Prescribing hearing aids for adults and children

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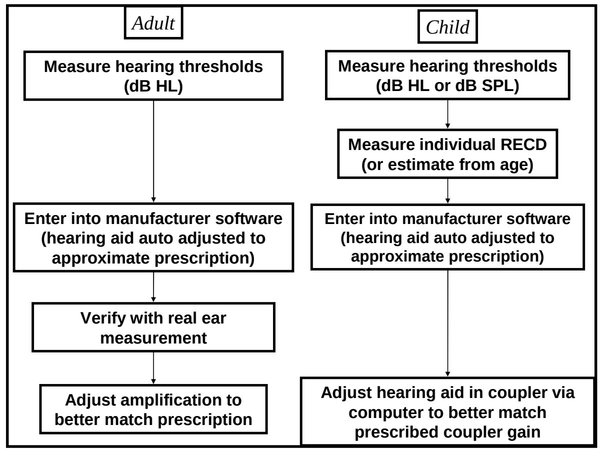
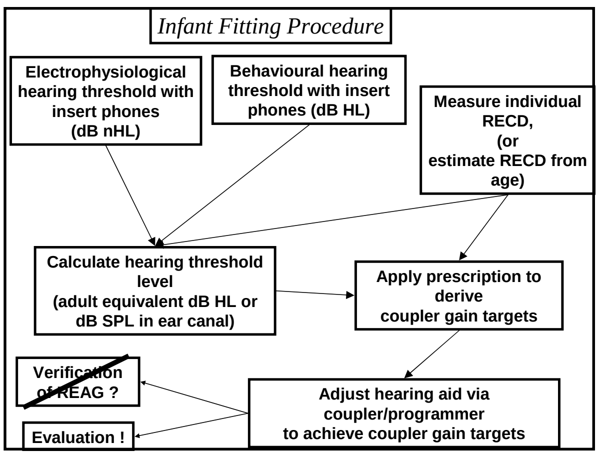
HEARing CRC
National Acoustic Laboratories

Audiology NOW!
San Diego
2010





Prescribe hearing aids to:

- Make speech intelligible
- Make loudness comfortable

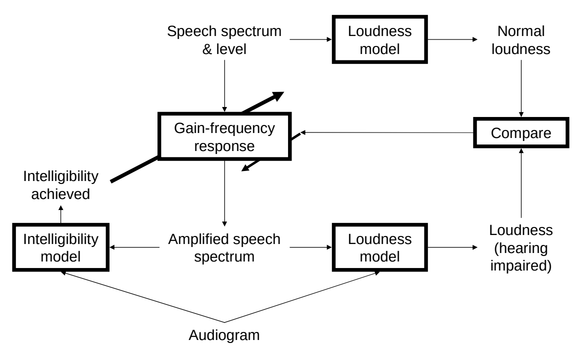
- Prescription affected by other things
  - localization,
  - tonal quality,
  - detection of environmental sounds,
  - naturalness.

The rationale for NAL proceudres

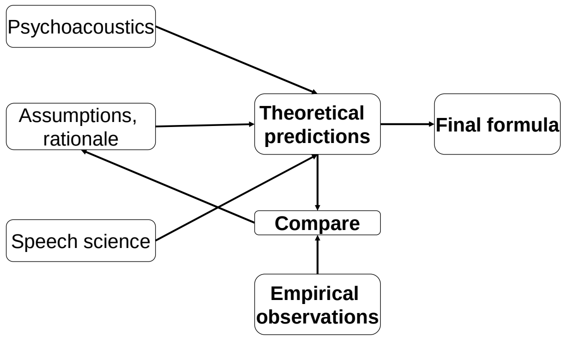
Maximize calculated speech intelligibility ,
but
Keep total loudness less than or equal to normal

NAL-NL1 (1999) → empirical studies
→ psychoacoustic studies
→ speech intelligibility models
} NAL-NL2

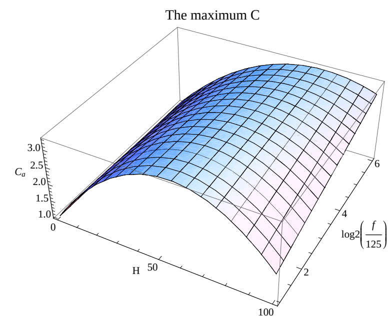
Deriving optimal gains - step 1



Overall approach to prescription

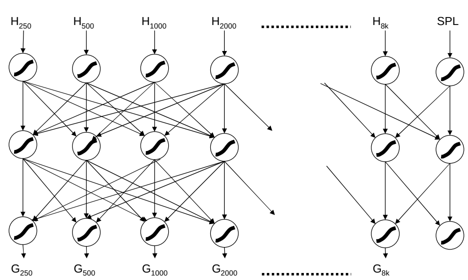


Limiting compression ratio



Multi-dimensional equation:

A neural network

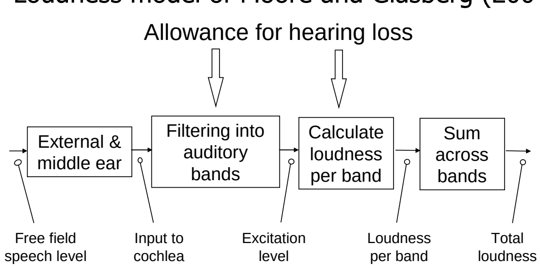


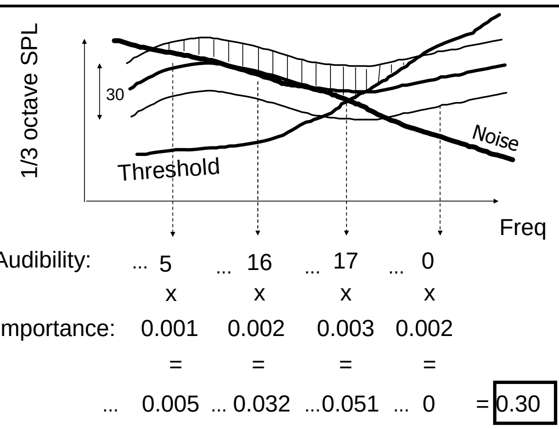
Effect of language

- Gain at each frequency depends on importance of each frequency
- Low frequencies more important in tonal languages
- Two versions of NAL-NL2
  - Tonal languages
  - Non-tonal languages

Calculating loudness

Loudness model of Moore and Glasberg (2004)





Speech Intelligibility Index

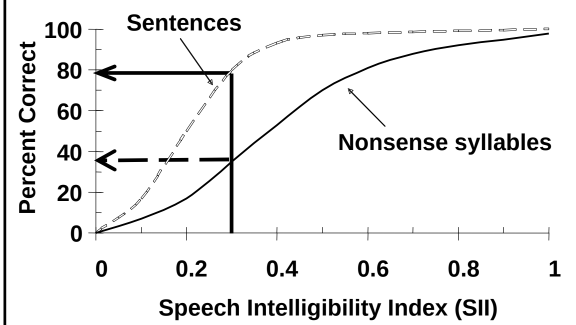
Sum

$$SII = \sum A_i I_i$$

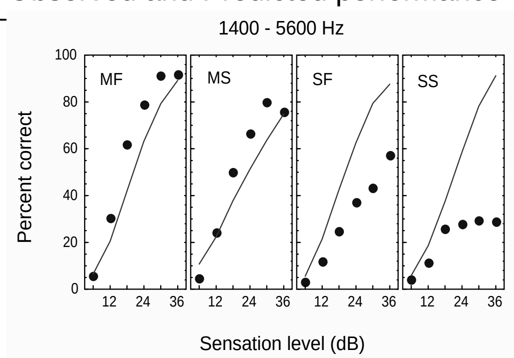
Audibility Importance

But intelligibility gets worse if we make speech too loud!

The transfer function

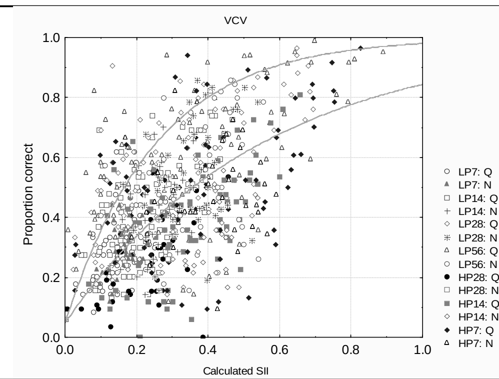


Observed and Predicted performance

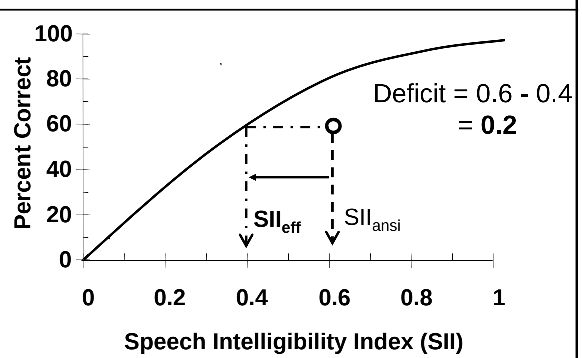


Ching, Dillon & Byrne, 1998

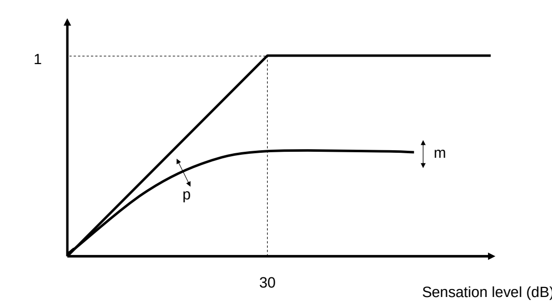
Audibility and Speech intelligibility – H.I.

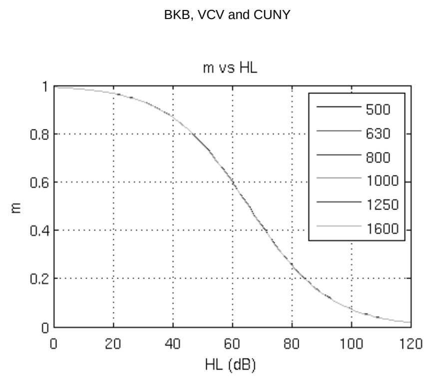


Deficit = S_{ansii} - SII_{eff}

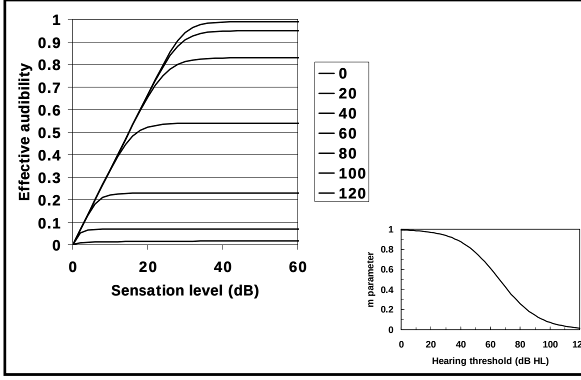


Intelligibility and audibility





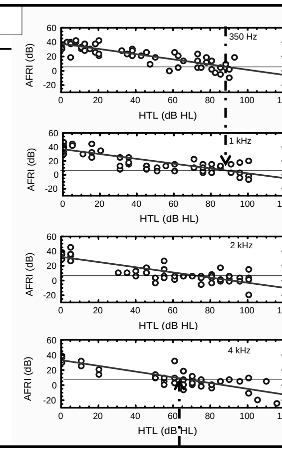
Desensitisation for hearing loss



Psychoacoustics

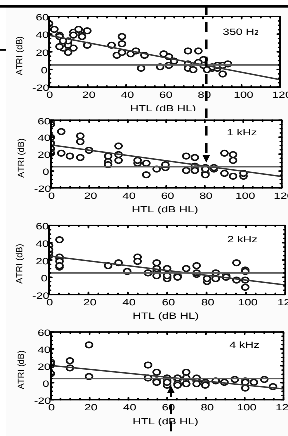
Why measure only pure tone thresholds?

Frequency resolution



Reason: OHCs lost

Temporal resolution

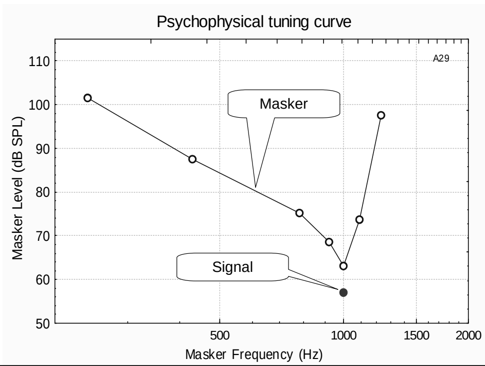


Reason: OHCs lost

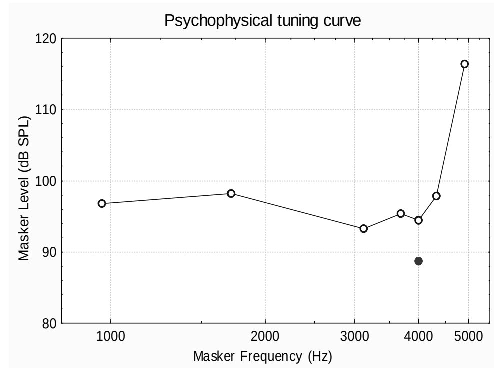
Other measurements

- Hearing threshold levels
- Outer hair cell function
  - click-evoked otoacoustic emissions
- Frequency resolution
  - psychophysical tuning curves
  - cochlear dead regions – TEN test
- Cognitive ability
- Age

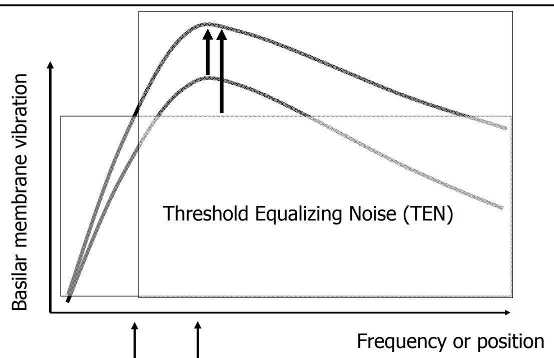
Healthy PTC – no dead region



Poor PTC: Dead region at 4 kHz

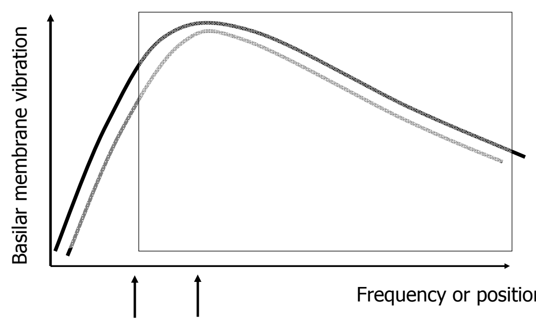


Off-frequency listening: TEN test



Based on Moore (2004)

Off-frequency listening: PTC



TEN and PTC (non) agreement

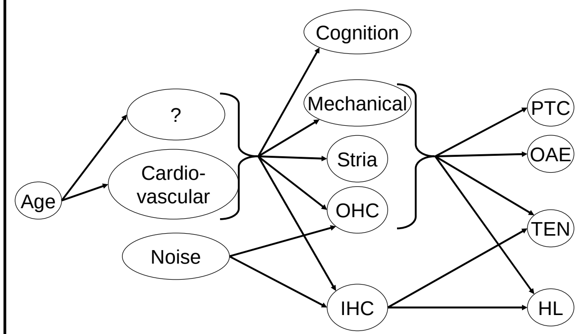
2 kHz	TEN: Alive	TEN: Dead	TEN uncertain
PTC: Tip in place	60	1	1
PTC: Tip shifted	4	3	2
PTC uncertain	1	2	1

Can we better predict intelligibility if we use psychoacoustic results?

Yes, a little – speech deficit increases as frequency selectivity gets broader

But not once we fully build HL into the SII prediction

Likely intermediate effects



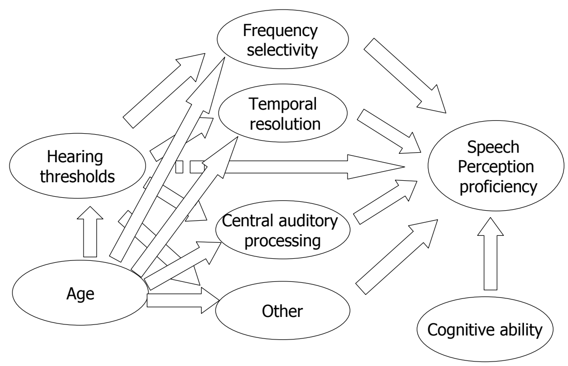
Implications for prescription

Pure tone thresholds critical

Knowledge of temporal resolution, frequency resolution, dead regions adds relatively little to prediction of intelligibility

Age and cognitive ability affect all frequency bands similarly → no effect on gain needed

Why are hearing thresholds so useful?



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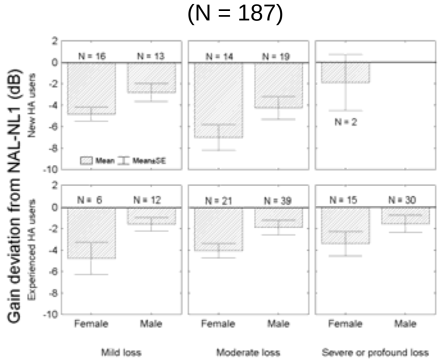
Gain; adults, medium input level

(N = 187)



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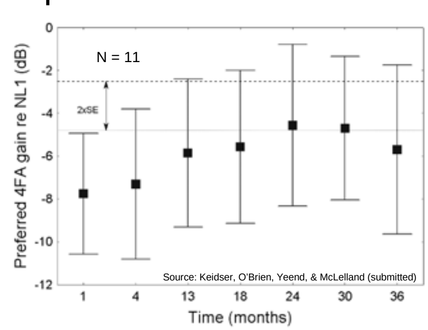
Gain preference over time



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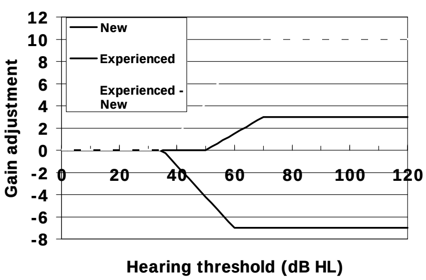
Adjustments to prescription to allow for experience



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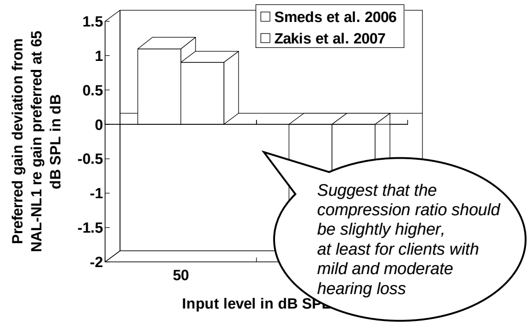
Gain; adults, low and high input levels



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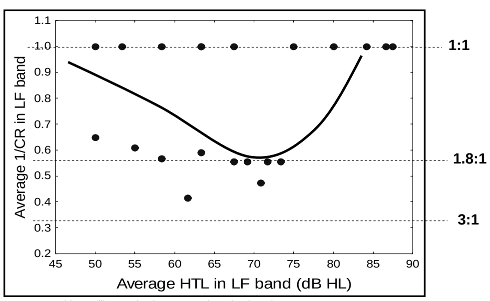
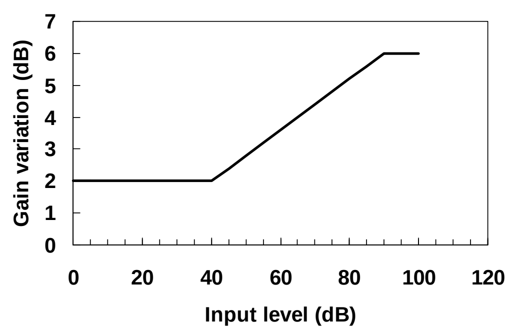
Compression ratio preferences: severe and profound hearing loss

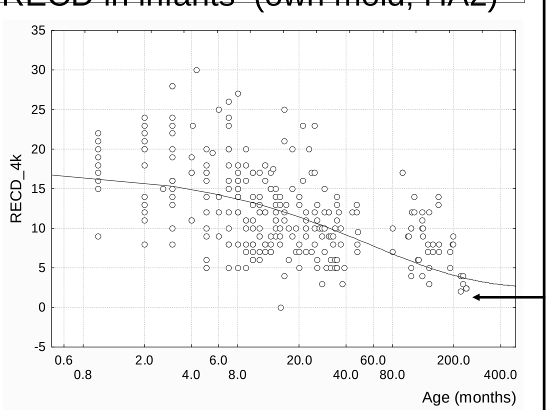


Source: Keidser, Dillon, Dyrlund, Carter, and Hartley (2007)

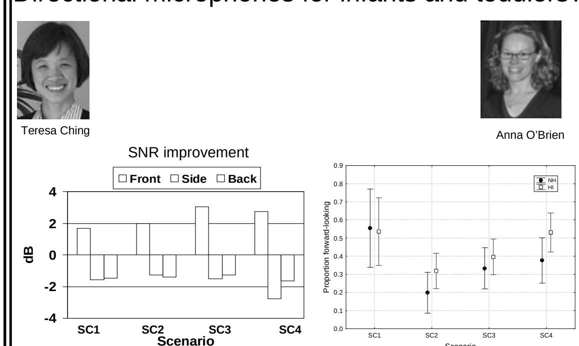
Binaural loudness correction



RECD in infants (own mold; HA2)



Directional microphones for infants and toddlers?

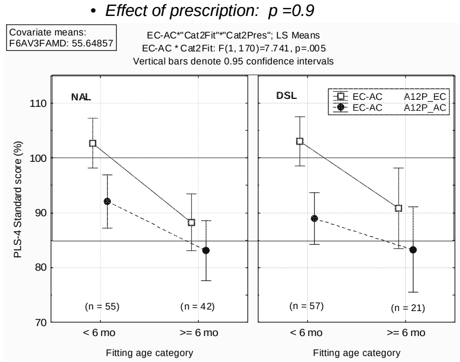


Yes ! More to gain than there is to lose.

Ching, O'Brien et al, 2009

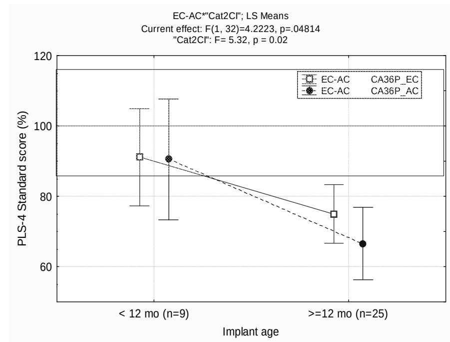
Language at 12 months after fitting

- *Effect of age of fitting: p = 0.0001**
- *Effect of hearing loss: p < 0.0001**
- *Effect of prescription: p =0.9*

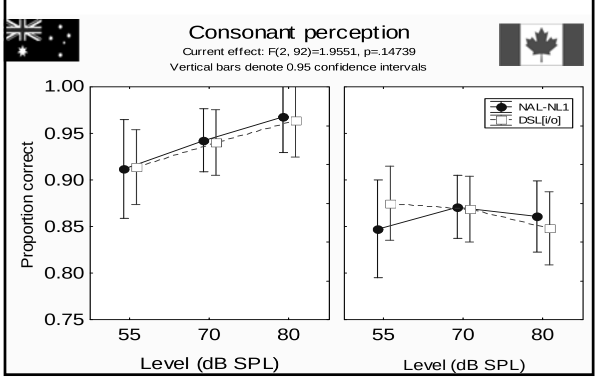


Language skills at 3 yrs

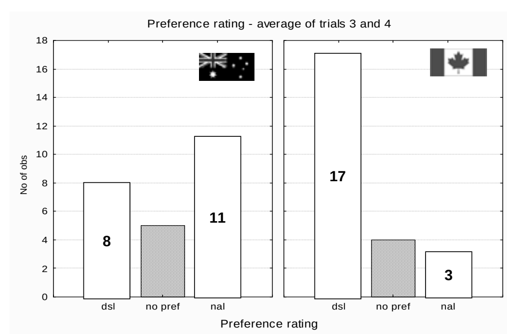
Effect of age of implant: p = 0.02



Consonant perception at 55, 70, 80 dB



Preference rating in real life



T Ching, NAL, CRC CI&HA INN

Empirical evidence: variations from NAL-NL1