Critical Review: Do School-Aged Children with Hearing Loss have Improved Speech Recognition in Noise when Using Directional Microphones versus Omni-directional Microphones?

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This critical review examines whether school-aged children perform better on speech recognition tasks when using directional microphone hearing aid technology, as compared to conventional omni-directional technology. Overall, the reviewed literature indicates that directional microphone technology improves speech recognition in background noise for children with hearing loss. However, the research also suggests that the use of directional microphone technology to improve signal to noise ratio (SNR) should only be considered for older children and only when FM technology, the system of choice in difficult listening environments, is not being used.

Introduction

One of the primary complaints from individuals with sensorineural hearing loss is their inability to hear effectively in background noise. Studies with adults and children have revealed that

Studies selected for inclusion in this critical review were required to investigate whether directional microphones provide greater speech recognition in noise than omni-directional microphone technology when used by school-aged children. No limits were set regarding the methodological design of the research studies.

Data Collection

Research of the literature yielded the following types of articles congruent with the selection criteria: group comparison in an experimental design using a three-way mixed statistical analysis of variance (2).

Gravel, Fausel, Liskow, and Chabot (1999) examined the efficacy of dual-microphone technology versus omni-directional microphone technology by assessing children's speech recognition abilities for words and sentences

omni-directional analog hearing aids at each of the three SNR levels assessed. On the LIFE questionnaire the digital directional hearing aids were rated higher by the students than their own omni-directional analog hearing aids (some with FM) in many of the listening situations listed. Of the parents who completed the parent questionnaire, 16 of 18 reported that the digital directional hearing aids improved their child's listening.

The results of this study revealed that children's speech recognition performance was improved when using directional technology in a typical laboratory environment. Ratings of school behavior on the LIFE questionnaire were higher when using the digital directional hearing aids, and there was a preference for keeping the digital directional aids over the children's own omni-directional analog hearing aids.

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Both of the reviewed studies assessed the effectiveness of directional microphone technology over traditional omni-directional microphone technology in a population of school-aged children. The results of both studies revealed that directional microphones provide a significant advantage over omni-directional microphones for speech recognition in noise by children with sensorineural hearing loss up to a severe degree. However, there were a number of limitations to the findings. First, both studies used small sample sizes of twenty children and testing was conducted in a typical laboratory environment (e.g. low reverberation and fixed azimuths of signal and competition) using closed sets of monosyllabic words and sentence materials. The results obtained under these conditions may not reflect children's performance in a real world listening environment where there is significant reverberation and speech messages are unrestricted. Second, during the speech in noise testing of both studies a single noise source was presented from 180 degrees azimuth to the children. This presentation provides limited external validity, because noise typically comes from all directions in children's daily listening environments. Directional microphone studies that have been conducted with adults have presented noise at five azimuths to the sides and back of the listeners (Ricketts & Dhar, 1999). This type of presentation would have improved the external validity of the reviewed studies. Finally, because the study by Kuk et al. (1999) compared digital directional hearing aids to analog omni-directional hearing aids, it is difficult to say if the children's improved performance and preference for the digital directional hearing aids can be attributed to the directional microphone technology alone rather than a synergistic effect of all the digital hearing aid features. Kuk et al. (1999) attempted to increase the external validity of their study by using subjective measures of performance and found that the advantages of a directional microphone can be seen in an improvement of listening behavior in the classroom and at home.

Despite the demonstrated advantages of directional microphones in the reviewed studies, both caution the application of these findings when fitting infants and young children for a number of reasons. First, directional microphones create a reduction of sounds arriving from directions other than in front of the listener and infants and young children require these inputs in order to develop basic auditory processes, such as selective listening and localization. Second, children require acoustic inputs from all directions in order to attend to important communication messages and environmental sounds for the purpose of safety. Finally, the use of directional microphone technology by children may have an adverse effect on the incidental learning of speech and languancencidhacil 2.64358(n)-7(')7.07018(s)2.7114.71676
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should be variable. In other words, the selected hearing aid should provide the wearer with the ability to switch between directional and omni-directional conditions. However, use is cautioned with younger children because research indicates that the use of multi-program functions is highly age dependent (Bohnert & Brantzen, 2004). For instance, young children may switch into a directional program when in a noisy environment, but then forget to switch back when in quiet. Due to advanced digital technology it is possible for audiologists to de-activate the directional program until the child is old enough that they are capable of adjusting their program settings appropriately and reliably based on different listening situations in order to optimize communication.

It is important for audiologists to counsel caregivers about which listening situations could be improved with the use of a directional program, so that parents can assist the audiologist in deciding when this technology would be appropriate for their individual child based on personal and environmental factors. If caregivers are motivated to manually switch between directional and omni-directional programs, using a program switch or remote control, depending on their child's particular listening environment, than that child may be able to make use of directional technology at a younger age. However, whether parents can truly master appropriate and reliable switching between two or more hearing aid programs remains to be demonstrated through field trials. Thus, the decision regarding when to set up a directional program for a child should be at the discretion of the clinician.

Further research is required in order to more clearly understand the appropriateness of providing directional microphone technology to the pediatric population. Classroom noise levels, reverberation, and large speaker-to-listener distances are primary communication barriers for children with hearing loss and therefore, studies of directional microphone technology need to be conducted in real-world listening environments. These future studies should use larger sample sizes, minimize confounds, and include follow-up testing. Further, these studies should focus on the effects of directional microphone technology on safety, incidental speech and language learning, and development, so that clinicians are provided with more clarity regarding these concerns.

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