Children with hearing loss have been shown to have smaller vocabularies than their normally hearing peers suggesting a delay of 2 to 3 years in lexical development (Pittman et al. 2003, Blamey et al. 2008). The purpose of the present study was to examine the effects of noise on the word learning of children with normal hearing and children with hearing loss. Additionally, the benefits of digital noise reduction, available in most commercial hearing aids, was assessed. Previous research with noise reduction technology has shown no benefits to speech perception or speech reception threshold in children or adults. Therefore, it was hypothesized that the word learning of children with hearing loss would be poorer than that of children with normal hearing in quiet and in noise, and that the digital noise reduction feature would offer little benefit to children with hearing loss.

Method

Participants

Normal Hearing Children: 20 - ages 8 to 9 years (mean 8;1) 21 - ages 11 to 12 years (mean 11;11)

Hearing Impaired Children: 13 - ages 8 to 9 years (mean 9;0) 15 - ages 11 to 12 years (mean 11;13)

Figure 1 shows the hearing levels of frequency for the right and left ears of the younger and older children, respectively. Average hearing levels (+1 SD) for the younger (filled symbols) and older (open symbols) groups are shown in each panel.

Stimuli

Table 1 shows the orthographic and phonetic transcription of the nonsense-words created for this study.

The stimuli and noise were presented in the sound field at 50 dB SPL for a nominal SNR of 0 dB. Figure 2 shows the amplified waveforms for one child with hearing loss. The stimuli and noise are shown with DNR off (upper panel) and with DNR on (lower panel). The average effective SNR for all children with hearing loss (Figure 3) was -1.7 and -2.6 dB for the younger and older children without DNR, respectively. When DNR was activated, the average effective SNR was 0.6 and -0.3 dB for the younger and older children, respectively, for an average improvement of 2.3 dB for both groups. The effective SNR ranged from -8.4 to 4.2 dB across conditions for the nominal SNR of 0 dB.

Procedure

The children’s task was to learn the word belonging to each picture using an interactive computer game that promotes word learning through a process of trial-and-error (Figure 4). In the game, a piece of the puzzle is added after each correct response, but not after incorrect responses.

Results

The trial-by-trial data were reduced to ten data points by calculating the average of the last 10 trials. Figure 5 shows the data for one 11-year-old child with normal hearing learning in the quiet listening condition. The data were fit with an exponential growth function resulting in a curve growing in a smooth fashion from a raised floor at chance performance. The number of trials corresponding to 70% correct performance was then determined.

Figure 6 shows the learning functions for the younger and older children learning in quiet and in noise. For the children with normal hearing (NHIC), older children required significantly fewer trials to learn than the younger children, but no differences were found between the quiet and noise conditions. The children with hearing loss (HIC), required significantly more trials to learn the words than the children with normal hearing, with the poorest learning occurring in noise. These results indicate that learning new words is more difficult for children with hearing loss, particularly in noise.

Discussion

The results of this study suggest that DNR may provide amplification with which children can tolerate and learn in noise. This notion is further supported by research showing that children with hearing loss prefer amplification with more gain in quiet listening situations and less gain in noisy listening conditions. It is possible that the small improvement in overall SNR (average of 2.3 dB), the reduction in overall stimulus level (average of 5.3 dB), and the older children’s greater vocabulary knowledge provided the conditions necessary for the benefits of DNR to become apparent. More importantly, the results suggest that both children with early and later identified hearing loss are able to benefit from digital noise reduction.

Reference


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