REPORT: Acceptable Noise Level: Effect of Presentation Level, Digital Noise Reduction, and Stimulus Type

ABSTRACT

Reports indicate that the unaided acceptable noise level (ANL) is correlated with hearing aid success and that aided ANL scores may be reduced by digital noise reduction (DNR) when measured using sentences in continuous speech-shaped noise. Here, ANL scores were determined using read speech and multi-talker babble for 36 subjects with normal and impaired hearing. Aided ANLs were significantly lower with DNR and increased with speech level for subjects with mid and high ANLs but not for subjects with low ANLs.

INTRODUCTION

Willingness to accept hearing aids relates to willingness to accept or tolerate background noise in the presence of conversational speech - Acceptable Noise Level (ANL).

It is possible that overall hearing aid satisfaction (and use) will increase if hearing aid technology can enhance comfort and quality and reduce fatigue in noisy environments.

Digital Noise Reduction (DNR) may lead to better (lower) ANL scores, indicating greater acceptance of noise, and by deduction, improved hearing instrument satisfaction and use.

Characteristics of the ANL

• Not correlated with SPIN scores.
• Not related to type of hearing aid, age, or degree of hearing loss (unaided ANLs).
• Gender difference: No;11 Females prefer lower noise levels.
• Similar in unaided and aided conditions.
• Increases with increasing speech presentation level in normally hearing Ss.
• Stable over time (3 month period).
• Is repeatable/reliable? Yes; 2, No;11

Purpose of Study

• To determine the effect of DNR on aided ANL measures in multi-talker babble.
• To determine the effect of stimulus presentation level on aided ANL measures.
• To establish within session intraindividual repeatability (test-re-test) using fixed presentation level procedures.

METHODS

Participants

• 36 subjects (mean age = 67 years), mild to moderately-severe, symmetrical, sensorineural hearing loss.

Cohorts (Nabelek et al. 2006)

• Low ANL (≤ 7.0 dB): n=19 unaided, n=12 aided.
• Mid ANL (7.1 to 13.0 dB): n=12 unaided, n=13 aided.
• High ANL (> 13.0 dB): n=5 unaided, n=11 aided

Procedures

1. Automated testing
• Instructions, stimulus timing, response collection, stimulus level under automated MATLAB GUI control.
• Auditory and visual instruction slides match GUI.

2. Unaided ANL at presentation level of 65 dBA
• Arizona Travelogue, 12-talker babble at 0° azimuth.
• Starkey X Series RIC, custom earmold.
• NAL-NL, 23 dB, real ear (Verifit) speech mapping.
• Advanced signal processing features enabled.
• Voice IQ DNR algorithm at most aggressive setting.

4. Aided ANL Conditions
• 3 fixed speech presentation levels: 50, 65, and 80 dBA.
• 2 DNR settings: DNR on (maximum setting); DNR off.
• 3 AIDs per unaided and aided condition.
• 18 total aided condition counter-balanced.

RESULTS

Unaided versus Aided ANL Scores

Figure 3. Upper Panel: Unaided ANL (speech presentation level 65 dBA) ordered from low to high for 36 subjects. Subject numbers on the x axis match the upper panel.

Figure 4. Unaided vs. Aided ANLs. Moderate correlation between unaided and aided ANLs (r = 0.59; p = 0.35).
• Unaided ANLs were significantly lower than aided ANLs (β = -3.514, p = 0.001).
• Unaided ANLs ranged from 3.3 to 10.3 dB (mean: 6.6 dB; SD: 5.4 dB).
• Aided ANLs ranged from -4.0 dB to 27.7 dB (mean: 10.3 dB; SD: 8.0 dB).

ANL as a Function of Presentation Level and DNR

Figure 5. Aided ANL vs. input speech level across DNR off (shaded) and DNR on (open) conditions for the High (upper) Mid (middle) and Low (panel) ANL cohorts based on Nabelek et al. criteria.

Figure 6. Change in ANL (Unaided + DNR off) as a function of input speech level across subjects for bars = indicate 1 standard deviation.

ANL Decreases with DNR

RMANOVA (p < 0.001) and post-hoc testing:
• ANL values were significantly different across cohort (largest for High and smallest for Low).
• ANLs increased with increasing input speech level (significant change with level for the Mid but not Low cohorts).

DNR Benefit

Figure 6. Change in ANL (with DNR On minus ANL with DNR Off) as a function of input speech level averaged across subjects (bars = indicate 1 standard deviation).

ANL decreased 3.9 dB for the High cohort, 2.3 dB for the mid cohort, and 0.0 dB for the low cohort.

RESULTS CONTINUED...

REFERENCES


CONCLUSIONS

• Aided ANL scores increase with increasing speech presentation level for the High and Mid but not the Low cohort.
• ANL is significantly lower with DNR engaged for the High and Mid but not the Low cohort.
• Aided ANL has high intra-subject repeatability.
• Aided ANL scores vary widely across subjects.
• Specification: ANL task decision criteria may be “loudness” based for some subjects (e.g., Mid and High cohorts; level and DNR level) and “intelligibility based for other subjects (e.g., Low cohort; independent of level and DNR).

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