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Simulated Conductive Hearing Loss in Children

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Abstract

Otitis media with effusion (OME) often results in hearing loss for children with the condition. In order to provide appropriate and effective audiologic management, it is important to understand the impact of OME on speech recognition ability when hearing loss is present. This study examined the speech recognition abilities of normal-hearing six- and seven-year-old children (n = 12) and adults (n = 12) using monosyllabic words and nonsense syllables presented at two levels of simulated conductive hearing loss characteristic of OME. Average speech recognition scores decreased as the degree of simulated conductive hearing loss increased. Both age groups scored significantly poorer for nonsense syllables than for monosyllabic words. In general, the children performed more poorly than the adults with the exception of the easiest listening condition for word stimuli. Furthermore, children appeared less able than adults to use their knowledge of familiar words to improve performance. These findings suggest that rehabilitative strategies may best be focused on combining familiarization techniques and amplification options.

Key Words: Children, conductive hearing loss, nonsense syllables, otitis media, speech recognition

Abbreviations: OME = otitis media with effusion; PBK = Phonetically Balanced Kindergarten; rms = root mean square; SCHL = simulated conductive hearing loss; SII = speech intelligibility index

Sumario

La otitis media con efusión (OME) produce a menudo una pérdida auditiva en los niños que la padecen. Para poder aportar un manejo audiológico apropiado y efectivo, es importante entender el impacto de la OME en la capacidad de reconocimiento del habla cuando está presenta una hipoacusia. Este estudio examinó la capacidad de reconocimiento del habla de niños normo-oyentes de seis y siete años de edad (n = 12) y de adultos (n = 12), utilizando sílabas sin sentido y palabras monosilábicas, presentadas a dos niveles de hipoacusia conductiva simulada, característicos de la OME. Los puntajes promedio del reconocimiento del habla disminuyeron conforme el grado de hipoacusia conductiva simulada se incrementó. Ambos grupos de edad rindieron significativamente peor con las sílabas sin sentido que con los monosilábicos. En general los niños rindieron peor que los adultos con la excepción de las condi-

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ciones de escucha más fáciles con palabras. Más aún, los niños lucieron menos aptos que los adultos para utilizar su conocimiento de palabras familiares en el mejoramiento de su rendimiento. Estos hallazgos sugieren que las estrategias rehabilitativas deben enfocarse en la combinación de técnicas de familiarización y opciones de amplificación.

Palabras Clave: Niños, hipoacusia conductiva, sílabas sin sentido, otitis media, reconocimiento del lenguaje

Abreviaturas: OME = otitis media con efusión; PBK = lista fonéticamente balanceadas para niños de jardín de infantes; rms = raíz media cuadrada; SCHL = Hipoacusia conductiva simulada; SII = Indice de inteligibilidad del habla

Nearly every child will experience otitis media with effusion (OME) during childhood (Paradise et al, 1997). Generally, age is inversely related to the prevalence of OME. Infants show higher prevalence rates than children in preschool who, in turn, show higher prevalence rates than children in elementary school (Howie et al, 1975; Strangerup et al, 1994; Williamson et al, 1994; Daly et al, 1998). Although fewer investigations report prevalence rates of OME for children older than six years of age, those that do corroborate the inverse relationship with age. Prevalence rates are about 20% at age five and decrease to 5–10% by age eight. Beyond this age, reported rates range between 2 and 7% (Bennett et al, 1980; Stool et al, 1980; Lous and Fiellau-Nikolajsen, 1981; Chalmers et al, 1989; Williamson et al, 1994; Bess et al, 1998).

Episodes of OME can resolve spontaneously, although many children experience persistent OME for prolonged periods. Roland and colleagues (1989) found that OME resolved without medical intervention in 17% of their infant population within 30 days. However, the median number of days before resolution of OME was 72 days. Most preschool- and school-aged children who develop OME will experience the disease for more than two months before spontaneous resolution (Casselbrant et al, 1985; Zielhuis et al, 1990). Thus, the number of cases remaining unresolved beyond two months is substantial. In any case, when OME is present one associated factor is some degree of conductive hearing loss. In children, this hearing loss is generally within the mild-to-moderate hearing loss range (Kokko, 1974; Fria et al, 1985; Hunter, 1993). Given the high prevalence and often lengthy time for resolution of OME, many children with the condition are at risk for significant hearing loss over extended periods.

In order to make appropriate and effective recommendations for audiologic management of children with recurrent OME, it is important to understand how the associated hearing loss impacts speech recognition. Dobie and Berlin (1979) provided preliminary data for anticipated performance by simulating a mild conductive hearing loss and preparing a spectral analysis of the "filtered" speech. From this simulation, they hypothesized the potential impact on speech perception. In 1998, Crandell and Flannagan showed that a simulated mild conductive hearing loss (SCHL) significantly impacted speech perception in normal-hearing adult subjects, both in quiet and background noise. Although the latter study found significant effects of SCHL on speech recognition abilities, the data were derived from adults only. Larger effects might be expected for young children who are developing speech and language skills or those learning new concepts in the classroom environment. Likewise, effects might be larger for greater degrees of hearing loss.

Previous reports have shown children's speech recognition performance to be poorer than adults' when presented with stimuli of similar contexts. Normal-hearing children require a higher level of audibility, better signal-to-noise ratio, and less distortion than normal-hearing adults to reach similar performance levels (Elliott, 1979; Nittouer and Boothroyd, 1990: Eisenberg et al, 2000; Stelmachowicz et al, 2000). Johnson (2000) recently showed that children's correct identification of nonsense syllables in conditions of either noise alone or reverberation alone did not reach adultlike performance until after 14 years of age. For a combined noise and reverberation condition, performance did not reach adultlike levels until the later teens. Even in a quiet control condition, the children scored more poorly at all intensity levels than an adult group.

Young children with OME histories perform more poorly on speech recognition tasks than their peers without OME histories (Jerger et al, 1983; Brown, 1994; Gravel and Wallace, 1992; Rosenfeld et al, 1996). Notably, all of these reports assessed speech recognition in the presence of normal or near normal hearing sensitivity. The existence of deficits in speech perception with normal or near normal hearing levels suggests that an even greater deficit will be observed when conductive hearing loss is still present. Accordingly, children with minimal degrees of sensorineural hearing loss (i.e., pure-tone thresholds between 15 and 30 dB HL) score more poorly on speech recognition tests than their normal-hearing peers (Crandall, 1993). The disparity between children with and without hearing loss increased as the difficulty level of the task or the adversity of the listening condition increased (Boney and Bess, 1984; Crandell, 1993). Although these reports included children with permanent hearing loss, the degree of the loss was consistent with hearing loss associated with OME. Based on these findings, it is indeed possible that children who are experiencing hearing loss secondary to OME would exhibit performance deficits on speech recognition tasks similar to those with minimal sensorineural hearing loss.

As such, the communication competence of children with OME in the classroom or any learning environment may be compromised during an episode of OME or even after its resolution. Information regarding any such deficits could play a critical role in developing preventative strategies or direct interventions to lessen the educational impact of the hearing loss associated with OME. The purpose of this investigation was to measure and compare the possible effects of OME on speech recognition in children and adults by simulating configurations of hearing loss commonly associated with the condition.

METHOD

Participants

Twelve six- and seven-year-old children (seven males, five females) with a mean age of 7.25 years (SD = 0.71 years) were evaluated. Twelve adults (five males; seven females) ranging in age from 21 to 43 years, with a mean age of 31.60 years (SD = 7.40 years), served as a comparison group and received identical testing.

All participants had normal middle ear function and demonstrated pure-tone hearing thresholds ≤15 dB HL at octave frequencies from 250 through 8000 Hz and at the two additional frequencies of 3000 and 6000 Hz bilaterally on the test date. Normal middle ear function included tympanograms with peak pressure between 0 daPa and -150 daPa, tympanometric width within 60 to 168 daPa (Nozza et al, 1994), and both ipsilateral and contralateral acoustic reflex thresholds ≤105 dB HL at 1000 and 2000 Hz. All participants had a negative history for head trauma, ear surgery, or speech-language therapy.

The children had a negative history for middle ear dysfunction before two years of age. Negative history was defined as less than five episodes of otitis media (either acute or OME) for which a prescribed medication was taken, never visiting an otolaryngologist for ear problems, never experiencing ear drainage, and caregivers never suspecting a hearing loss. No subjects had ear infections in the year prior to testing. The parent(s) supplied children's medical histories. All children passed a developmental screening for articulation and language using the Sounds in Words Subtest from the Goldman-Fristoe Test of Articulation 2 (Goldman and Fristoe, 2000) and the Peabody Picture Vocabulary Test—Third Edition (Dunn and Dunn, 1997). Participants were compensated for their participation in the study. The study was reviewed and approved by the Health Affairs Institutional Review Board at Vanderbilt University. Children provided verbal assent, and their parent provided written consent for their child's participation in the study.

Table 1. Attenuation Levels in dB Used to Simulate the Average and Maximum Hearing Loss Conditions

Attenuation Level (in dB)	Frequency in Hz 125	250	500	1000	2000	4000	6000	8000
Average	28.8	27.0	30.0	30.0	22.8	28.8	31.8	33.6
Maximum	40.2	39.8	42.0	43.2	34.8	43.2	46.8	48.6

Equipment

A clinical audiometer (GSI-16, Grason-Stadler) and acoustic immittance instrument (GSI-33, Grason-Stadler) were used to assess hearing and middle ear function. The speech material was presented through a loudspeaker via a compact disc player (SL-PG440, Technics) coupled to the clinical audiometer. All testing took place in a sound-treated booth. Calibration stability was corroborated by frequent output measurements (i.e., sound level meter measurements) throughout the study.

Materials

Speech stimuli included the Phonetically Balanced Kindergarten (PBK) word lists (Haskins, 1949, Lists 1, 3, and 4) and 50 syllables from the Nonsense Syllable Test (Levitt and Resnick, 1978; see the Appendix for test items). Speech materials were copied from compact discs and saved onto a personal computer. Carrier phrases were removed from all lists using Sound Forge software v4.0 (Sonic Foundry, Inc). After removal, the root mean square (rms) values were computed based on the digital waveforms in order to ensure similarity among the individual speech stimuli. One word, "bounce," was significantly different from the others and was adjusted by 12.8 dB to be consistent with the average rms of the other words in the same list. All remaining words varied by less than 9 dB. Then, the word lists and the nonsense syllable lists were concatenated, and the rms level for each list was measured. The rms levels were adjusted among the lists in order to obtain an unattenuated presentation level for each of 65 dB SPL (±2 dB) in the sound field (ANSI, 1996). After the lists were matched for level, the same carrier phrase, "say the word," and approximately 750 msec of silence were inserted before each of the speech stimuli. The level of the carrier phrase matched the level of the average speech stimuli. Approximately 3 sec of silent space was inserted between each stimulus.

Three randomizations of the selected 50 nonsense syllables were made from the original list and saved as three separate lists. All word and nonsense syllable lists were digitally filtered using Cool Edit Pro software (Syntrillium). Filtering conditions were designed to simulate average and maximum (i.e., mean +1 SD) hearing loss levels found for children with otitis media (Kokko, 1974). Table 1 shows the levels of attenuation employed.

One of the three randomized nonsense syllable lists was filtered with the average attenuation levels, and a second was filtered with maximum attenuation. The third list remained unattenuated. Each of the PBK word lists was filtered using the average and maximum attenuation levels. Therefore, each of the PBK word lists was saved on disc in these conditions: unattenuated, average, and maximum attenuation levels. Figure 1 compares the amplitude spectra of the original word and nonsense syllable stimuli and the two attenuated conditions. Panel A compares the amplitude spectra for the three filter conditions for one of the PBK word lists. The spectra for the remaining two-word lists were similar. Panel B shows the same comparison for the nonsense syllables. The spectra are comparable across the two speech stimuli. The greater intensity difference between the unattenuated and average filter conditions, and the average and maximum filter conditions is evident. All unattenuated and attenuated lists were recorded onto CD for presentation to the participants.

Procedure

All participants were seated in a sound booth directly facing the loudspeaker, which was six feet from the participant's head and three and a half feet from the floor (i.e., approximately at ear level). Participants were instructed to repeat the word they heard and were encouraged to "guess, if necessary." Responses were tape recorded for scoring offline.

Order of presentation of the speech stimuli type was counterbalanced. Half of the participants from each age group received the monosyllabic words first, whereas the other participants received the nonsense syllables first. For either set of speech stimuli, the attenuation conditions were presented in one of the following orders of presentation: unattenuated, average, maximum; average, maximum, unattenuated; maximum, unattenuated, average. These orders of presentation were equally presented across the participants in each age group. In all cases, the word list order remained the same (i.e., List 1, List 3, List 4); however, the filter conditions changed as mentioned above. A practice list of 20 speech stimuli was presented before testing to familiarize the participants to the task. The practice list consisted of syllables presented at 65 dB SPL in an unattenuated condition. No practice items appeared in any of the test lists.

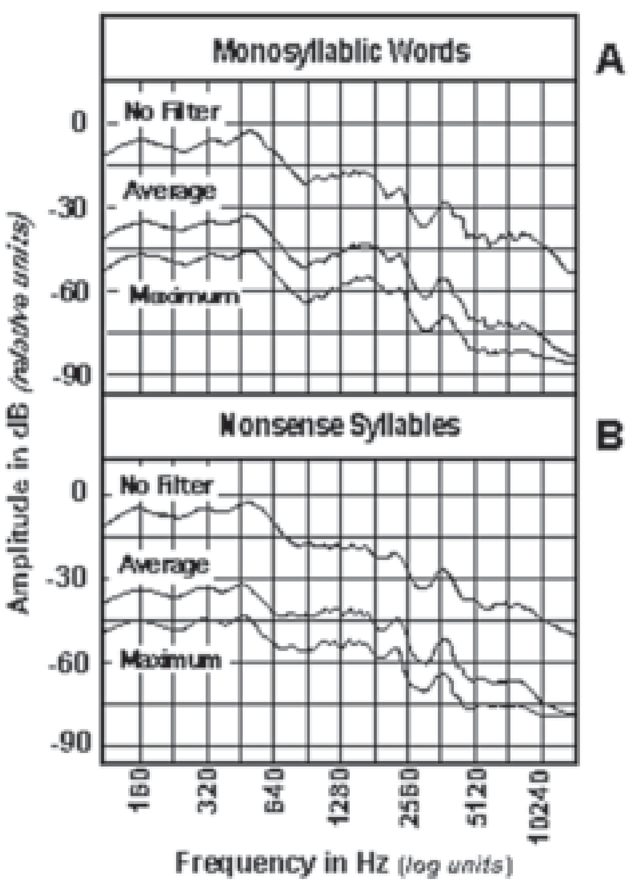

Figure 1. Amplitude spectra for original speech stimuli and two attenuated conditions are shown. Relative units in dB are used to make comparisons among the three filter conditions. Panel A compares the levels for the monosyllabic words. Panel B compares the levels for the nonsense syllables.

At least one break was offered during testing, or a break was given at the subject's request. Test time took from 45 to 90 minutes.

Statistical Analysis

Data were analyzed by a mixed-design analysis of variance (ANOVA). There was one between-subject factor (age) and two within-subjects factors (filter condition, stimulus type). Because recognition scores were reported in percent correct and were not normally distributed, arcsine transformations were conducted prior to the statistical analyses (Zar, 1974). Post hoc analyses were performed using a Tukey HSD test. Statistical significance was evaluated at the alpha level of 0.05.

RESULTS

Table 2 summarizes the speech recognition performance data for the adults and for the children. The mean recognition scores in percent correct decreased as the degree of attenuation increased for both age groups and for both monosyllabic words and nonsense syllables. Ceiling effects were observed for unattenuated words for both age groups. In fact, all adults and 7 of the 12 children scored 100% at this condition. In addition, four adults scored 100% for the average attenuation, word condition. Floor effects were not observed.

The statistical analysis revealed significant main effects for age ($F[1,22] = 31.81$, $p < 0.0001$), stimulus type ($F[1,22] = 334.47$, $p < 0.0001$), and degree of attenuation ($F[2,44] = 241.59$, $p < 0.0001$). On average, the adults performed significantly better than the children. In addition, average performance for monosyllabic words was significantly better than performance for nonsense syllables at similar listening conditions. Finally, a significant inverse relationship was found between degree of attenuation and performance. In other words, as attenuation increased, speech recognition scores decreased for both groups.

In addition, significant interaction effects between degree of attenuation and age group ($F[2,44] = 8.82$, $p = 0.0006$), as well as between degree of attenuation and stimulus type ($F[2,44] = 6.07$, $p = 0.005$), were observed. The three-way interaction was not significant ($F[2,44]$, $p = 0.21$). The data from Table 2

Table 2. Average Speech Recognition Scores (in Percent Correct), Standard Deviations, and the Range of Scores for 12 Children and 12 Adults

	Adults			Children		
Speech Stimuli	Mean	SD	Range	Mean	SD	Range
Monosyllabic Words						
Unattenuated	100.00	0.00	100–100	98.82	1.80	94–100
Average	97.83	1.80	96–100	87.67	7.90	70–98
Maximum	86.17	5.01	76–94	62.50	14.02	34–78
Nonsense Syllables						
Unattenuated	90.83	5.62	76–98	84.33	5.90	76–94
Average	82.67	5.28	74–88	68.50	14.72	24–78
Maximum	66.33	6.87	54–76	46.33	17.18	6–62

Note: Scores are shown for two speech stimuli across three attenuation conditions.

are plotted in Figure 2 in order to observe the possible source of the interaction. Clearly, the adults' performance for word stimuli (i.e., open squares) was less affected by increasing attenuation than was performance for the nonsense syllables (i.e., filled squares). In fact, scores fell only 14% from the unattenuated to the maximum attenuation condition for words, while scores for the syllables decreased 24% across the same conditions. The children's performance, on the other hand, was essentially identical for the two stimulus types (i.e., open circles = words; filled circles = nonsense syllables). The children's performance scores decreased by 36% and 38%, for the word and syllable stimuli, respectively, across the same attenuation conditions. Post hoc analysis revealed that the two levels of attenuation significantly impacted both word and syllable recognition scores for the children, while only influencing syllable recognition scores for the adults. For adults, the average attenuation level did not negatively impact word recognition scores as compared to scores in the unattenuated condition. Scores at the maximum attenuation condition, however, were significantly affected for the adults. It should be noted that some of these patterns might have been influenced by the ceiling performance for words exhibited by adults in the unfiltered and average conditions and by children in the unfiltered condition.

Additionally, audibility values were computed based on the Speech Intelligibility Index (SII; ANSI, 1997) for both types of speech materials used. SII values are shown in Table 3. The values were similar between the two speech stimuli. Table 4 includes approximate predicted performance levels for adults that were calculated for three measures of speech recognition (ANSI, 1969). Performance predictions are made for phonemically balanced (PB) words based on a smaller test vocabulary size of 256 words, and for PB words based on a larger vocabulary of 1000 words, and for nonsense syllables. The two vocabulary sizes for PB words, one more limited than the other, were used to be more analogous to the vocabularies of the two age groups.

Comparison of these predictions and the 95% confidence intervals for the adults and children show that the children scored more poorly than predicted for both word groups and for nonsense syllables. The adults' words scores approximated the PB words with the 1000 item vocabulary, but their scores for

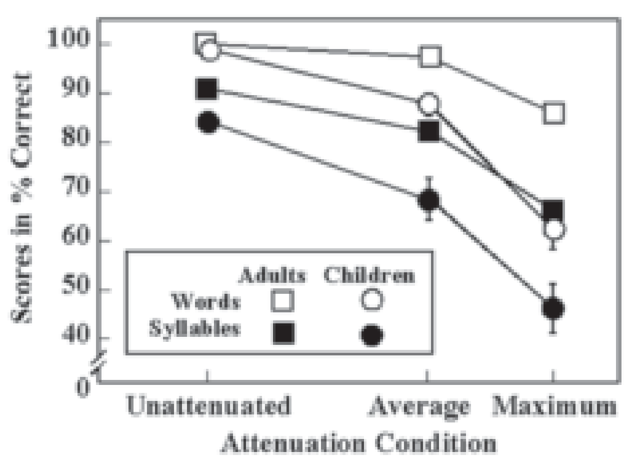

Figure 2. Average speech recognition scores for the two age groups are shown in this figure. A greater distance between the unattenuated and the average attenuation condition than the average and maximum attenuation conditions represents the intensity differences in the overall spectra. The scores for the adults are represented by the squares, and the children's scores are represented by the circles. Scores are shown for the monosyllabic words (open symbols) and the nonsense syllables (filled symbols) across the three attenuation conditions. The error bars represent one standard error of the mean.

Table 3. Speech Intelligibility Indices (ANSI, 1997) for the Monosyllabic Words and the Nonsense Syllables across the Three Levels of Attenuation

Attenuation Condition	Monosyllabic Words	Nonsense Syllables
Unattenuated	1.00	0.98
Average	0.92	0.93
Maximum	0.58	0.64

syllables were slightly less than the SII predictions. These values suggest that any differences observed in average scores were not due to audibility of the speech stimuli.

DISCUSSION

This study examined the effects of simulated conductive hearing loss (SCHL) on speech recognition of children and adults utilizing two degrees of attenuation. The speech recognition abilities of children and adults were compared for monosyllabic word and nonsense syllable stimuli. Performance was anticipated to be poorer for children than for adults for both word and syllable stimuli, and, indeed, this was the case. These results corroborate earlier findings that children perform more poorly than adults on speech recognition tasks when both groups are given similar acoustic stimuli (Elliott, 1979; Nittouer and Boothroyd, 1990; Eisenberg et al, 2000; Stelmachowicz et al, 2000). The present work extends this finding to stimuli presented at hearing levels characteristic of hearing loss due to OME.

Audibility was not considered to be a contributing factor to the performance differences observed between the two speech stimuli. The SIIs (ANSI, 1997) for the words and nonsense syllables were found to be similar. Furthermore, although not formally assessed, attention and motivation of the participants did not appear to differ across or within the age groups. All children and adults remained on task and in all cases the participants responded or guessed when necessary.

As the level of SCHL increased, speech recognition scores decreased for both the children and the adults. It is speculated that the adults would have better vocabulary knowledge than the children; that is, they had more established listening vocabularies. The performance scores from the adults are consistent with this explanation. Recall that the adults' scores showed a greater difference between word and nonsense syllable scores as the degree of attenuation increased. For children, the level of simulated hearing loss affected both types of speech stimuli equally. In other words, the most difficult listening conditions showed a greater performance difference between words and nonsense syllables for the adults than for the children. Others have reported similar findings when comparing speech recognition scores based on vocabulary knowledge or contextual cues. Nittrouer and Boothroyd (1990) reported that young children scored more poorly for high predictability sentences (i.e., those with contextual cues) from the Speech Intelligibility in Noise (SPIN) test (Kalikow et al, 1977) than young adults. In addition, the difference

Table 4. Word and Syllable 95% Confidence Intervals for the Speech Stimuli (Words and Syllables) for the Adults and the Children Compared to Predicted Scores for Similar Speech Materials

	Adults	Children	Predicted Scores		
Speech Stimuli	95% CI	95% CI	256 Words	1000 Words	NS
Monosyllabic Words					
Unattenuated	100%	98–100%	100%	99%	—
Average	97–99%	83–92%	100%	98%	—
Maximum	83–89%	55–70%	97%	82%	—
Nonsense Syllables					
Unattenuated	88–94%	81–88%	—	—	97%
Average	80–86%	60–77%	—	—	96%
Maximum	62–70%	37–56%	—	—	83%

Note: Two-word scores were predicted based on functions from a test vocabulary size of 256 and a test vocabulary size of 1000 words (ANSI, 1969). NS = nonsense syllables.

scores between zero predictability sentences (i.e., containing no contextual cues) and high predictability sentences were much smaller for the children than for the adult group. Eisenberg and colleagues (2000) found a similar pattern for children aged five to seven years. In their study, the younger subjects did not utilize sentence context to help identify words within sentences from the Hearing in Noise Test for Children (HINT-C; Gelnett et al, 1995), and their scores were similar for PBK words and HINT-C sentences. Performance scores for older children (10–12 years) and adults were significantly greater for the HINT-C sentences than they were for words across varying levels of spectral resolution. Elliott (1979) found that children were less able to use the contextual cues in sentences than were adults and that the inability was directly related to age. In other words, sentence context provided less contribution to speech recognition for young children than older children and adults. These results suggest that young children who are still learning language rely more on the acoustic features of speech in order to recognize both words and syllables than do adults. Reduced redundancy of the speech due to signal attenuation resulted in greater difficulties understanding both words and nonsense syllables for the children while the attenuation impacted only adults' recognition of nonsense syllables. This difference in performance suggests that an established vocabulary makes adults less susceptible to the effects of attenuation due to SCHL than children who are still developing their lexicon.

Consideration of this inefficiency to utilize contextual information is important when developing rehabilitative strategies for children. For example, educators might wish to pre-tutor or provide vocabulary terms before a lesson in order to make novel or unfamiliar vocabulary more familiar to the child. However, when setting goals for this strategy, the child's age should be considered. Expectations should be weighed according to results reported in this and other previously published reports of speech recognition abilities in young children. In other words, in some children familiarization alone may not provide enough benefit to reduce adequately the impact of hearing loss due to OME.

Additional rehabilitative strategies, such as the use of FM systems, might be appropriate to provide effective aural rehabilitative management. Since speech recognition abilities of children in this study of SCHL were not affected by stimulus type, the results suggest that audibility is critical to optimal understanding. Said differently, in the case of words, children cannot revert to a firmly established lexicon when speech becomes less redundant due to attenuation. Moreover, because they performed more poorly on the nonsense syllable recognition tasks than adults, their phonological repertoire appears to be even more sensitive to the effects of decreased redundancy of the speech signal. Therefore, increasing the overall level of speech and improving the signal-to-noise ratio may be the best means of ensuring children with conductive hearing loss have full access to the acoustic features necessary for speech understanding.

These results suggest that elementary school-aged children who have recurrent bouts of OME with concomitant hearing loss may be at a distinct disadvantage in the classroom. While a loss of hearing sensitivity is present, their speech recognition abilities are affected more so than would be predicted for adults. The effect may be significant enough to impact educational achievement (Davis et al, 1986; Bess et al, 1998). Furthermore, if the listening environment is noisy or less than ideal, the impact on a child's hearing is likely to be even greater. Because the children in this study had no significant abnormal middle ear disorder in their medical histories and all had normal speech and language development, these findings may not predict the performance of children with positive OME histories. Indeed, data suggest that children with histories of OME but normal hearing at the time of evaluation are likely to require an even more advantageous signal-to-noise ratio for optimal speech understanding as compared to their peers without such a history (Gravel and Wallace, 1992; Schilder et al, 1994). Children with significant OME histories could exhibit even worse performance, if any concomitant language deficits are present (Gravel and Wallace, 1998).

In sum, this study of the effects of simulated conductive hearing loss on speech recognition abilities suggests that children are more affected by amounts of hearing loss that do not adversely impact the performance of adults. Moreover, the results suggest that children still developing language and listening skills cannot use the same strategy, in this case, a large adultlike vocabulary, to compensate for a reduction in the redundancy of speech resulting from signal attenuation. Further, the effects of signal attenuation in general impact children with normal hearing and absent OME histories significantly more than normally hearing adults. Since the hearing loss associated with OME has frequently been described as a "simple effect of attenuation," our study suggests that the interaction of age and attenuation may make the effects of even "mild" conductive hearing loss of greater consequence than could be predicted from the performance of adults. Additional studies of speech recognition abilities of children with simulated conductive hearing loss and actual hearing loss secondary to OME will be useful in order to delineate more completely the impact of this common condition of childhood.

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APPENDIX

1. /ak/
2. /at/
3. /ap/
4. /af/
5. /as/
6. /a ʃ /
7. /up/
8. /us/
9. /uk/
10. /ut/
11. /uf/
12. /uʃ/
13. /ip/
14. /ik/
15. /if/
16. /iθ/
17. /it/
18. /i ʃ/
19. /is/
20. /az/
21. /an/
22. /ang/
23. /aθ/
24. /am/
25. /ad/
26. /ab/
27. /ag/
28. /av/
29. /ta/
30. /fa/
31. /ka/
32. /sa/
33. /tʃa/
34. /θa/
35. /pa/
36. /ha/
37. /ʃa/
38. /da/
39. /dza/
40. /ga/
41. /wa/
42. /ba/
43. /ra/
44. /ja/
45. /la/
46. /tha/ (voiced th)
47. /va/
48. /ma/
49. /za/
50. /na/