Individual differences in self-adjusted gain for noisy rooms: effects on intelligibility

Peggy Nelson1, Dianne VanTasell1,2, Melanie Gregan1 Joseph Hinz1, Adam Svce1
1Department of Speech-Language-Hearing Sciences, University of Minnesota; 2Ear Machine, LLC, Chicago IL

Introduction

- Noisy restaurants are among the most challenging listening situations for hearing aid users, but little data are available to guide hearing aid fitting for these situations.
- Anechoic evidence suggests that listeners may value comfort over speech intelligibility as noise increases.
- Ear Machine™ technology allows users to adjust all parameters of multiband compression. MSP lab facility replication of noisy real-world settings, and allows experimental control of SNR in those backgrounds, along with direct observation of users' preferences for settings as SNR is experimentally varied.
- Previous results indicated that as signal-to-noise ratio (SNR) became less favorable, some but not all listeners self-adjusted gain considerably, possibly sacrificing intelligibility for comfort.
- Data are shown here from listeners with mild to moderate sensorineural hearing loss who self-adjusted amplification parameters in laboratory simulated restaurant environments.
- Estimates of individual audibility were computed post-hoc and were converted to predicted intelligibility scores (% correct).
- Most listeners selected lower gain settings at SRNs poorer than that which yield intelligibility of about 80%.
- For a proportion of the listeners, this resulted in reduced intelligibility at challenging SNRs.
- Overall, the data provide information about individual differences regarding the trade-off between reducing noise and maximizing intelligibility.

Our primary research question is: When listeners self-adjust gain, do they sacrifice intelligibility for comfort in noise?

Subjects and Methods

- Subjects used a mobile application, developed by Ear Machine LLC, running on the Apple iOS platform and implemented on an iPod Touch.
- Etymotic® headphones with foam tips delivered stimulus to both ears.
- 9-band multiband wide-dynamic range compressor/limiter
  - fast attack and slow release times
  - 12-band equalizer
  - signal processing was designed to provide a close match to a commercial hearing aid
- Subjects manipulated 2 controls on the Ear Machine interface.
- Loudness control changes gain, compression and limiting parameters in all 9 compression channels simultaneously.
- Fine tuning control changes overall frequency response in the 12 equalization bands.

STIMULUS
Speech stimuli were Connected Speech Test (CST, Cox et al., 1987) sentences presented at a level of 53 - 55 dBC, spatialized to match the room acoustics.

Listeners were tested while seated in the Multisensory Perception Laboratory at the University of Minnesota.

Listeners were instructed:

- Adjust the wheels until you can understand what the woman talking in the restaurant is saying as clearly as possible.
- Go back and forth between the wheels until you are satisfied that you have the best setting.

Figure 1. Average audiograms for 15 participants Extraction t=1.4 dB

Results: Overall Trends

- The figure below shows the change in gain along the x-axis as a function of the predicted change in intelligibility for the self-adjusted (SA) or NAL prescribed gain. The gray area represents the range of predicted intelligibility change between +5 and -10%. A few points fall outside that range.

Gain Change vs. Predicted %

- When the SNR (and overall level) increased such that intelligibility fell below 80%, subjects started turning down the gain, as seen in the staircase Figure 6 below. Differences between self-adjusted and NAL prescribed gain are plotted as a function of the predicted percent correct.

Figure 2. Predicted percent correct is shown as a function of the difference between self-adjusted gain and NAL prescribed gain. The gray area shows the 5-10 dB change.

A great deal of variation in self-adjusted gain is observed, especially when the SNR was least or most favorable. Listeners at times chose 10 - 20 dB more gain than NAL prescription for quiet conditions, and as much as 15-20 dB less gain for noisy conditions.

Figure 3. Average audiograms for 15 participants Extraction t=1.4 dB

Subjects and Methods

ReCDD and ReUEG were measured for each subject so that self-adjusted insertion gain (xG) could be compared to NAL and NL2 targets.

When the SNR was least or most favorable, the data provided information about individual differences regarding the trade-off between reducing noise and maximizing intelligibility.

Overall, the data showed considerable individual variability in self-adjusted gain, with some listeners trading intelligibility for comfort in certain noise conditions.

- At -10 dB SNR, the poorest SNR and the highest SPL self-adjusted gain was reduced but the least amount of intelligibility because intelligibility is already at minimum. At 0 and -5 dB SNR, gain was reduced by as much as 10 dB vs. NAL NL2 in a few cases, and it reduced intelligibility by as much as 20% for those subjects who chose to do so. They chose reduced gain (presumably comfort) over intelligibility in these cases.
- At positive SNRs, no participant chose gain that reduced intelligibility, and increased gain remained gain relative to NAL targets by a bit. There is a wide range of gains around NAL prescription targets (about 18 dB or so) where the intelligibility outcome is the same.

CONCLUSIONS

- In very difficult listening conditions, listeners turned down gain by 10-20 dB but kept sacrifice intelligibility; the noise was the dominant signal and no amount of gain would improve speech recognition.
- In moderately difficult listening conditions (around 0 dB SNR) listeners varied; some reduced gain by 10 dB and sacrificed some intelligibility.
- In favorable conditions, listeners varied in their self-adjusted gain but neither improved nor reduced overall intelligibility.

FUTURE DIRECTIONS

Intelligibility testing is underway to confirm the predicted findings.

Acknowledgements

This work was supported by the NIDCD: R01 DC 12827 to PN. We are grateful for the assistance of Elaine Britzer and Eugene Brandewie (Cox Instruments, Alexandria, VA) Development of the Connected Speech Test (CST). Ear Machine and Etymotic Research, Inc. for access to equipment and participants.

References