Estimation of Realistic Signal-to-Noise Ratios

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ABSTRACT

The appropriateness and limitations of adaptive speech tests as outcome measures when evaluating hearing-device features have been discussed. The obvious alternative to adaptive speech testing is to test at a fixed signal-to-noise ratio (SNR). But, which SNRs should be used?

In a previous study (Wagener et al., 2008), twenty hearing-aid users made binaural recordings in everyday environments. 72 of the recordings were analysed in the current study.

After abandoning automatic noise estimation procedures, a manual estimation method was used. An accuracy measure was also developed.

Estimated overall signal-to-noise ratios (SNRs) with corresponding confidence intervals, frequency-specific SNRs, and overall RMSs are presented for a number of situations: “quiet”, babble, noise from cars and public transport, kitchen noise, music, and radio/TV.

The range of SNRs found in the material was large. The estimation accuracy was generally good, but got worse at negative SNRs.

METHOD

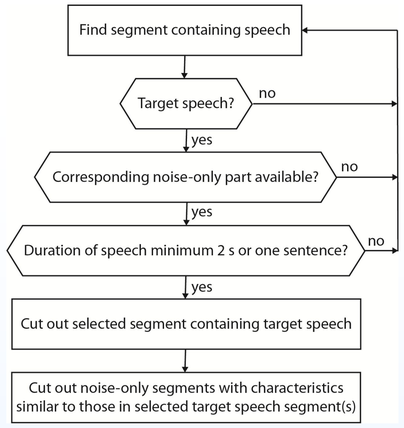
Recordings

Recordings by Wagner et al. (2008):

- 20 experienced and satisfied HA users (18-81 years, mean 51 years)
- Various social backgrounds and occupations
- DAT recorder, bilateral microphones close to HA microphones
- Encouraged to record “situations in daily life” for 3-4 days
- Duration of recorded material: 46-121 min, average 84 min
- Representative 1-min segments cut out
- 8-25 (average 17) sequences per informant
- Lab evaluation of own recordings showed that informants had recorded relevant everyday situations

Analysis

A manual SNR estimation procedure was used.



Underlying assumptions:

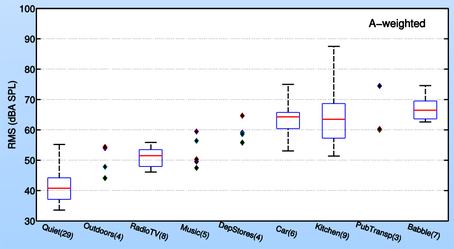
- Speech and noise are uncorrelated.
- Speech and noise are fluctuating signals but the underlying distributions are stationary over the duration of the segment.
- Spectral properties of the noise are similar in the noise-only segments and in the mixed noise-speech segments.

Estimation uncertainty:

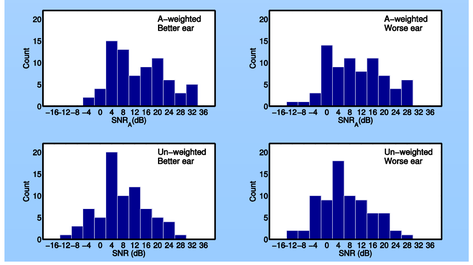
- 68% confidence intervals are determined for the SNR estimate.
- Calculations are based on the noise variance, determined as averages over 250 ms sections of the noise-only segments.

RESULTS

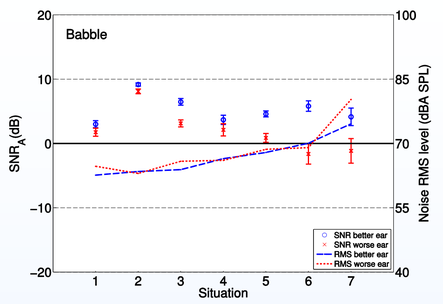
RMS levels

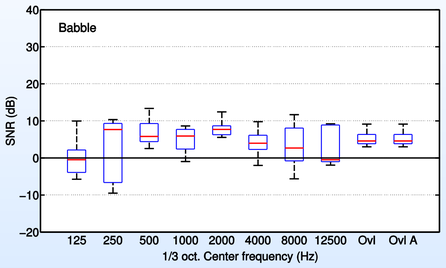


Overall histograms

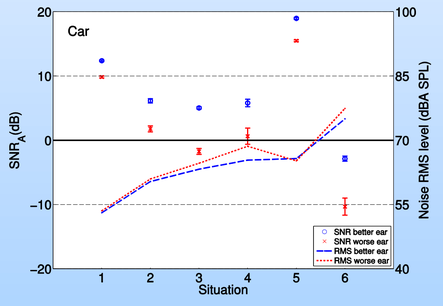


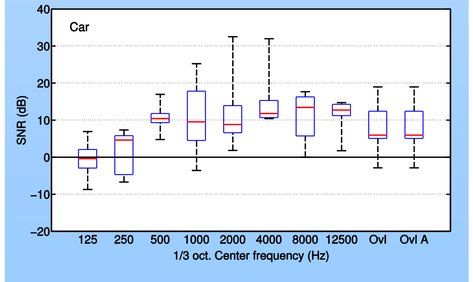
Babble noise



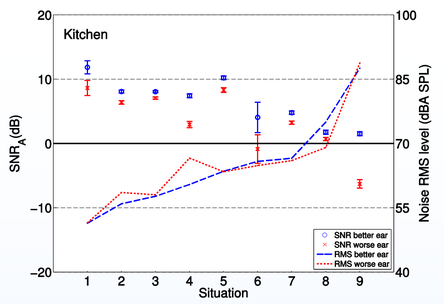


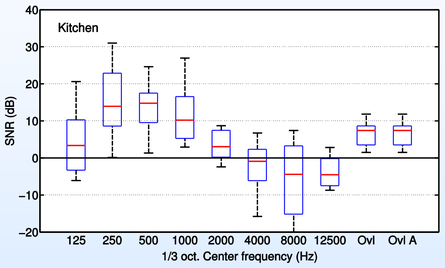
Car noise



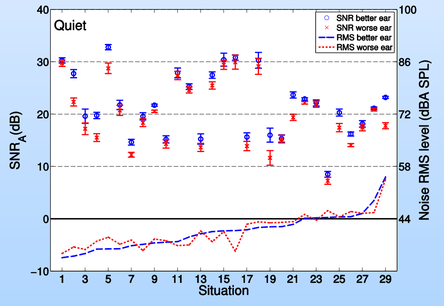


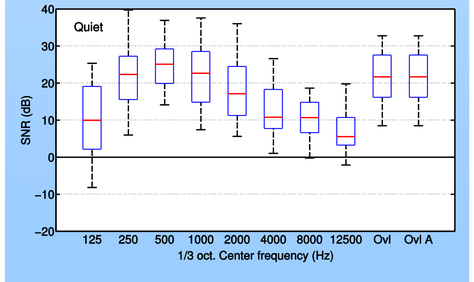
Kitchen noise



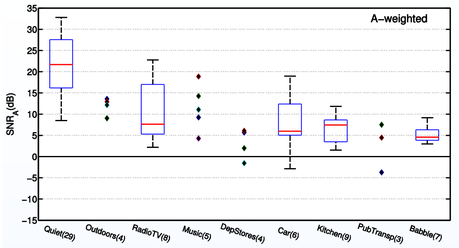


Quiet





Overall



Summary table

Category	SNR dB (dBA)		Accuracy dB (dBA)		Noise RMS dB SPL (dBA SPL)	
Medians	Better	Worse	Better	Worse	Better	Worse
Quiet (26)	14 (20)	12 (19)	±0.6 (0.7)	±0.6 (0.7)	52 (41)	53 (41)
Outdoors (4)	3 (12)	1 (9)	±0.8 (0.6)	±1.0 (0.7)	63 (51)	61 (49)
Radio&TV (8)	8 (8)	4 (5)	±0.7 (0.6)	±0.7 (0.7)	58 (52)	58 (52)
Music (5)	12 (11)	9 (11)	±0.3 (0.4)	±0.7 (0.4)	60 (56)	59 (50)
Dep.Stores (4)	-1 (3)	-4 (1)	±0.8 (0.7)	±1.0 (0.7)	69 (59)	68 (58)
Car (6)	-5 (3)	-6 (5)	±1.8 (0.4)	±1.8 (0.3)	92 (65)	91 (64)
Kitchen (9)	5 (7)	3 (3)	±0.3 (0.3)	±0.3 (0.4)	67 (64)	67 (65)
Publ. Transport (3)	-3 (4)	-4 (-4)	±1.0 (0.6)	±0.7 (0.6)	82 (60)	81 (62)
Babble (7)	4 (5)	2 (2)	±0.5 (0.5)	±0.6 (0.7)	69 (66)	70 (66)

DISCUSSION AND CONCLUSIONS

The range of SNRs found in the material was large. The estimation accuracy was generally good, but got worse at negative SNRs.

The number of babble recordings was smaller than anticipated. The reason could be the short recording time. A fairly large number of recordings were done in “kitchen noise”, judged important by the informants. The noise in these situations varied, but generally contained more high-frequency energy than most other situations. The recordings classified as “quiet” by the informants showed SNRs from 8 to 33 dB(A).

It is impossible to specify one “typical” realistic SNR, and even when the recordings are divided based on the situation, the SNRs within one category vary substantially.

REFERENCES

Pearsons, Bennett, & Fidell (1977). Speech levels in various noise environments. Project 68 01-2466. Washington, DC, U.S. Environmental Protection Agency.

Wagener, Hansen, & Ludvigsen (2008). Recording and classification of the acoustic environment of hearing aid users. J Am Acad Audiol 19(4): 348-370.