User self-adjustment of a simulated hearing aid in laboratory versus real-world noise

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Abstract

Noisy environments — especially noisy restaurants and meeting places — are among the most challenging for hearing aid users, but little is known about optimal hearing aid settings in real environments. This report will focus on validation of a lab environment that replicates noisy real-world environments. Noise levels were measured and environmental recordings were made in three area noisy restaurants and a quiet environment. Stimuli recordings were convolved with room impulse responses and played in a multisensory lab through 48 loudspeakers. Participants listened using an iPod Touch running a real-time simulation of a multichannel compression hearing aid, with all gain/compression parameters adjustable via a simple user interface (EarMachine). They adjusted the lab at noise levels from 45 to 75 dB. Participants then went to the original restaurants and made iPod adjustments in the real environment from which the lab setup was derived. A comparison of participant-adjusted settings from real and simulated settings will be presented. Validation of the lab environment will allow us to conduct future experiments in the laboratory, where stimulus conditions can be controlled much more precisely than in real settings.

Introduction & Subjects

• Listeners vary in their satisfaction with amplification in noisy environments (e.g., Kochkin, 2010)
• Part of the large variation in listener amplification preference in noisy settings is the variation across noisy settings themselves (overall level, SNR of target speech to background noise) and the noise level that can be difficult to control for in an actual restaurant or other “real world” noisy situation.
• This experiment looked at how hearing-impaired (HI) listeners self-adjusted their amplification device in recorded restaurant noise in a laboratory setting versus how they set their devices in a real-world restaurant setting.
• To date, 10 listeners with sensorineural hearing loss have participated in laboratory experiments.

Stimuli and Procedures

The Connected Speech Test (Cos, Alexander, and Gilmore, 1987) recordings were passed through a filter such that they were spatialized to match the restaurant sizes and estimated noise environments. During data collection, the CST spatialized to match the Potbelly restaurant was only used during sampling of the Potbelly background noise, and the same was true for the other recording locations.

Laboratory simulations were obtained in a 10’ by 13’ double-walled chamber (Height 8.5’). It contains a 48-channel speaker array, Anthony Gallo Acoustics - Ac12s 5 Speakers, 24 Crown XL2-1500 Power Amplifiers.

The setup for each set of recordings was a Schoeps CMC6 MK4 cardioid microphones pair in an ORTF configuration and a Roland R-4 portable sound recorder (settings: gain at 3 dB, 24-bit quantization, 48 kHz sampling rate).

The room dimensions for each location are noted below. (L x W x H).

- Potbelly: 58’ x 24’ x 9’
- Pobbeli: 38’ x 30’ x 25’
- Purple Onion: 80’ x 56’ x 13’
- Shevin Hall Conference Room: 80’ x 35’ x 9’

Recordings were calibrated for presentation from 60-75 dB in the lab.

Field recordings were made in a variety of listening locations over the lunch hour. Measures were made in a conference room and three restaurant locations. A photograph of one restaurant is below.

Listeners had at least 1 yr experience with amplification (VanTasell et al., 2010).

Stimuli and Procedures

The participant shown at left increased gain in noise, even when background noise levels increased (as in lower right).

Field studies have shown that participants adjusted gain at rest to the same overall level, but chose larger increments in more noisy conditions. The figure below shows average self-adjusted gain insertion gain by frequency for the ten participants.

• Insertion gain for the different lab-simulated noise conditions are shown in solid lines, including SNRs of +25 (living room), +10, +5, and 0 dB SNR (26 trials). The level of the target speech (CST) in all of these conditions was fixed at 65 dB SPL.

Most participants in most simulated noise condition turned gain down as background noise levels increased, like the listeners shown at left.

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Average NL-2 targets are shown in dashed lines for 65 and 80 dB HL.

Overall listeners adjusted gain in a manner predicted by the NL-2 targets. More gain was selected for the quieter conditions. Most listeners decreased gain when noise was present at +5 dB SNR.

Lab Measures: IG v. NAL Targets

Lab vs. Field IG Measures

• Exact comparisons of field and laboratory insertion gain settings are challenging; overall SPL values were most similar for the field and the MIP lab at +5 dB SNR (lab) settings.
• On average, laboratory (-5 dB SNR) and field IG measures are similar for the first 5 subjects.
• Overall to date, listeners self-adjust gain settings to be few dB greater in the lab than in the field, and this difference is consistent across frequencies.

Stimuli and Procedures

• Listeners select a few dB more gain in the lab than in the field.
• We anticipate that we will be able to accurately interpolate from laboratory settings (which are much more controllable) to field settings.
• Test validity within the laboratory setting was satisfactory.
• Differences between field and laboratory settings fell generally within the ±3 dB range.
• When self-adjusting gain, most subjects set gain parameters for quiet conditions first, and then increase gain to match to a commercial hearing aid.
• When listening conditions get poorer (at 0 and -5 dB SNR) listeners behave differently.
• Some turn gain down significantly.
• Others make small changes in gain
• Others continue to turn gain up, even in negative SNRs, presumably to try to understand the speech.

FUTURE DIRECTIONS

• Laboratory simulations of restaurant noise conditions are validated by the first 5 subjects. Self-adjust amplification settings were similar in real restaurants and field settings.
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• We anticipate that we will be able to accurately interpolate from laboratory settings (which are much more controllable) to field settings.
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FUTURE DIRECTIONS

• Additional data collection is underway to investigate individual differences between NAL targets and self-adjusted gain and to determine if these result in different speech intelligibility and/or satisfaction with overall sound quality in noisy situations.

References