Update on the Recommended Maximum Background Noise Levels for Voice Measurements

Jan G. Švec[1], Hana Šrámková[1], Svante Granqvist[2], Christian T. Herbst[1]

1 Voice Research Lab, Department of Biophysics, Faculty of Science, Palacký University, Olomouc, Czech Republic
2 Department of Basic Science and Biomedicine, School of Technology and Health (STH), Campus Haninge, Royal Institute of Technology (KTH), Handen, Sweden

Introduction

Measurement of acoustic voice characteristics involves technical and methodological challenges. One of them is constituted by background noise, which can pollute the recorded sound and make the measurements inaccurate. In 1982 Union of European Phoniatricians (UEP) recommended background noise levels below 40 dB(A) for voice measurements. However, recent analysis of data published in previous studies suggested that the softest human phonations may be produced at the levels below 40 dB(A) at the recommended distance of 30 cm from the mouth – see Fig.1 (Šrámková et al., 2015). If such low sound levels in voice can be confirmed, the UEP recommendation should be updated as it may not allow accurate voice measurements.

This study therefore aimed at:
1)accurately determining the softest sound levels of human voice in normal subjects
2)establishing the minimum signal-to-noise ratios for accurate measurements of softest phonations
3)based on these, updating the recommendations on background noise levels for scientific and equipment manufacturers' purposes.

Material

-80 healthy untrained participants (40 females, 40 males)

-Sound level meter (B&K 2238) at 30 cm distance from the mouth; and simultaneously
-Head-mounted microphone (DPA 4066)
-Sound calibrator (B&K 4231)
-Digital audio recorder (Microtrack II, M-Audio)
-Very quiet rooms [background noise level 18-23 dB(A), reverberation radius 0,6-1,6 m]

-Software Praat and Matlab®

Methods

-Voice Handicap Index to verify vocal normality

-Two-step calibration of the head-mounted microphone with the sound level meter
-Sustained vowels [a:] phonated as softly as possible
-Voicing detection by Praat software
-A-weighted and C-weighted one-second-equivalent sound levels of the softest phonations obtained according to IEC 61672-1 standard by custom-made Matlab® scripts (Šrámková et al., 2015).

Results

The sound levels of the softest sustained phonations were found to be in the range of 48-61 dB(C)/41-53 dB(A) for females and 49-64 dB(C)/35-53 dB(A) for males (5% to 95% quantile range) at 30 cm distance.

A signal-to-noise ratio (SNR) greater than 10 dB was found to influence the measured sound levels by less than 0,5 dB (Fig. 2).

When combining the SNR >10 dB criterion with the low boundaries of the measured sound levels of voice, ***the newly recommended maximum background noise levels are 38 dB(C) and 25 dB(A)*** for the softest voice measurements ***at 30 cm distance*** (Fig.3).

Conclusions

The new recommendations allow sound level measurements of softest phonations at 30 cm distance with an accuracy of 0.5 dB or less for 95% of the normal subjects. They also ensure sufficiently large SNR for accurate perturbation measurements of comfortably loud phonations.

The newly recommended maximum background noise level of 25 dB(A) is ***15 dB lower than the previously recommended value*** by UEP and may be difficult to reach in common conditions. ***A practical alternative*** appears to be the use of a ***head-mounted microphone at a distance of about 5-10 cm***, which results in the voice signal being about 10–15 dB stronger than at 30 cm distance (Svec and Granqvist, 2010). In that case ***the maximum background noise levels of 40 dB (A-weighted) and 53 dB (C-weighted) may be considered acceptable*** for accurate soft voice measurements.

These background noise levels are supposed to encompass the room, microphone, as well as the recording equipment internal noise. In any case, the background noise levels (complemented by information about the applied frequency and time weighting methods) should always be measured and reported together with the actual voice sound level data.

References

IEC 61672-1 (2002). Sound level meters—Part 1: Specification. Geneva, Switzerland: International Electrotechnical Commission.
Schutte, H. K., & Seidner, W. (1983). Recommendation by the Union of European Phoniatricians (UEP): Standardizing voice area measurement/phonetography. Folia Phoniatr. 35, 286-288.
Šrámková, H., Granqvist, S., Herbst, C.T., & Švec JG. (2015). The softest sound levels of human voice in normal subjects. J. Acoust. Soc. Am. 137: 407-418.
Švec, J. G., and Granqvist, S. (2010). Guidelines for selecting microphones for human voice production research. Am. J. Speech Lang. Pathol. 19, 356-368.

Acknowledgment:
The research has been currently supported by the Czech Science Foundation (GA CR) project no GA16-01246S.

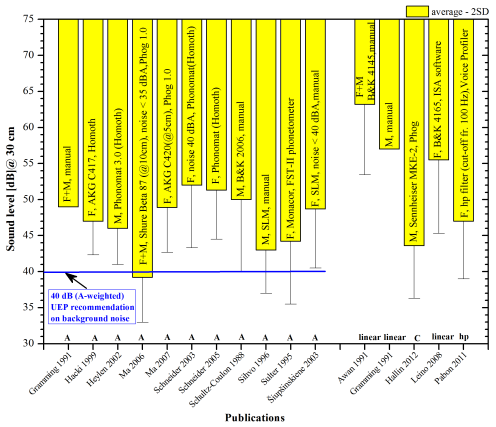

*Fig.1: **Examples of softest sound levels** for vocally healthy speakers published **in previous studies**. Notice that some studies report the softest levels below 40 dB(A), thus below the level recommended by UEP for the background noise in voice measurements (Schutte and Seidner, 1983).
The whiskers indicate two standard deviations from the mean value.
A = A-weighting, C = C-weighting, hp = custom high-pass (hp) filtering (with the cutoff frequency indicated), lin. = no filtering.
(For more detailed information, see Šrámková et al. 2015).*

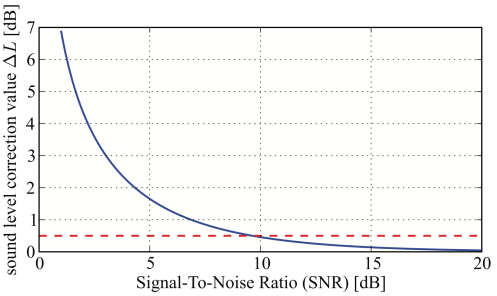

*Fig. 2: **Inflation of sound level due to background noise**. Theoretical dependence on signal-to-noise ratio (SNR). The criterion of SNR > 10 dB ensures that the measured sound level is inflated by less than 0,5 dB. (For more information, see Šrámková et al. 2015).*

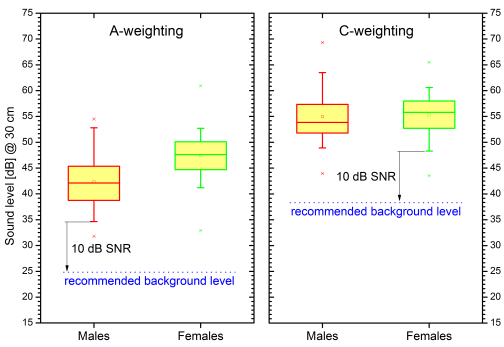

*Fig. 3: Statistical distribution of the measured A-weighted and C-weighted one-second-equivalent **sound levels in male and female softest phonations** at 30 cm distance. **The newly recommended background noise levels** are derived by subtracting the 10 dB signal-to-noise ratio (see Fig. 2) from the 5th percentile margin of the softest SPL values measured for males and females, respectively.*