Preferences for Digital Noise Reduction Settings

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Background

Digital noise reduction algorithms have been available in hearing aids for over a decade (Bentler & Chiou, 2006). Although it has been shown repeatedly that hearing impaired listeners prefer this feature (Boymans & Dreschler, 2000; Ricketts & Hornsby 2005; Brons, Houben, & Dreschler, 2014), to date, attempts at customizing this feature to an individual during the fitting session have not resulted in clear clinical guidance. The lack of clarity is largely the result of variability in the amount of noise reduction listeners prefer (Brons, Houben, & Dreschler, 2014; Gregan, 2001; Zakis, Hau, & Blamey, 2009) and a lack of correlation between these preferences and any available patient variables. Therefore, this feature has typically been fit on a trial-and-error basis, in which the audiologist sets the amount of noise reduction to a default setting and adjusts it only after the patient has tried the hearing aids in the real world and expressed a preference for a setting other than the default.

Recently, several research studies have shown that noise reduction algorithms can allow people to tolerate a greater amount of background noise while listening to running speech (Mueller, Weber, & Hornsby, 2006; Edwards, et al. 2011; Eddins, Klein, Arnold, & Ellison, 2013). Further, people who are intolerant of background noise received the most benefit from these algorithms. In these studies, "benefit" was measured as improvement on the Acceptable Noise Level (ANL) test. The ANL test is a measure of the maximum amount of background noise, in dB, that someone is "willing to put up with" while listening to running speech (Nabelek, Tucker, & Letowski, 1991). It is calculated as the difference between the listener's Most Comfortable Listening Level (MCL) for speech and the maximum background noise level (BNL) that the listener is "willing to put up with" while listening to the speech; ANL = MCL – BNL. This is exciting news because it suggests that people who are intolerant of background noise may need more aggressive noise reduction algorithms than people who are already very tolerant of background noise. The goal of our study was to determine whether we could predict preferences for strength of noise reduction (NR) based on an individual's ANL.

Method

Dozens of individuals with hearing impairment were screened with the ANL test in order to identify 10 people with a high tolerance for background noise and 10 with a low tolerance for background noise. All 20 study participants were native English speakers with sloping, symmetrical, sensorineural hearing loss. Participants were tested with the ANL test using the stimuli and method described by Nabelek and colleagues (2006). Speech (the Arizona Travelogue (Cosmos Dist. Inc., n. d.)) and noise (multi-talker babble (Bilger, et al. 1984)) were presented from a loudspeaker that was positioned at a distance of 3 feet from, and at a 0° azimuth relative to, the listener, who was seated in a sound-treated booth. ANLs (MCLs and BNLs) were tested five times each using an adaptive procedure. The first iteration was practice, iterations 2-5 were averaged to calculate the individual's ANL.

Study participants who were tolerant of background noise had unaided ANLs of 1.4 to 5dB (i.e., they were willing to listen to speech at low signal-to-noise ratios (SNRs); this group was termed the "low ANL" group), and those who were intolerant of background noise had unaided ANLs of 9.5 to 18dB (i.e., they were only willing to listen to speech at very high SNRs; this group was termed the "high ANL" group).

Once identified, study participants were fitted with bilateral Muse i2400 Behind-The-Ear (BTE) hearing aids coupled to lucite, skeleton earmolds with select-a-vents. Hearing aids were prescribed to NAL-NL2 targets as verified using Audioscan Verifit 2 real-ear equipment. A different NR setting was programmed into each of the four hearing aid memories, with maximum attenuation values of 0, 6, 10 and 20dB.

All participants completed paired comparison testing in which they selected their preferred setting (memory) while listening to running speech and background noise. The Arizona Travelogue (Cosmos Dist. Inc., n. d.) was presented from a loudspeaker at a 0° azimuth relative to the listener and speech-shaped noise (SSN) was presented from loudspeakers at 135°, 180° and 225°. All loudspeakers were positioned 3 feet from the listener, who was seated in a sound-treated booth. Two SNRs were tested: speech 71 dBA/noise 70 dBA and speech 78 dBA/noise 80 dBA. Test levels were chosen to be representative of real-world noisy situations (Olsen, 1998). At each SNR, participants compared each NR setting (0, 6, 10 and 20dB) to each other setting 10 times and marked their preferred setting on a touchscreen monitor positioned in front of them. Participants were allowed to toggle between the two settings as many times as desired before indicating their preference. Testing was automated using a custom software application, which randomized the order in which the NR settings were compared and blinded both the experimenter and the participant to the test condition.

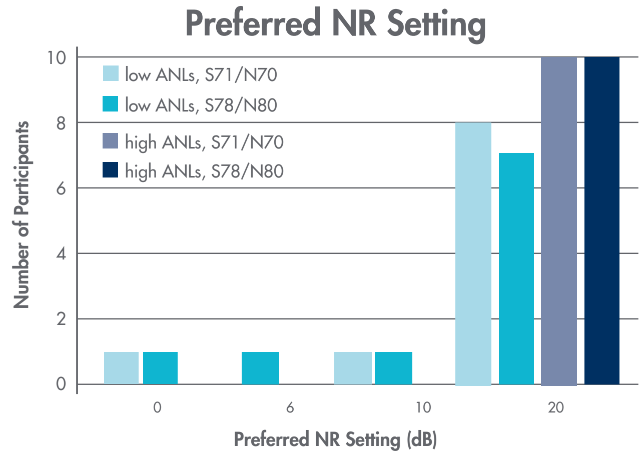

Figure 1: Preferred NR settings for listeners with low and high ANLs. Participants were tested at two SNRs: speech 71 dBA/noise 70 dBA and speech 78 dBA/noise 80 dBA. Almost all listeners preferred the maximum setting of 20 dB.

Results

Figure 1 shows the preferred NR setting for each individual at each SNR. Three individuals with low ANLs had inconsistent preferences across the two SNRs. Specifically, two individuals preferred a NR setting that was equal to or less than the default setting of 10dB, and one individual preferred a setting of 10dB at one SNR and 20dB at the other SNR. The remaining seven individuals with low ANLs, and all 10 individuals with high ANLs (85% of participants), preferred the maximum NR setting of 20dB at both SNRs.

Discussion

The goal of this study was to determine whether knowledge of one's tolerance for background noise, as measured by the ANL test, would allow the audiologist to customize NR to the patient. We hypothesized that participants with high ANLs would prefer greater amounts of NR than those with low ANLs. While those with low ANLs were more likely than those with high ANLs to prefer a low NR setting, the majority of individuals in both ANL groups preferred the most aggressive NR setting of 20dB. This result suggests that almost all listeners, regardless of ANL, would benefit from the increased listening comfort provided by the most aggressive NR. Results from a concurrent study by Smith and colleagues (2017) support this recommendation. In their study, 55 individuals—half with low ANLs and half with high ANLs—compared two hearing aid memories in the field. One memory had basic directionality and NR while the other had more aggressive directionality and NR. After a 1-month field trial, 64% with low ANLs and 70% with high ANLs preferred the memory with more aggressive directional microphones and NR.

Conclusion

Independent of noise tolerance, almost all participants preferred the maximum accessible noise reduction setting of 20dB. These preferences were consistent across a laboratory and complementary field study from two independent research sites. Based on the results of these studies, audiologists can feel confident that a selection of the maximum NR will be preferred and benefit patients by allowing them to enjoy improved listening comfort in background noise.

References

Bentler, R., & Chiou, L.-K. (2006). Digital noise reduction: An overview. Trends in Amplification, 10(2), 67-82.

Bilger, R. C., Neutzel, J. M., Rabinowitz, W. M., et al. (1984). Standardization of a test of speech perception in noise. Journal of Speech and Hearing Research, 27, 32-48.

Boymans, M., & Dreschler, W. A. (2000). Field trials using a digital hearing aid with active noise reduction and dual-microphone directionality. Journal of the American Academy of Audiology, 39, 260–268.

Brons, I., Houben, R., & Dreschler, W. A. (2014). Effects of noise reduction on speech intelligibility, perceived listening effort, and personal preference in hearing-impaired listeners. Trends in Hearing, 18, 1-10.

Cosmos Dist. Inc. (n. d.) Quality recordings for the hearing health care industry. Kelowna, B.C.

Eddins, D. A., Klein, A. V., Arnold, M. L., & Ellison, J. (2013). Acceptable noise level: Effect of presentation level, digital noise reduction, and stimulus type. Poster presented at the annual meeting of the American Academy of Audiology, Anaheim, CA.

Edwards, B., Abrams, H., Ellison, J., McKinney, M., Recker, K., & Valentine, S. (2011). Psychoacoustic mechanisms behind acceptable noise level thresholds. Podium presentation presented at the annual meeting of the American Auditory Society, Scottsdale, AZ.

Gregan, M. (2001). Axent: Summary of clinical trials: Final report.

Mueller, H. G., Weber, J., & Hornsby, B. W. (2006). The effects of digital noise reduction on the acceptance of background noise. Trends in Amplification, 10(2), 83-93.

Nabelek, A. K., Freyaldenhoven, M. C., Tampas, J. W., Burchfiel, S. B., & Muenchen, R. A. (2006). Acceptable noise level as a predictor of hearing aid use. J Am Acad Audiol, 17(9), 626-639.

Nabelek, A. K., Tucker, F. M., & Letowski, T. R. (1991). Toleration of background noises: Relationship with patterns of hearing aid use by elderly persons. Journal of Speech and Hearing Research, 34(3), 679-685.

Olsen, W. O. (1998). Average speech levels and spectra in various speaking/listening conditions: A summary of the Pearson, Bennett, & Fidell (1977) report. J Am Acad Audiol, 7, 1-5.

Ricketts, T. A., & Hornsby, B. W. (2005). Sound quality measures for speech in noise through a commercial hearing aid implementing "Digital Noise Reduction". Journal of the American Academy of Audiology, 16, 270–277.

Smith, S. L., Lilly, J., & Spanos, G. (in progress). Comparison of two hearing-aid noise management schemes in listeners with low and high tolerances for background noise.

Zakis, J. A., Hau, J., & Blamey, P. J. (2009). Environmental noise reduction configuration: Effects on preferences, satisfaction, and speech understanding. International Journal of Audiology, 48, 853-867.