

The Acceptable Noise Level (ANL): Erfaringer med dansk, svensk og ikke-semantic version

Steen Østergaard Olsen
Forskningslaboratoriet, Øre-næse-halskirurgisk
Klinik, Rigshospitalet, København



Contributors:

Lars Holme Nielsen
Forskningslaboratoriet, Øre-næse-halskirurgisk Klinik, Rigshospitalet, København

Johannes Lantz
Audiologisk afdeling, Øron-, næs- og halsklinikken, Skånes universitetssjukhus,
Malmö

K. Jonas Brännström

Lucas Holm

Tobias Kastberg

Institutionen för kliniska vetenskaper, Logopedi, foniatri och audiologi,
Lunds Universitet, Lund



Acceptable Noise Level (ANL)

- A method for quantification of the level of background noise a subject can accept when listening to speech at MCL

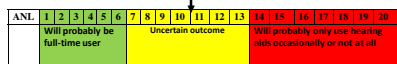
– Used for prediction of individual hearing aid use patterns

- "I use my hearing aid whenever it is needed"
- "I use my hearing aid occasionally"/ "I don't use my hearing aid at all"

- Inherent factor

Nabelek et al (1991; 2004)

The chance for success and failure is equal



- Used for evaluation of hearing aid features

- Directional microphone systems
- Noise reduction algorithms

Freyaldenhoven et al, 2005; Mueller et al, 2006; Kim and Bryan, 2011

3

Questionnaires & ANL

- APHAB outcome and ANL
 - No association (Freyaldenhoven et al. 2008)
- IOI-HA outcome and ANL
 - ANL is a predictor of IOI-HA outcome (Taylor 2008)
 - No association (Brännström et al. 2012)

4

Acceptable Noise Level (ANL)

- Huge variation of ANL across individuals and studies
- Mean ANL across studies 6.5 – 17.7 dB
- SD across studies 1.8 – 7.0 dB
 - (Nabelek et al, 1991; 2004; Rogers et al, 2003; Freyaldenhoven et al, 2006; Franklin et al, 2006; Freyaldenhoven et al, 2007)

5

ANL - level or range of levels?

- ANL is described as a *level*
- ANL might be a *range of levels* just like the MCL
Holm & Kastberg, 2012
- The acceptable range of speech level is defined as the range that maximizes word intelligibility scores and that does not cause a significant increase in listening difficulty

Sato et al, 2011

6

Speech signals for Danish & Swedish ANL

- Danish (Dantale CD, track 12) (Elberling et al., 1989)
 - Female speaker
 - Duration 4 min, 23 sec
 - 40 syllables/10sec
 - 16% is silence
- Swedish ("Priset på vatten i Finistère", track 6) (Malmsten, 2003)
 - Female speaker
 - Duration 4 min, 7 sec
 - Ca 30 syllables/10sec
 - 19% is silence
- International speech test signal (ISTS) (Holoube et al., 2010)
 - Syllables from six selected female speaker (Arabic, English, French, German, Mandarin and Spanish)
 - Were then concatenated into utterances closely resembling running speech
 - Duration 4 min
 - 40 syllables/10sec
 - 17% is silence

7

Noise signals

- Dantale noise (Dantale CD, track 12) (Elberling et al., 1989)
 - Speech shaped noise
 - Amplitude modulated
- ANL-babble (Arizona Travelodge, Cosmos Distributing Inc)
 - 12 speakers
 - Identical with noise from SIN test (Bilger et al, 1984)

8

Method

- Speech presentation
 - monaurally through earphones
 - Loudspeaker (for measurements of hearing aid performance)
- Speech set to MCL by test subject
- Add noise to speech
 - Same earphone
 - Speech kept at the selected level
- Noise set to highest acceptable level (BNL) by subject
 - repeat entire procedure three times
- ANL = MCL – BNL
- Reported ANL is the mean value from three trials

9

ANL Instruktion

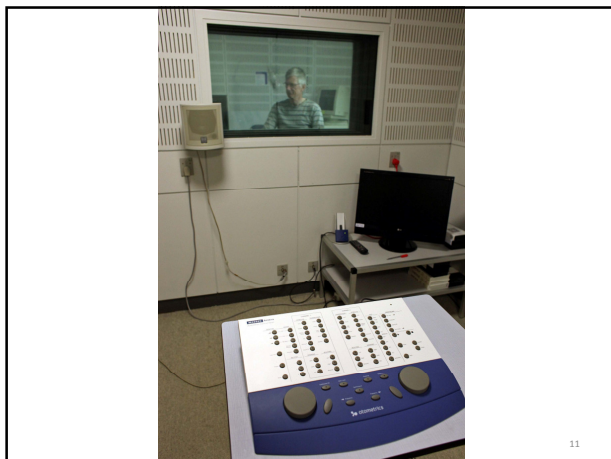
1) Indstilling af tale (MCL)

Du skal lytte til en historie i hovedtelefonen. Når du har lyttet et øjeblik, vil vi bede dig om at indstille lydstyrken på historien, så den er mest behagelig, - ligesom når du lytter til radio. Vi giver dig en knap, så du kan skrue op eller ned for lyden i små trin. Skru først op for talen så den bliver for kraftig og derefter ned, så den bliver for svag. Derefter skal du indstille lydstyrken, så den er mest behagelig for dig. Sig til når du har fundet det mest behagelige niveau.

2) Indstilling af støj (BNL):

Du skal nu lytte til historien igen, men denne gang i baggrundsstøj. Når du har lyttet et øjeblik, vil vi bede dig om at finde den KRAFTIGSTE lydstyrke på baggrundsstøjen, som du vil kunne acceptere uden at anstrenge dig og uden at blive træt, mens du lytter til historien. Skru først så højt op for baggrundsstøjen, at den bliver for kraftig og skru derefter så langt ned for støjen, at talen bliver meget klar og tydelig. Indstil til sidst støjens lydstyrke (op eller ned) til det KRAFTIGSTE niveau, som du vil kunne acceptere, hvis du i lang tid skal følge historien. Sig til når du har fundet det korrekte niveau.

10



11

ANL not affected by.....

- Age (Nabelek et al, 1991)
- Gender (Rogers et al, 2003)
- Hearing loss degree (Nabelek et al, 1991; 2004; Harkrider & Smith, 2005; Freyaldenhoven et al, 2006)
- Middle ear function (Harkrider & Smith, 2005)
- Outer hair cell function (Harkrider & Smith, 2005)
- Olivocochlear bundle function (Harkrider & Smith, 2005)
- Speech scores in noise (Nabelek et al, 2004; 2006; von Hapsburg & Bahng, 2006; Olsen et al, 2012)

12

May affect ANL

- Medication (Freyaldenhoven et al, 2005)
- Instructions and attitudes (Wu et al. 2012; Brännström et al. 2012)
- Speech presentation level (Franklin et al, 2006)
- Exercises strengthening auditory self-control (Nichols & Gordon-Hickey, 2012)
- Working memory capacity (Brännström et al, 2012)
- Speech understanding and Language (Brännström et al, 2012; Gordon-Hickey and Moore, 2008)
- Speech velocity (Brännström et al, 2012; Goldman, 2009)
- Type of noise (Brännström et al, 2012)

13

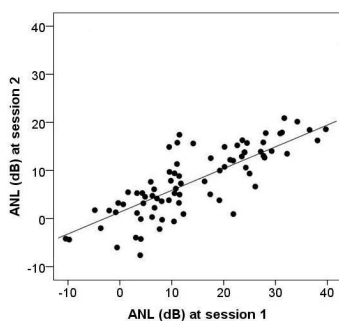
ANL reliability

ANLs are reliable in

- Hearing impaired listeners
 - Nabelek et al., 2004
- Normally hearing listeners
 - Freyaldenhoven et al., 2006

14

Association



15

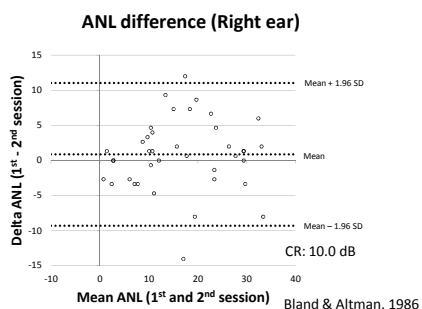
The coefficient of repeatability (CR)

- CR = 1.96 x SD of the intra-subject differences between repeated measures
- The value below which the absolute intra-subject differences between results from repeated measurements may be expected to lie with a probability of 95%.

Bland & Altman, 1986

16

Bland-Altman plot (Normal listeners) 1st session – 2nd session (n=39)



Bland & Altman, 1986

17

Coefficients of repeatability

	Right ear	Left ear	
Normal	10.0	9.7	n=39
Impaired	8.3	7.4	n=63

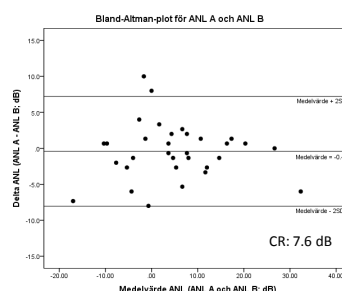
18

Absolute test-retest differences (Individual listeners)

Study	Normal Hearing	Impaired hearing
Freyaldenhoven et al (2006)	0 - 14.3 dB (n=30)	
Nabelek et al (2004)		0 - 4 dB (n=50)
Olsen et al (2012)	0 - 14.7 dB (n=39)	0 - 14.7 dB (n=63)
Holm & Kastberg (2012)	0 - 14.0 dB (n=32)	

19

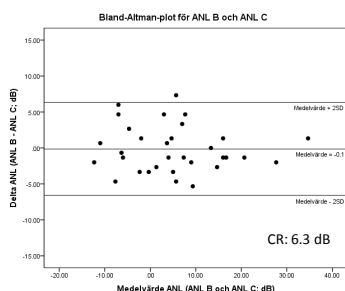
CR and training (1)



Holm & Kastberg, 2012

20

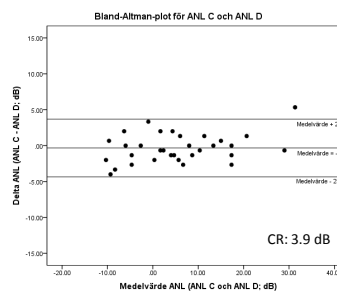
CR and training (2)



Holm & Kastberg, 2012

21

CR and training (3)



Holm & Kastberg, 2012

22

Intertester reliability

- ANL was measured for one group of listeners by three testers.
- Intraclass correlation coefficients were significant and revealed that MCL, BNL, and ANLs **are reliable across testers**.
- 32% of the subjects **changed ANL category** from tester to tester.

(Gordon-Hickey et al, 2012)

23

Intertester reliability

- Using the original data from Gordon-Hickey et al (2012) we calculated the max CR = 7.6 dB across testers.
- Our conclusion: Since agreement between the measurements is only 68% and the CR is almost double the MCID, ANL is not reliable across testers.

24

Order effect

	Normal		Impaired	
	First ear - Second ear (n=39)		First ear - Second ear (n=63)	
	1. session	2. session	1. session	2. session
Condition 1:	-1.8*	-1.7*	-1.6*	-0.8
Condition 2:	-1.1	-1.0*	-1.3*	-1.4*
Condition 3:	-1.9*	-1.3*	-1.2*	-1.0*

(Olsen et al, 2012a; 2012b) 25

Conclusions (1)

- Swedish and Danish ANL-versions yields approximately the same results as american studies.
- Extrinsic factors play a roll for ANL-results:
 - Noise type
 - Semantic content or no semantic content
 - Instructions, instructor attitude
 - Cultural differences

26

Conclusions (2)

- ANL cannot be used for individual evaluations
- ANL results cannot be compared across sites
- Improvements of the method are needed
 - Repeatability
 - Order effect
 - Training

27

Litterature (1)

- Bilger R.C., Nuetzel J.M., Rubinowitz M.M. & Raczakowski C. 1984. Standardization of a test of speech perception in noise. *J Speech Hear Res*, 27, 32–48.
- Bland J.M., Altman D.G. 1996. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet*, 327, 307–310.
- Brånström, K.J., Lantz, J., Nielsen, L.H. & Olsen, S.O. 2011. Acceptable Noise Level with Danish, Swedish and non-semantic speech materials. *Int J Audiol*, 51, 146–156.
- Brånström K.J., Lantz J., Nielsen L.H., Olsen S.O. Prediction of Danish IOH-HA scores using speech reception thresholds and speech discrimination scores in quiet. *Int J Audiol*. Submitted.
- Brånström, K.J., Borovac, A., Zunic, E., & Ibertsson, T. 2012. Acceptance of background noise, working memory capacity, and auditory evoked potentials in subjects with normal hearing. *J Am Acad Audiol* 23, 542–552.
- Eberling C., Luørgen C. & Svinggaard P. 1985. DAN-TALE: a new Danish speech material. *Scand Audiol*, 18, 169–175.
- Franklin C.A. Jr., Thelin J.W., Nabelek A.K. & Burchfiel S.B. 2006. The effect of speech presentation level on acceptance of background noise in listeners with normal hearing. *J Am Acad Audiol*, 17, 242–246.
- Freyaldenhoven, M.C., Nabelek, A.K., Tampas, J.W. 2008. Relationship between acceptable noise level and the abbreviated profile of hearing aid benefit. *J Speech Lang Hear Res*, 51, 136–146.
- Freyaldenhoven M.C., Pjyler P.N., Thelin J.W. & Hedrick M.S. 2007. The effects of speech presentation level on acceptance of noise in listeners with normal and impaired hearing. *J Speech Lang Hear Res*, 50, 878–885.
- Freyaldenhoven M.C., Smiley D.F., Muenchen R.A. & Korrad T.A. 2006. Acceptable noise level: Reliability measures and comparison to preference for background sounds. *J Am Acad Audiol*, 17, 640–648.
- Freyaldenhoven, M. F., Thelin, J. W., Pjyler, P. N., Nabelek, A. K., Burchfield, S. B. 2006. Effect of stimulant medication on the acceptance of background noise in individuals with attention deficit/hyperactivity disorder. *J Am Acad Audiol*, 16, 677–686.
- Goldman J.J. 2012. The effects of testing method, alternate types of target stimuli and attention on Acceptable Noise Level (ANL) scores in normal hearing listeners. James Madison University, Doctor of Audiology dissertation.
- Gordon-Hickey, S., Moore, R.E. 2008. Acceptance of noise with intelligible, reversed, and unfamiliar primary discourse. *Am J Audiol*, 17, 129–135.
- Gordon-Hickey S., Moore RE, Latta JM. 2012. The impact of listening condition on background noise acceptance for young adults with normal hearing. *J Speech Lang Hear Res*. 2012 Mar 12. [Epub ahead of print]
- Harkerider A.W. & Smith S.B. 2005. Acceptable noise level, phoneme recognition in noise, and measures of auditory efferent activity. *J Am Acad Audiol*, 16, 530–545.
- Holm L, Kustberg T. 2012. Stabilitet för Acceptable Noise Level (ANL) hos normalhörande vuxna personer vid upprepade mätningar inom samma testsession och dess relation till arbetsminneskapacitet. Lunds Universitet, Medicinska Fakulteten, Magister Uppsats.
- Holube I., Fredelake S., Viaming M. & Kollmeier B. 2010. Development and analysis of an International Speech Test Signal (ISTS). *Int J Audiol*, 49, 891–903.
- Kim J.S., Bryan M.F. 2011. The effects of asymmetric directional microphone fittings on acceptance of background noise. *Int J Audiol*, 50, 230–236.
- Malmström B. 2003. *Priser & vetter i Finst & re. Stockholm: Bonnier Audio.*
- Mueller, H.G., Weber, J., Hornsby, B.W. 2006. The effects of digital noise reduction on the acceptance of background noise. *Trends Amplif*, 10, 83–93.

28

Litterature (2)

- Nabelek A.K., Freyaldenhoven M.C., Tampas J.W., Burchfiel S.B. & Muenchen R.A. 2006. Acceptable noise level as a predictor of hearing aid use. *J Am Acad Audiol*, 17, 626–638.
- Nabelek A.K., Tampas J.W. & Burchfiel S.B. 2004. Comparison of speech perception in background noise with acceptance of background noise in aided and unaided conditions. *J Speech Lang Hear Res*, 47, 1001–1012.
- Nabelek A.K., Tucker F.M. & Letowski T.R. 1991. Tolerance of background noises: Relationship with patterns of hearing aid use by elderly persons. *J Speech Hear Res*, 34, 679–685.
- Nichols A.C., Gordon-Hickey S. The relationship of locus of control, self-control, and acceptable noise levels for young listeners with normal hearing. *Int J Audiol* 2012; 51: 353–359.
- Olsen SØ, Brånström KJ, Lantz J, Nielsen LH. Acceptable Noise Level with Danish and non-semantic speech materials in adult subjects diagnosed with unilateral Ménière's disease. *Int J Audiol*. Submitted.
- Olsen SØ, Nielsen LH, Lantz J, Brånström KJ. 2012. The Acceptable Noise Level: Repeatability with Danish and non-semantic speech materials for adults with normal hearing. *Int J Audiol*, 51, 507–563.
- Olsen SØ, Nielsen LH, Lantz J, Brånström KJ. 2012. Acceptable Noise Level (ANL) with Danish and non-semantic speech materials in adult hearing aid users. *Int J Audiol*, 51, 678–688.
- Rogers D.S., Harkerider A.W., Burchfiel S.B. & Nabelek A.K. 2003. The influence of listener's gender on the acceptance of background noise. *J Am Acad Audiol*, 14, 372–382.
- Sato H, Morimoto M, Ota R. Acceptable range of speech level in noisy sound fields for young adults and elderly persons. *J Acoust Soc Am*. 2011, 130,1411-9.
- Shaghnoshy Schwartz, K. & Cox, R. 2012. Does acceptable noise level predict hearing aid success? *American Auditory Society, Annual Meeting March 8-10, 2012 Scottsdale, Arizona, US.*
- Taylor B. (2008) *The Acceptable Noise Level Test as a predictor of real-world hearing aid benefit. Hear J* 61 (09), 39-42.
- von Hapsburg D. & Bahng J. 2006. Acceptance of background noise levels in bilingual (Korean-English) listeners. *J Am Acad Audiol*, 17, 649–658.
- Wu, Y.H. 2012. Language and stimulus intelligibility effects on ANL: A cross-country study. *American Auditory Society, Annual Meeting March 8-10, 2012 Scottsdale, Arizona, US.*

29