Critical Review: Is There Evidence to Support the Use of Directional Microphone Technology within the Pediatric Population?

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Abstract

This critical review examined the literature available regarding the use of hearing aid directional microphone technology within the pediatric population, in comparison to conventional omni-directional technology. Each of the studies employed group comparison, experimental designs. Overall, research findings indicated that directional microphone technology improves speech recognition for children with hearing loss in background noise; however, results are limited to sound-treated test environments. Further, no studies were found that evaluated this technology in children under the age of 5 years.

Introduction

The first few years of a child's life are a critical time for developing speech and language. If a child has a hearing loss, the impact on speech perception could be quite significant. Decreased auditory input from a hearing loss could interfere with speech and language development, the developing auditory nervous system, and future academic performance. One way to lessen the magnitude of impact on children with hearing impairment is to fit them with hearing aids.

There is a lot to consider when fitting a young child with amplification, such as individual traits and abilities, as well as communication and learning situations. Audiologists must also consider the variety of features available in current digital amplification. Directional microphone technology is now a popular feature that is included in most hearing aids on the market. This technology favours the pick-up of sounds from the front of the listener compared to sounds from the back or sides, whereas, a traditional omni-directional microphone will pick-up sounds equally from all directions. Directional microphone technology can objectively increase the signal-to-noise ratio (SNR), assuming the desired signal is coming from the front, which eases speech perception in background noise. People with hearing loss require a higher SNR for satisfactory communication.

Although directional microphones improve the SNR, concerns arise when fitting infants and young children with this technology. For instance, will they be missing important environmental cues and sounds if the technology is focused in one direction? When fitting infants and young children with hearing aids, there is a decision to be made, during the critical period for speech and language development, between directional microphone technology and omni-directional technology.

To date, almost all of the research conducted has concentrated on the adult population. For this critical review, only two studies were discovered that examined the efficacy of directional microphone technology versus omni-directional technology for school-aged children. These can be used to investigate whether the technology should be used when fitting the pediatric population.

Objective

The purpose of this paper was to critically evaluate the existing literature regarding the use of directional microphone technology within the pediatric population, in hopes to assist pediatric audiologists making amplification decisions.

Method

Search Strategy

Computerized databases including CINAHL, PubMed, MedLine, and EMBASE were searched using the following strategies:

((directional microphone technology) OR (directional microphones) OR (directional hearing aids) AND (pediatrics) OR (infants) OR (children)).

This strategy was unsuccessful; therefore, a pediatric expert was contacted for guidance and provided relevant material. Other

articles were discovered through article referencing.

Selection Criteria

Research studies selected for inclusion in this critical review paper were required to examine the use of directional microphone technology within the pediatric population. The original focus was strictly 0-5 years of age, but due to the lack of research, studies involving any children were included. No limits were set regarding the methodological design or outcome measures.

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).

Results

Kuk, Kollofski, Brown, Melim, and Rosenthal, examined the efficacy of hearing aids with a directional microphone in children aged 7 to 14. This was achieved by objectively measuring speech recognition using the CID W-22 word lists at different SNRs in a background noise. Levels of 72, 65, and 52 dB SPL were presented in the presence of a 65 dB SPL party noise. Two subjective measures were also used to collect data: the Listening Inventory for Education (LIFE) questionnaire and a parent questionnaire.

Researchers recruited 20 children from 18 different elementary schools from a region and grouped them by degree of hearing loss; mild to moderately-severe and moderately-severe. The children all previously wore analog hearing aids, bilaterally, since the ages of three or four. All had similar audiological backgrounds, and a detailed description of the fitting procedure used on the participants was provided. The children were fitted with Widex Senso digital hearing aids, and wore the aids 30 days prior to the initial testing.

Appropriate statistics were used to analyze the gathered data. This study was a three-way mixed analysis of variance (F-stat). Post hoc analyses were done using the Honesty Significant Difference Test. A paired t-test revealed differences on the LIFE behaviours.

The outcome of this study indicated that children had better speech recognition performance with directional technology in a test booth for all SNRs. School behaviour ratings for the directional aids were higher on the LIFE questionnaire, and there was a preference for keeping the directional aids over their own omni-directional analog aids.

Gravel, Fausal, Liskow, and Chobot in 1999 examined the efficacy of dual-microphone technology versus omni-directional technology in children by measuring speech recognition abilities for words and sentences presented in multi-talker background noise. An adaptive test procedure was used to estimate the SNR that reduced an individual's ability to 50 percent by varying the noise level. The speech was fixed and the noise varied in 2 dB HL levels. A secondary goal was to decide if receptive language abilities correlated with the outcomes. The Receptive One Word Picture Vocabulary Test was used to determine language age, and is a standardized test on children between 2 years and 11 years, 11 months of age.

There were 20 participants recruited from one children's hearing program in Bronx, New York. These children were grouped by age: ten children aged 4 – 6 years, ten children 7-11 years. There was no significant difference in hearing loss between the groups. The children were all previous hearing aid users and were fitted with Phonak PiCs programmable hearing aids, bilaterally, using the same prescriptive procedure.

Appropriate statistics were again used to analyze the data. This was another three-way mixed analysis of variance. Significant effects were found for microphone type, speech material, and age group. An analysis of covariance was performed with receptive language as the covariate. Significant effects for microphone type and speech material were found, but not age group. A post hoc comparison was done using the Tukey Honestly Significant Difference Method, and correlations (r-stat) examining associations between outcomes, chronological age, language age, and degree of loss were completed.

After application of statistical measures, it was found that under testing conditions, dual-microphone technology provided a significant listening advantage in noise compared to conventional omni-directional technology for words and sentences in both age groups. The younger group required more SNR to perform at the same level as the older group. Receptive language ability was found to correlate well with the outcomes, as well as chronological age. This

would help explain why the older children required less SNR to achieve 50 percent performance.

Discussion

The results demonstrate efficacy of directional microphone technology, although they may not be generalizable to infants and young children. Small sample sizes of twenty were used in controlled test environments. Study conditions do not represent typical acoustic environments in which these children are in daily. Both studies used objective measures of speech recognition. The two tests involved measuring speech in noise, with speech entering the hearing aids from the front, and the noise from 180 degrees behind the subjects. In the real world, noise may be surrounding a person wearing hearing aids, and therefore, these results may not be representative of outside a clinic. Counterbalancing test conditions controlled for order effects. Kuk, et al. did incorporate subjective questionnaires as an attempt to increase external validity.

Although there was an advantage to using the directional microphone technology in the studies, both included discussions on potential harms and limitations to using it with infants and young children. A common concern in the literature is safety, which arises around the fact that young children may not always face or attend to environmental sounds if wearing directional hearing aids. There may be problems perceiving important sounds and communication coming from all directions due to reduction of acoustic input. Another concern is that surrounding input may be necessary to establish binaural developmental skills, such as localization. A final concern is how this technology could also affect incidental learning and limit speech and language development.

Conclusion

Outcomes from the studies indicate that directional microphone technology improves speech recognition for school-aged children that are hearing impaired in background noise, when compared to omni-directional technology. Research findings are limited to controlled test environments, but do show the efficacy of such technology. Due to the lack of evidence for the pediatric population, the question of use and benefit of directional microphone technology is inconclusive.

Recommendations

Audiologists providing pediatric amplification should cautiously make decisions regarding the use of directional microphone technology at present time. Personal and environmental factors play a major role when selecting and fitting amplification. Although there was an advantage found in the above studies for the technology, it was limited to controlled test environments and school-aged children. Not only is there a lack of research and evidence for the pediatric population, but also, there are speculations provided in the article discussions of safety, developmental, and speech and language concerns if this technology is to be used with infants and young children.

However, there may be certain situations where using directional microphone technology may be advantageous to this age group. The option of using this technology should then be made available. Over the course of the habilitation process, clinicians can educate and inform caregivers about directional microphone technology and appropriate environments for use. Caregivers may even come to the audiologist with questions pertaining to difficult communication situations they experience with their children. An audiologist may then suggest the use of such technology to increase the SNR, if the caregivers are deemed capable of handling the responsibility to manually switch between directional and omni-directional programs appropriately.

There is a need for further research to better understand the efficacy and effectiveness of directional microphone technology within the pediatric population. Instead of speculating concern, studies should be conducted focusing on environmental warning signals, localization, or speech and language for infants and young children. New research should aim for larger sample sizes of infants and children ages 0-5 years of age, and include more follow-up testing to ensure reliability of results.

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