. Overall, a better understanding of the various applications of directional microphones in children's hearing aids is required.

The impact of directional microphones on speech audibility as well as overall benefit for improved SNR requires further

development. A clear verification protocol to assess these important clinical topics is necessary to support the use of directional microphones in pediatric hearing aid fittings.

As we learn about directional microphone technology and how to verify it, we need to define candidacy. For the children with whom we work who wear hearing aids, we need tools to support our clinical recommendation (or not) of directional microphones. Understanding how the application can impact communication development for a child of a particular age (e.g., 6 months versus 6 years) and degree of hearing loss (e.g., mild versus severe) is important. Additionally, the combinations of directional microphones and other technologies such as ANR and remote microphone hearing assistance technologies are of interest when managing our young patients. Using outcome measures that are sensitive to the impact of noisy environments can identify the need for directional microphones and, with the appropriate tools, assess their impact.

Although in recent years evidence to inform the use of directional microphones for children with hearing loss has become available, additional understanding of the technology is needed – e.g., defining candidacy and conducting clinical verification and validation in infants, toddlers and school-aged children.

What we should consider in the meantime

It is important to ensure that caregivers participate in the decision-making process. Until further evidence is available to guide our recommendations for directional microphone use in pediatric hearing aid fittings, caregivers should be informed about the current state of technology and evidence to support use or non-use. The need for directional microphones can be identified through conversations with caregivers or other team members and formal outcome assessments. Some outcome measures (e.g., Parents' Evaluation of Aural/Oral Performance of Children [PEACH], Ching & Hill, 2007) have items pertaining to noisy environments that can flag further discussion about the application of directional microphones or other noise management technologies. The motivation and readiness of the caregivers are essential to support effective use and monitoring.

Additionally, it is convenient that directional microphones are a standard feature in most hearing aids provided to children, so the activation of the technology for a trial period is a viable option. Administering outcome measures to assess benefit following directional microphone activation will

inform future adjustments. Furthermore, if large pediatric centers or EHDI programs develop protocols for applying, verifying and monitoring the use of directional microphones in children, this can further inform on the impact of the technology and contribute to the existing evidence.

Although more research on the use of directional microphones in children with hearing loss, especially infants and toddlers, is needed, relevant findings have contributed to the development of guidelines and protocols for pediatric audiologists who are considering this technology for their young patients. In the meantime, informative discussions with the child's family and other team members to share current knowledge and foster a collaborative approach to monitoring, should the technology be applied, is vital. A child who has hearing loss requires access to speech in a variety of listening situations and it is important to have a clear understanding of how directional microphones can impact this goal.

Summary information for professionals and caregivers

Directional microphones are readily available in children's hearing aids but are often not activated in the early stages of language development. This is because the young listener must turn his/her head toward the talker of interest for maximal effectiveness of the technology. Research shows that this skill is not well-developed in young children; thus directional microphones can potentially reduce the volume of speech that children need to hear in order to develop communication skills appropriately. Although some directional microphones attempt to orient to speech automatically, they can respond differently in various situations. Furthermore, effective protocols for audiologists to verify the activity of directional microphones are not well-developed.

Until audiologists can ensure that this technology provides consistent access to speech in the presence of noise for infants and young children, the clinical recommendation is to avoid activating directional microphones on a full-time basis. Part-time use can be considered as long as the impact is closely monitored by all care providers. For older children who have the maturity to understand how directional microphones work and are able to use them appropriately, they are a viable option. Access to remote microphone hearing assistance technologies should remain a viable option to combat the negative effects of noise for infants and children who have hearing loss.

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