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

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

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
  - Inherent factor
- Used for evaluation of hearing aid features
  - Freyaldenhoven et al, 2005; Mueller et al, 2006; Kim and Bryan, 2011

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)

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)
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
  - 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

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 (Riker et al., 1986)

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

ANL Instruktion

1) Indstilling af tale (MCL)

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 findes den KRAFTIGST lydstyrke på baggrundsstøjen, som du vil kunne acceptere uden at anstrenges dig og uden at blive træt. Du skal derefter skru op for baggrundsstøjen, indtil du finder den KRAFTIGST lydstyrke, som du vil kunne acceptere, uden at du føler at baggrundsstøjen forstyrer din øjeblikkelige lydestyresættelse.
   Derefter skal vi gå gjennem en identisk procedure i begge øre, hvor du skal meddelle, at lydstyrken er det mest behagelige niveau.

ANL not affected by.....

- Age (Nabelek et al, 1991)
- Gender (Rogers et al, 2003)
- Middle ear function (Harkrider & Smith, 2005)
- Outer hair cell function (Harkrider & Smith, 2005)
- Olivocochlar bundle function (Harkrider & Smith, 2005)
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)

ANL reliability

ANLs are reliable in
- Hearing impaired listeners
  - Nabelek et al., 2004
- Normally hearing listeners
  - Freyaldenhoven et al., 2006

Association

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

Coefficients of repeatability

<table>
<thead>
<tr>
<th></th>
<th>Right ear</th>
<th>Left ear</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>10.0</td>
<td>9.7</td>
<td>39</td>
</tr>
<tr>
<td>Impaired</td>
<td>8.3</td>
<td>7.4</td>
<td>63</td>
</tr>
</tbody>
</table>
### Absolute test-retest differences (Individual listeners)

<table>
<thead>
<tr>
<th>Study</th>
<th>Normal Hearing</th>
<th>Impaired hearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freyaldenhoven et al.</td>
<td>0 - 14.3 dB</td>
<td>(n=30)</td>
</tr>
<tr>
<td>Nabelek et al.</td>
<td>0 - 4 dB</td>
<td>(n=50)</td>
</tr>
<tr>
<td>Olson et al. (2012)</td>
<td>0 - 14.7 dB</td>
<td>(n=39)</td>
</tr>
<tr>
<td>Holm &amp; Kastberg (2012)</td>
<td>0 - 14.0 dB</td>
<td>(n=32)</td>
</tr>
</tbody>
</table>

### CR and training (1)

CR: 7.6 dB

Holm & Kastberg, 2012

### CR and training (2)

CR: 6.3 dB

Holm & Kastberg, 2012

### CR and training (3)

CR: 3.9 dB

Holm & Kastberg, 2012

### 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)

### 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.
Order effect

<table>
<thead>
<tr>
<th>Normal</th>
<th>Impaired</th>
</tr>
</thead>
<tbody>
<tr>
<td>First ear - Second ear (n=39)</td>
<td>First ear - Second ear (n=62)</td>
</tr>
<tr>
<td>1. session</td>
<td>2. session</td>
</tr>
<tr>
<td>Condition 1:</td>
<td></td>
</tr>
<tr>
<td>-1.3*</td>
<td>-1.7*</td>
</tr>
<tr>
<td>Condition 2:</td>
<td></td>
</tr>
<tr>
<td>-1.1</td>
<td>-1.0*</td>
</tr>
<tr>
<td>Condition 3:</td>
<td></td>
</tr>
<tr>
<td>-1.5*</td>
<td>-1.3*</td>
</tr>
</tbody>
</table>

(Olsen et al., 2012a, 2012b)

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

Litterature (1)

- Extrinsic factors play a roll for ANL-results:
  - Noise type
  - Semantic content or no semantic content
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  - Cultural differences

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

Litterature (2)