Critical Review:
Do Personal FM Systems Improve Speech Perception Ability for Aided and/or Unaided Pediatric Listeners with Minimal to Mild, and/or Unilateral Hearing Loss?

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This critical review examines whether FM devices improve speech perception abilities in unaided and/or aided pediatric listeners with minimal to mild and/or unilateral hearing loss in a classroom environment. Study designs included: single subject with alternating treatments studies and a single group repeated measures design. Overall, the evidence provided by the existing literature suggests that the use of FM devices in a classroom by unaided and/or aided pediatric listeners with minimal to mild and/or unilateral hearing loss does appear to improve speech perception abilities. However, further research is necessary to confirm this trend.

Introduction

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Classroom acoustics are important to consider in education. Noise, reverberation, and room modes typically interfere with the ability of listeners to understand speech (Berg et al., 1996). The 2002 ANSI standard on acoustical performance for schools has resulted in a heightened awareness of the effects of background noise and reverberation on student speech perception and learning (Anderson & Goldstein, 2004). The levels of background noise in a typical classroom are often higher than recommended levels, resulting in lower sentence repetition scores (Lewis, 1994).

Many strategies including personal hearing aids, environmental/teaching modifications and assistive listening devices have been used to assist hearing impaired children in the classroom setting (Lewis, 1994). Hearing health care professionals however, have become especially concerned with children who have minimal to mild hearing loss that are not severe enough to warrant the above solutions as beneficial. Children with minimal to mild hearing loss are often treated as if they were children with normal hearing, and must function in reverberant and noisy classrooms with little or no assistance (Johnson & Stein, 1997). Research shows that children with a mild and/or unilateral hearing loss are at greater risk for academic failure, language delays, problematic behavior, increased stress, increased difficulty concentrating, low self-esteem and social difficulties (Tharpe & Bess, 1999).

The lack of beneficial solutions for children with minimal to mild and/or unilateral hearing loss has resulted in the widespread use of educational amplification technology as a possible solution. Personal frequency modulated (FM) devices are used to improve the signal-to-noise (S/N) ratio at the listener's ear level by placing on the teacher a microphone

OR (unilateral) AND (assistive listening devices) OR
(frequency-modulation systems) OR (FM systems)
AND (speech perception) OR (speech recognition).

Limitations placed on the search strategy include:
Humans less than 18 years of age; English only articles

Selection Criteria

Selection of studies for this critical review were required to investigate the effectiveness of FM systems on improved speech perception or speech recognition ability tasks in unaided or aided school-aged children with minimal to mild and/or unilateral hearing loss. No limitations were placed on the setting for speech testing, the etiology of hearing loss or outcome measures used.

Data Collection

The results of the literature search generated three articles matching the search criteria mentioned above which will be discussed in this review. These included: 2 single subject with alternating treatments design and 1 single group with repeated measures design.

Results/Discussion

Anderson and Goldstein (2004) used a single-subject alternating treatments design to compare the speech recognition abilities of eight 9-12 year olds with mild to severe hearing loss. The children recruited were educated in general education classrooms and had normal intelligence, language abilities within 1 year of their age peers, and no other disabilities other than hearing impairment. Researchers wanted to test FM systems, infrared devices, and hearing aids to observe potential improvements in speech perception. However, for the purpose of this review, only the data from the FM devices will be reviewed and discussed.

All participants were long time binaural hearing aid users. Each child was required to verbally repeat sentences using the Hearing in Noise Test (HINT) while wearing their personal hearing aids alone to establish baseline performance. The HINT was then repeated using hearing aids in combination with an FM system. The conditions for each test included background noise at 10 dB SNR and a 1.1 second reverberation time. The experiment was performed in a kindergarten classroom, with a simulated teacher 1.7 m in from of the blackboard; typical of a classroom listening environment. The speech signal was delivered by a speaker to a microphone transmitter placed 8.9 cm from the speaker. To objectively evaluate the benefit of amplification with FM devices, there were a total of fifteen word lists; 50 key words per HINT sentence list with a total of 30 sentences.

this study for practical application, individual student characteristics and the specific acoustic characteristics of the learning environment need to be considered carefully (Anderson & Goldstein, 2004).

The outcome of this study indicated that in a noisy, reverberant classroom, benefit in speech perception was illustrated when a personal FM system in combination with personal hearing aids was used. Therefore, it appears that a personal FM system will provide listening benefits for children with mild to moderate

academic setting. The benefits appear to be in academics, attention, communication and participation in a classroom setting. However, results are suggestive and depend on many other factors. Conclusions should be made with caution as the study provides a low level (level 2c) of evidence.

Hawkins (1984) used a single group repeated measures research method to compare speech recognition in noise for nine children aged 8-14 who had mild to moderate sensorineural hearing loss using various hearing aid and FM system plus hearing aid combinations in a school classroom. This was achieved by objectively measuring performance using two measures: (1) an adaptive procedure to determine the signal to noise ratio necessary for 50 percent performance (2) word recognition scores were attained at signal to noise ratios representing a noisy (+6 dB) and relatively quiet (+15 dB) school classroom. For 11 conditions, the adaptive procedure used spondee words that were presented at 65 dB SPL with the level of speech noise varied in 2 dB steps. In the remaining 6 word recognition conditions, phonetically balances kindergarten (PB-K) word lists were presented through a tape recorder. All testing was performed in a school classroom with a mean reverberation time of 0.6s. Speech signals were delivered from a loudspeaker 2 m from the child located at 0 degrees azimuth. This location for the child was chosen to represent a favorable seating location in the classroom (Hawkins, 1984). Noise was delivered from the speaker 4 m from the child located at 180 degrees azimuth.
Each participant was fitted with Phonic Ear 805 CD behind-the-ear hearing aids bilaterally and was measured with this amplification initially. After performance was measured with the hearing aids, a Phonic Ear 441T FM transmitter and 445R FM receiver with controlled settings was added and this condition was administered to each participant in a random order.

A single factor repeated measures analysis of variance (ANOVA) was performed separately on both the adaptive procedure and word recognition conditions. A significant effect of amplification arrangement was found for both sets of conditions (Hawkins, 1894). The differences between conditions were calculated and analyzed using the Newman Keuls method.

The results illustrated that the largest differences were observed when the FM only conditions were compared to the hearing aid and FM + hearing aid microphone conditions (Hawkins, 1984). The FM only conditions all showed a significant signal to noise ratio advantage over all hearing aid and FM + hearing aid microphone conditions. In the word recognition procedure, the results indicated that the FM system with personal hearing aids, at a 6 dB SNR, had a better overall score than the hearing aids alo0a34(o)7(u)8op)d

variability seen in the data, it is apparent that children with minimal to mild hearing losses, who are not considered candidates for traditional hearing aids, should be fit with FM devices in educational settings. Unfortunately, due to small sample sizes, a limited number of studies and lack of randomized control trials, caution should be taken when drawing definite conclusions regarding the improvement of speech perception ability with the use of FM systems. Further research is needed to investigate why some children receive more benefit from the use of FM systems than others.

Clinical Implications

From the studies summarized in this literature review, it is clear that FM systems do provide children who have minimal to mild hearing loss with significant potential benefit in an educational setting. Compared to their normal hearing peers, children with hearing impairment require the use of FM technology in their classrooms to allow them to have equal access to verbal instruction (Anderson & Goldstein, 2004). Based on the variability in the data however, it is apparent that personal factors such as attention or attitude, and environmental factors such as classroom acoustics, affect whether or not a child will receive benefit from an FM system. Consequently, when fitting a child with an FM device, Audiologists should use a patient-