

Acceptable Noise Level Measured using Monitored Live Voice: A Pilot Study

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Received date: February 17, 2016; Accepted date: March 11, 2016; Published date: March 14, 2016

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Abstract

Objective: Background noise is a significant contributor to poor speech understanding for listeners with normal hearing. It creates an even greater challenge for listeners with hearing loss. Those with hearing loss who use hearing aids often complain of background noise. Specifically, background noise is the main complaint among hearing aid users when trying to follow a conversation. Half of the conversations occur in environments with some background present. The acceptable noise level (ANL) is a measure that attempts to quantify listener preference of background noise when listening to speech. Its use can contribute to clinicians and those with hearing loss by predictively differentiating full time hearing aid wearers from part time wearers or those who reject hearing aids. Thus, the ANL can be a valuable tool for the fitting of and counseling related to hearing aids. However, the ANL is not widely utilized by clinicians in the field. One of the possible reasons for this may be a factor of convenience in performing the ANL measurement with an audiometer alone, as a test easier for clinicians to administer may be more acceptable.

Methods: This pilot study compared differences in ANLs from eighteen listeners with normal hearing obtained using a commercially available recorded monologue with a monitored live voice (MLV) presentation of the same monologue.

Results: Statistical procedures for data analysis included a Paired Samples T-test to look for differences between the means of the data collected with the two signal types. Additionally, regression analysis using the Pearson Product Correlation was implemented to provide an illustration of the relationship between the two groups of data. Results indicated a strong correlation, but significant difference between the two presentation modes.

Conclusion: Although the means differed to the level of statistical significance, the difference may not be considered to have reached the level of minimal clinical importance. Since the ANL has the potential of being a valuable clinical tool, further research into the ANL measure obtained with MLV presentation will be needed.

Keywords: Acceptable noise level; Monitored live voice; Hearing; hearing loss; Hearing aids; MLV

Introduction

It is widely accepted that background noise is a key factor in poor speech understanding. This is true for listeners with normal hearing, but an even greater challenge for listeners with hearing loss [1]. As for hearing aid wearers, when trying to follow a conversation, the presence of background noise presents the greatest challenge of all [2]. Unfortunately, half of spoken communication occurs in environments with ambient noise of 50dB SPL or more [3]. This noise can come from traffic, mechanical and electrical equipment, music, and other people speaking.

Nabelek, Tucker, and Letowski examined the relationship between tolerance of background noise and hearing aid use [4]. They compared the tolerated signal-to-noise ratios (SNR) of young people with normal hearing, older adults with relatively good hearing, full-time hearing aid wearers, part-time hearing aid wearers, and hearing aid non-wearers [4]. Subjects were first instructed to listen to running speech from a recorded female speaker and choose their most comfortable listening

level (MCL). Next, background noise was introduced and the subjects were asked to select the "highest possible level of each background noise which the subject would be willing to tolerate or 'put up with' without becoming tense and tired when listening to and following words of a story". Nabelek et al. reported that full-time hearing aid wearers tolerated significantly higher levels of background noise than those who wore hearing aids on a part-time basis or had rejected hearing aids. This established the foundation for what is now the acceptable noise level (ANL) measure. The ANL is obtained by having a listener adjust a recorded story to their MCL, then background noise is introduced and the listener must choose the maximum background noise level (BNL) judged to be acceptable, while listening to the story. The background noise used has been either speech babble or speech-spectrum noise generated from an audiometer. Subtracting the BNL from the MCL provides the listener's ANL.

Acceptable noise levels have been found to be reliable over time [5]. Using two different types of background noise, speech-spectrum and speech-babble, results for three weeks of testing indicated high test-retest reliability. Nabelek et al. proposed the idea that a person's willingness to listen in background noise might be different from understanding speech in noise [4]. In 2004, Nabelek et al. compared

ANL values with Speech-in-Noise (SPIN) scores and concluded that ANL and SPIN scores “provide different contributions to the assessment of hearing-aid outcome use and benefit” [6]. In a follow-up study, Nabelek et al. reported smaller ANL values among full-time hearing aid wearers as compared to part-time wearers and non-wearers [7]. Combining the part-time wearers with non-wearers into a category referred to as “unsuccessful hearing aid wearers” to contrast with full-time wearers, referred to as “successful wearers”, the researchers established a prediction algorithm. This prediction method categorized successful wearers as those having low ANLs (≤ 7 dB), and unsuccessful wearers were described as having high ANLs (>13 dB) with 85% accuracy [7].

Although research indicates that the ANL is a useful clinical tool in the predicting hearing aid use [7], clinical application of the measure has been slow to develop. In a survey of clinicians regarding which pre-fitting measures were being used in dispensing hearing aids, Mueller reported that over half of those surveyed believed the ANL “sounded like a pretty good pre-test” yet fewer than 5% would actually use the measure [8].

Although there may be several reasons why the ANL is not widely used clinically, the ease of administering the test may be a factor affecting clinical implementation. ANL measures are typically conducted using a recording of running speech. Recorded test stimuli are considered to be the gold standard for obtaining speech recognition thresholds and word recognition scores in the basic audiometric test battery, as this allows for high test-retest reliability [9]. The American Speech-Language-Hearing Association (ASHA) guidelines state that “...recorded presentation is preferred because the stimuli are consistent to each patient tested with a given set of recorded test materials” [10]. But many clinicians do not utilize recorded stimuli as their standard of practice. According to Martin et al., 94% of 218 clinical audiologists surveyed use monitored-live voice for speech recognition testing and 82% use MLV in word recognition testing [11]. This information suggests that ANL testing with recorded speech may be inconsistent with commonly used methods of speech testing.

Based on the fact that clinicians are not using ANL measures as a pre-fitting tool for amplification, an alternative technique for obtaining ANLs may ease test administration. Thus, the goal of the present pilot study was to compare ANL values obtained with the recorded signal versus ANL values obtained with monitored live voice presentation of the same monologue.

Methods

Participants

Eighteen participants, between the ages of 18-32 years (mean=22.1) had hearing thresholds of 25 dB HL or better from 250-8000 Hz, with normal middle ear function, as illustrated by Jerger Type A tympanograms [12].

Test materials

The speech and noise stimuli were presented through an audiometer, calibrated to American National Standards Institute (ANSI) standards [13]. Testing was done in an audiometric sound booth that has met ANSI standards, as well [14]. The speech stimulus was a recorded CD of male running speech (Arizona Travelogue, Cosmos, Inc.) and a monitored live voice (MLV) presentation of the same monologue. The MLV presentation implemented clear female

speech at a controlled, steady rate. The noise stimulus was speech-spectrum noise generated by the audiometer. The recorded speech stimulus was played through the audiometer using a two-track compact disc player. All speech and noise stimuli were presented through a loudspeaker located at zero-degree azimuth, approximately one meter from the participant.

Procedure

The participants were given written and verbal instructions prior to starting the experiment. Instructions were based on the instructions from Nabelek et al., except that participants used hand signals (thumbs up, thumbs down) instead of handheld buttons to find their MCL and maximum background noise level (BNL) [6]. The instructions for establishing MCL were “You will listen to a story through a loudspeaker. After a few moments, select the loudness of the story that is most comfortable for you, as if listening to a radio. First, turn the loudness up until it is too loud and then down until it is too soft. Finally, select the loudness level that is most comfortable for you.” The instructions for establishing BNL were “You will listen to the same story with background noise of several people talking at the same time. After you have listened to this for a few moments, select the level of background noise that is the MOST you would be willing to accept or “put up with” without becoming tense and tired while following the story. First, turn the noise up until it is too loud and then down until the story becomes very clear. Finally, adjust the noise (up and down) to the MAXIMUM noise level that you would be willing to “put up with” for a long time while following the story.”

To establish MCL, the recorded speech stimulus was presented at an initial level of 0 dB HL and increased in 5 dB steps. The participant signaled (thumb down) that the signal had become too loud. The signal was then lowered until the participant signaled (thumb up) to raise the intensity once again; except this time, in 2 dB steps. The signal intensity was increased and decreased in 2 dB steps until the participant indicated MCL was reached.

For BNL measurement, the speech was presented at the participant’s MCL, while the noise was adjusted. The noise stimulus started at 0 dB HL and increased in 5 dB steps. Again, the participant signaled (thumb down) when the noise became too loud, and the intensity was then lowered. Once the intensity became very soft, the participant signaled (thumb up) to raise the noise intensity once again. The noise was increased and decreased in 2 dB steps until the participant indicated maximum BNL was reached. Three BNLs were obtained and averaged.

The ANL was calculated by subtracting the average of the BNL measures from the MCL measure in each testing situation. Participants were tested under two conditions: recorded speech and MLV, both with speech-spectrum noise. The order of presentation was counter balanced to minimize any potential order effect.

Results

MCL, BNL and ANL values were averaged across the eighteen listeners. The mean MCL for all listeners was 43.00 dB (SD=4.64 dB). The mean BNL for all listeners was 32.28 dB (SD=4.55 dB) when using recorded speech and 35.06 dB (SD=5.36 dB) when using monitored live voice. The mean ANL for all listeners was 10.72 dB (SD=5.85 dB) when using recorded speech and 7.94 dB (SD=6.45 dB) when using monitored live voice. A mean difference between ANL values obtained with recorded versus live voice presentation was 2.78 dB. The mean ANL values and standard deviations (SD) are illustrated in figure 1.

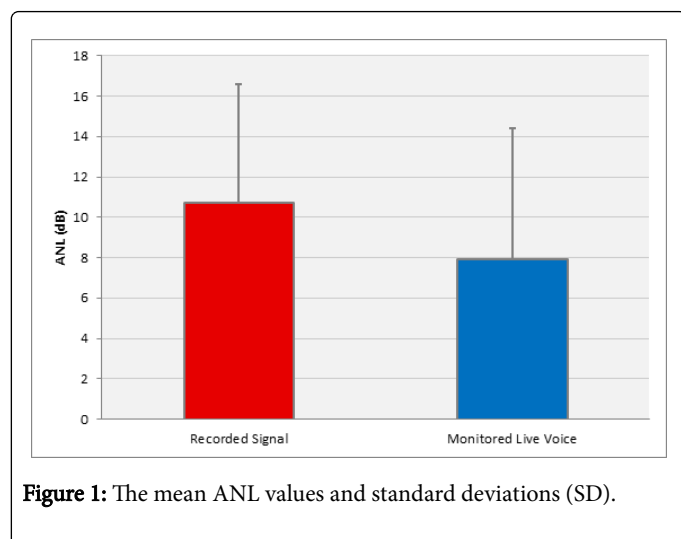


Figure 1: The mean ANL values and standard deviations (SD).

A Paired Sample T-test comparing the ANL values obtained using recorded speech with MLV indicated a statistically significant difference ($t=4.21$, $p<0.001$). A Pearson product correlation coefficient calculated for ANL values for the different presentation modes was strong and statistically significant ($r=0.901$, $p<0.001$), illustrated in figure 2. The Coefficient of Determination was $r^2=0.812$.

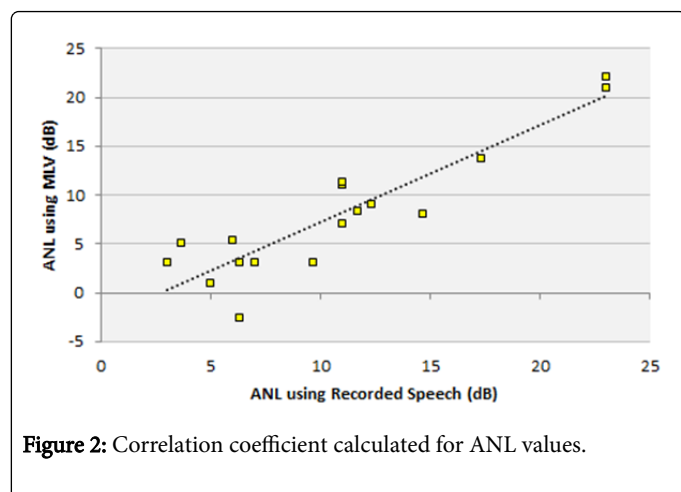


Figure 2: Correlation coefficient calculated for ANL values.

Discussion

The goal of this pilot study was to compare ANL values obtained using recorded speech versus monitored live voice presentation of the same monologue. The present study found MCL, BNL, and ANL values of 43.0 dB HL, 32.38 dB HL, and 10.7 dB, respectively; with data obtained using recorded speech. The values obtained are consistent with those from previous research on the ANL measurement [4,5,15].

Although the Paired Sample T-test found a statistically significant difference between ANL values obtained using recorded versus live speech, the mean difference was less than 3 dB. Factors related to these differences include, but are not limited to differences in speaker gender, rate, intensity fluctuations, dialect, and pronunciation. Although gender does not affect the ANL [16], it cannot be excluded as a potential factor in the results found in the present study. Additionally, rate, intensity fluctuations, dialect, and pronunciation were controlled,

as much as possible, via clear speech; the researcher made every effort to use clear speech, instead of conversational speech. Clear speech is a commonly used aural rehabilitative strategy in which speakers are instructed to slow their speaking rate somewhat and enunciate their words. Clear speech is easier to understand [17]. Additionally, the mean difference found in the present study may not be large enough to be considered as the minimal clinically important difference (MCID). As the name implies, the minimal clinically important difference is the threshold used to determine when two procedures produce differences considered to be clinically significant [18]. Although the means of the ANL values obtained using the two methods differ statistically, they are strongly correlated, with a large Coefficient of Determination. This strong correlation between the two measures and the corresponding indicator of how well the data fit the regression analysis contribute to the feasibility of possible future use of MLV for obtaining the ANL.

Conclusions

The ANL values obtained from the two methods employed in the present study are strongly correlated, allowing the MLV option to be a future consideration of ANL measurement. However, because of the difference observed in this pilot study, the use of MLV instead of a recording for obtaining the ANL is not ready for clinical application. Future studies may consider options for controlling for MLV issues, such as speaker rate, intensity fluctuations, dialect, and pronunciation, even if clear speech is used. Future studies may also measure the time required to complete various protocols. Additionally, a new question for researchers becomes, what is the MCID for the ANL value? To answer MCID issues, larger sample sizes of participants with hearing loss, to validate the measure, will be required. Lastly, if the future of ANL using MLV is to move forward, the question of implementation of the MLV method must be presented to clinicians.

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