

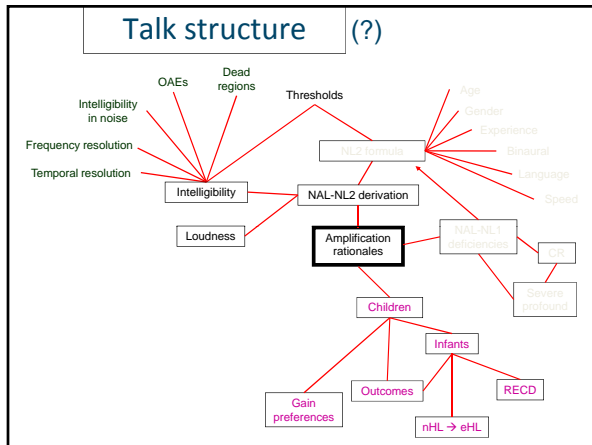
 

The NAL-NL2 prescription method for hearing aids

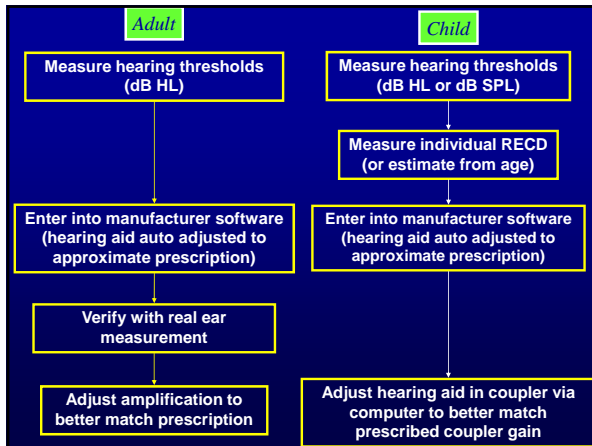
Harvey Dillon, Gitte Keidser, Teresa Ching,
Matt Flax, Scott Brewer

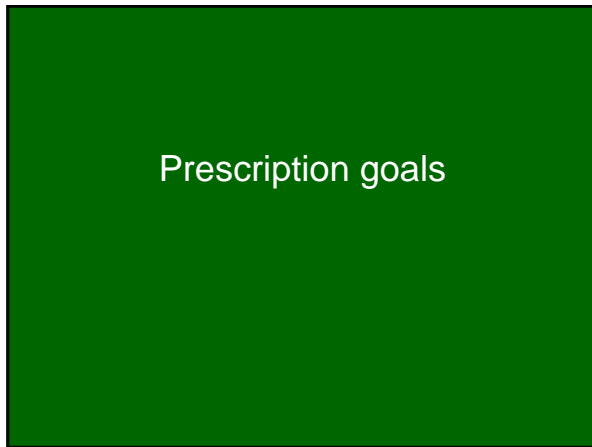
HEARing CRC
National Acoustic Laboratories, Australia

Audiology Online
June 2012



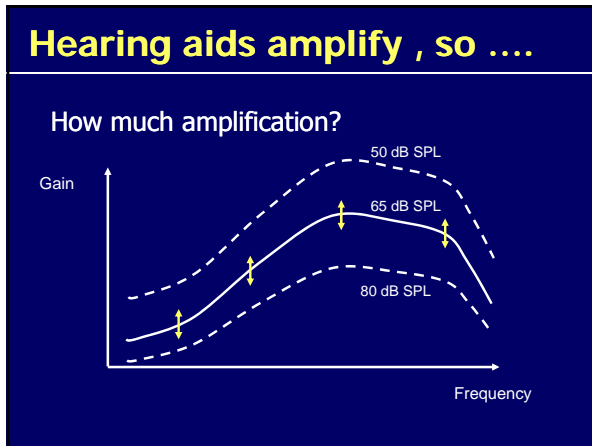
The Fitting Process



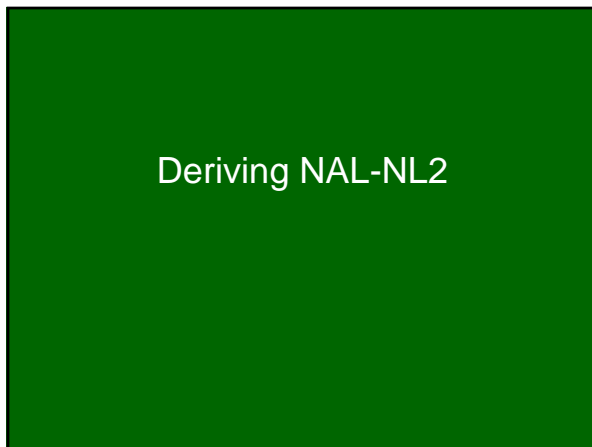


Prescribe hearing aids to:

- Make speech intelligible
- Make loudness comfortable
- Prescription affected by other things
 - localization,
 - tonal quality,
 - detection of environmental sounds,
 - naturalness.







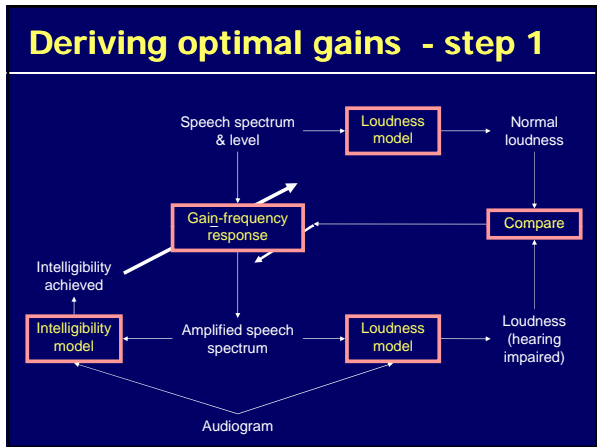
The rationale for NAL procedures

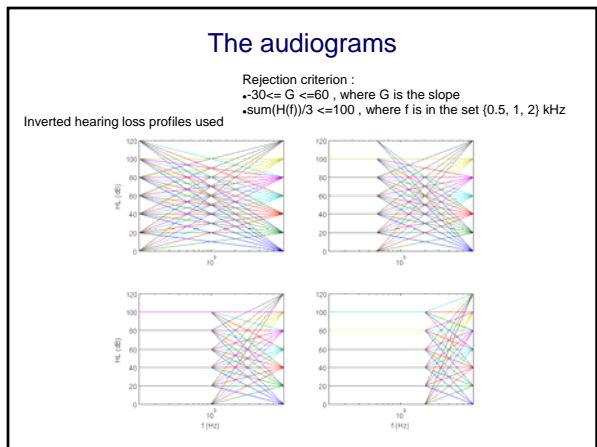
Maximize calculated speech intelligibility ,
but
Keep total loudness less than or equal to normal

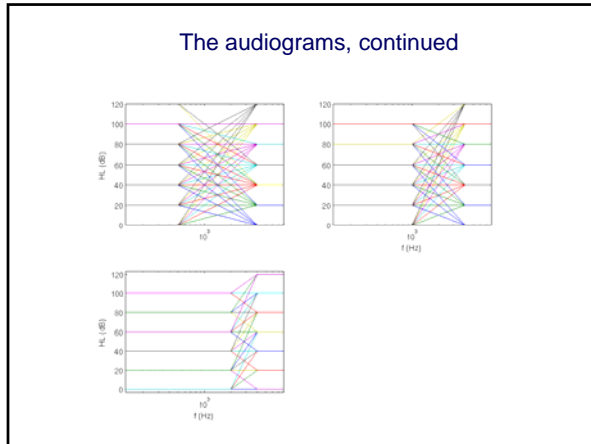
NAL-NL1 (1999) → empirical studies
→ psychoacoustic studies
→ speech intelligibility models

}

NAL-NL2



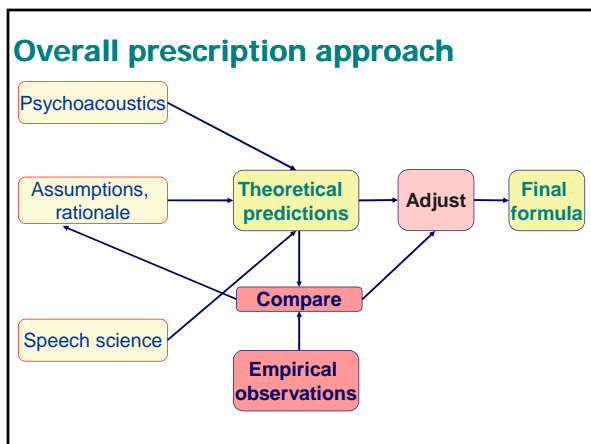


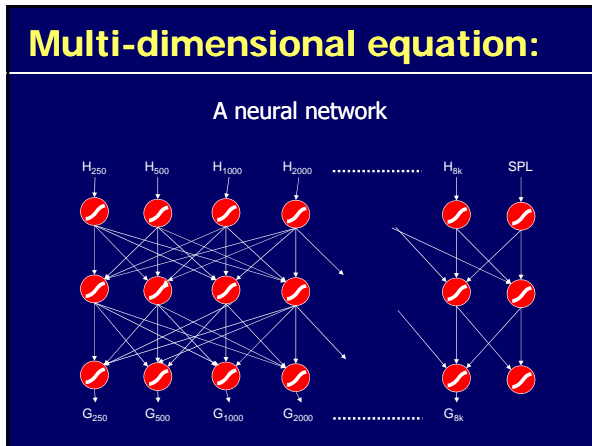


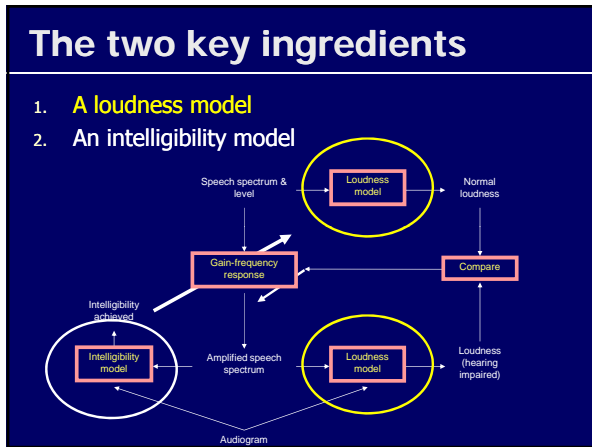
Deriving optimal gains - step 1

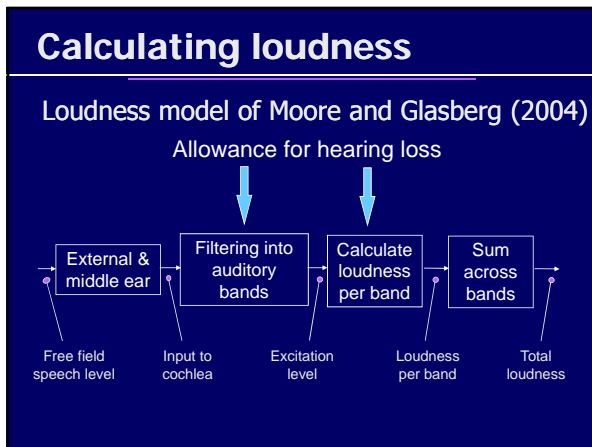
Audiogram 1	Speech level 1	Optimal gain frequency response
Audiogram 1	Speech level 2	Optimal gain frequency response
Audiogram 1	Speech level 3	Optimal gain frequency response
Audiogram 2	Speech level 1	Optimal gain frequency response

200 audiograms x 6 speech levels → 1200 gain–frequency responses,
each at 20 frequencies from 125 Hz to 10 kHz

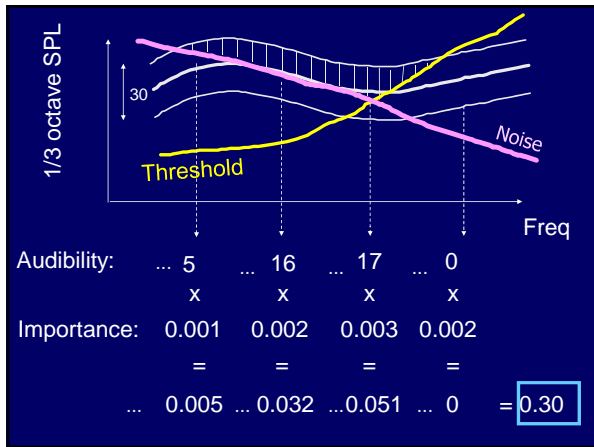








Speech intelligibility



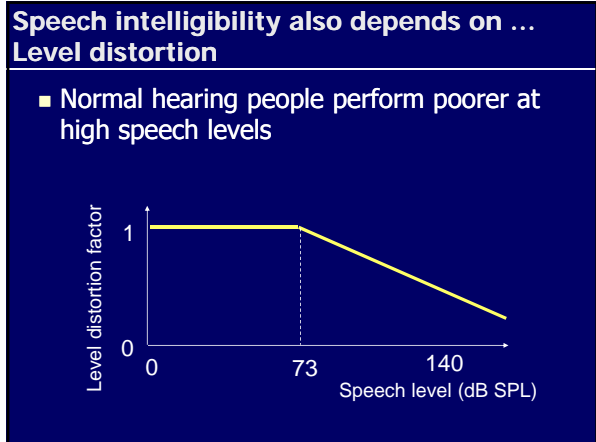
Speech Intelligibility Index

Sum

$$SII = \sum A_i I_i$$

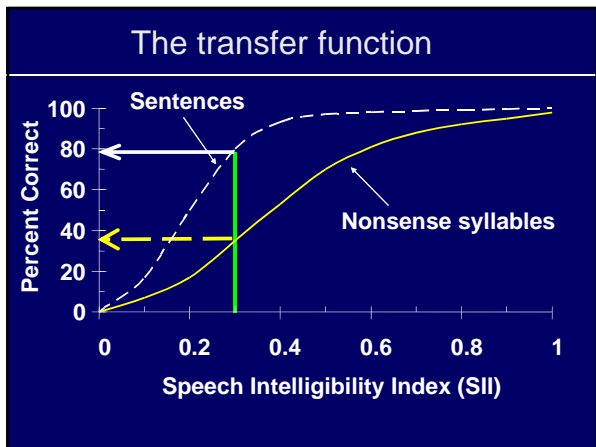
Audibility Importance

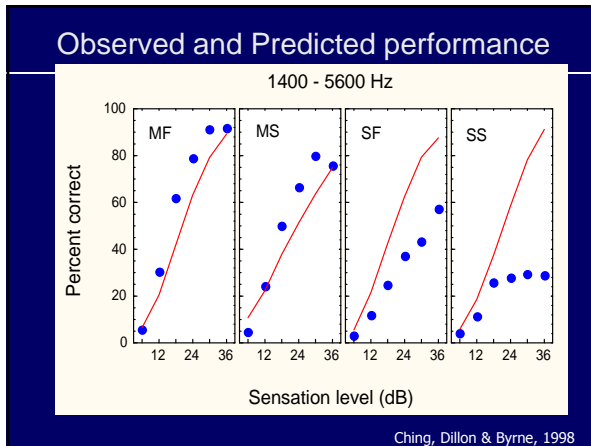
But intelligibility gets worse if we make speech too loud!

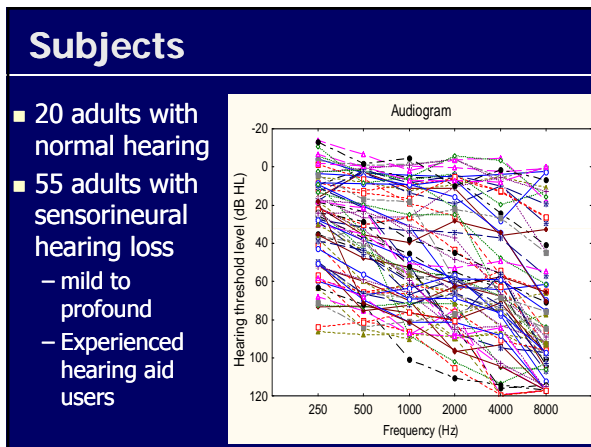


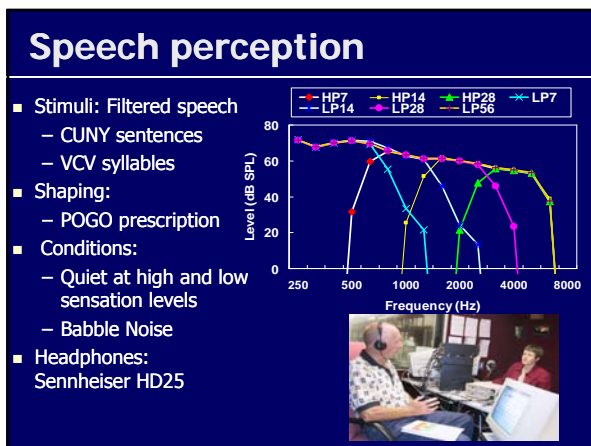
$$SII = \sum A_i I_i L_i$$

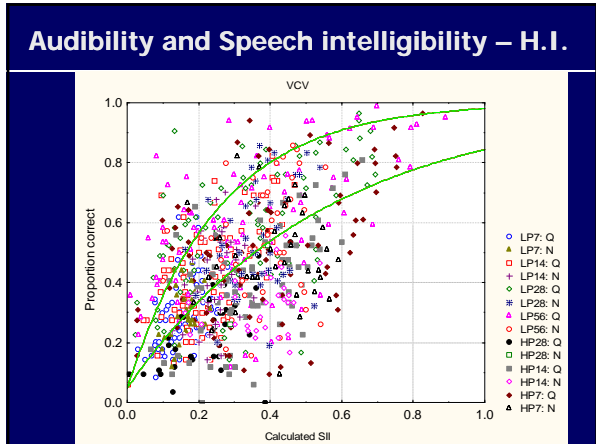
Level distortion factor

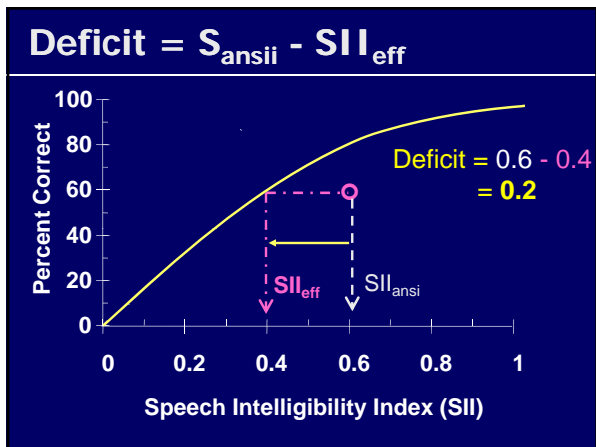


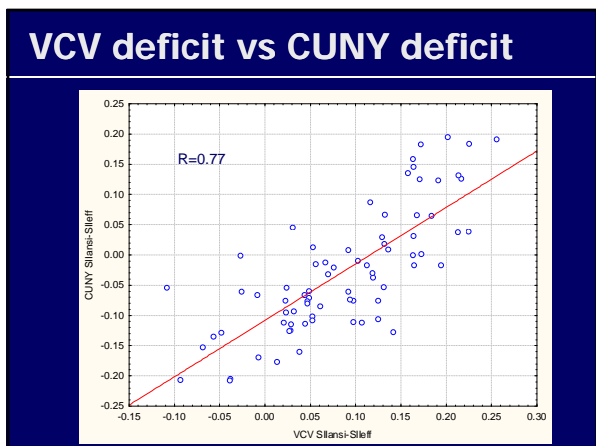


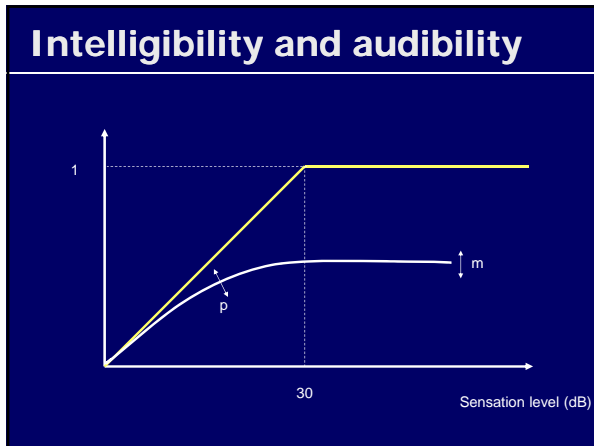


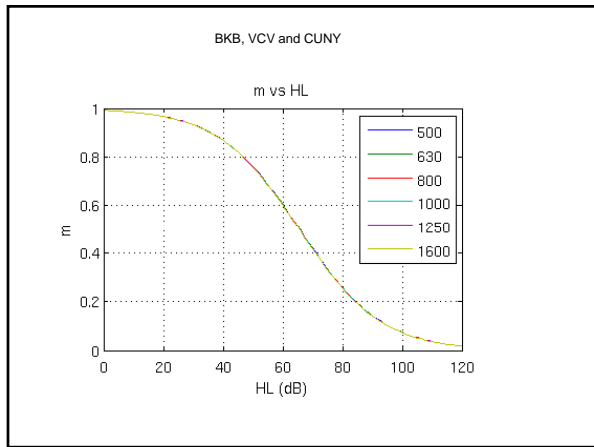


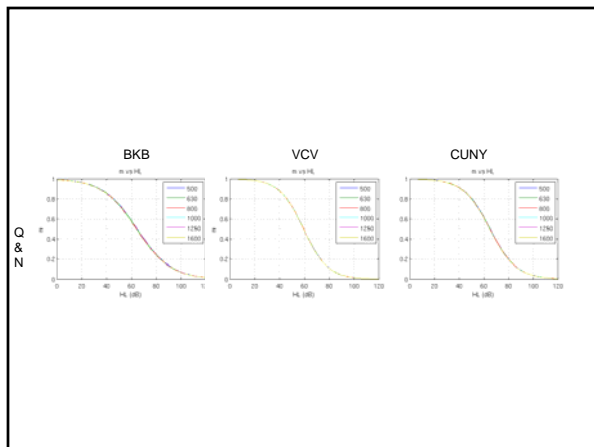


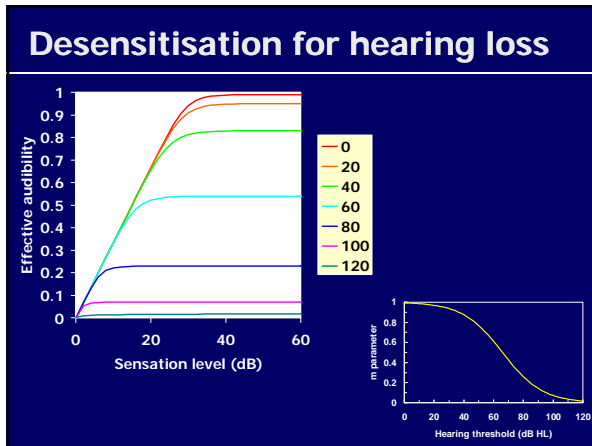













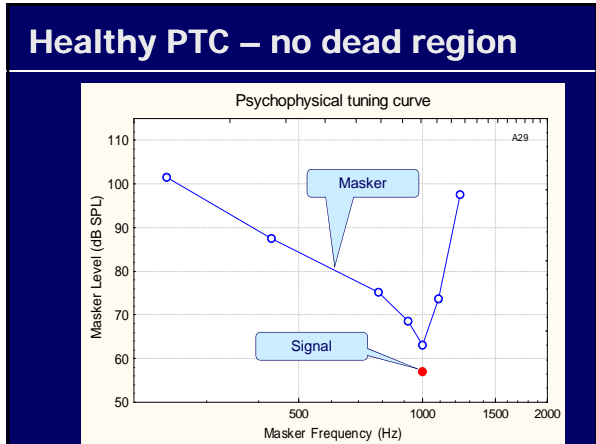
Psychoacoustics

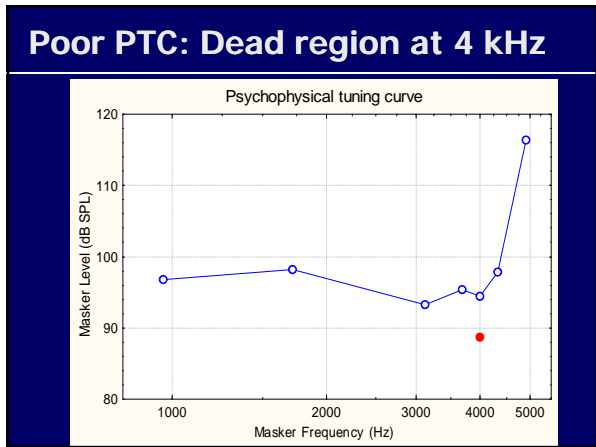
Why measure only pure tone thresholds?

Other measurements

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



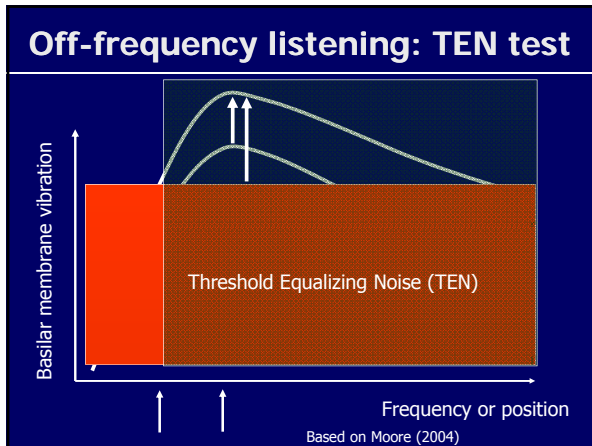




Dead regions

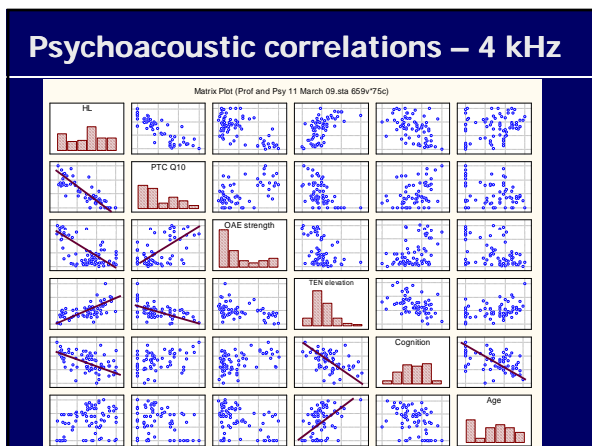
RIP

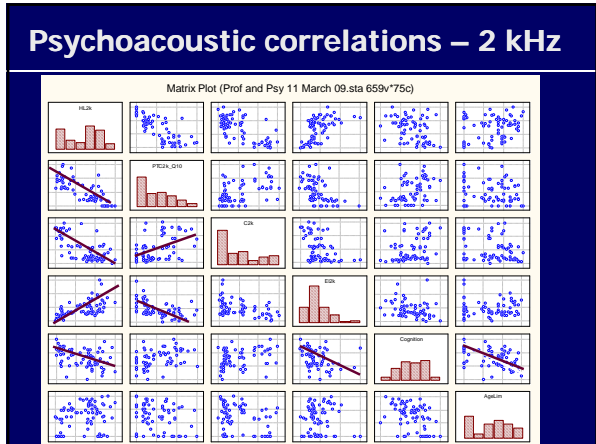
NAL-NL1 only allows for hearing loss desensitization on average



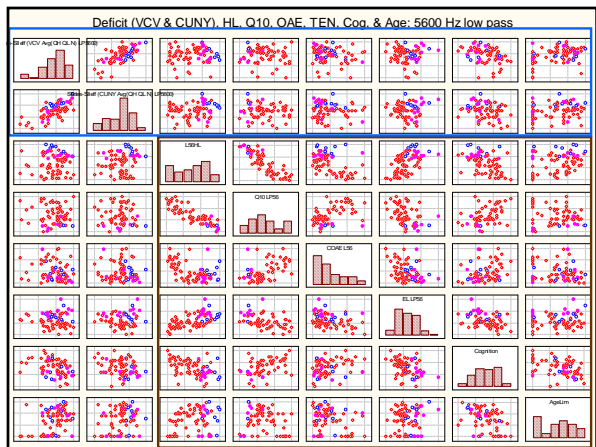
TEN and PTC (non) agreement

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?



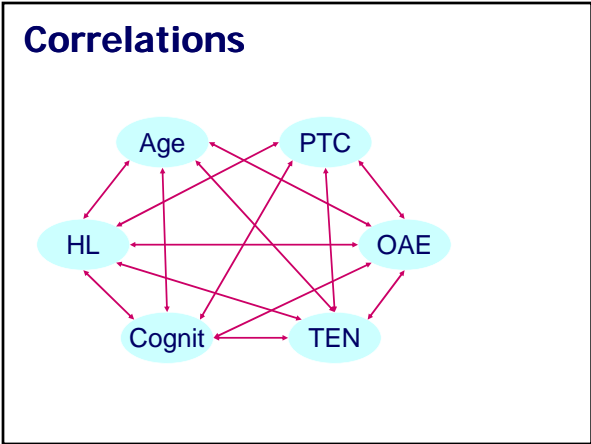
Yes, a little – speech deficit increases as frequency selectivity gets broader

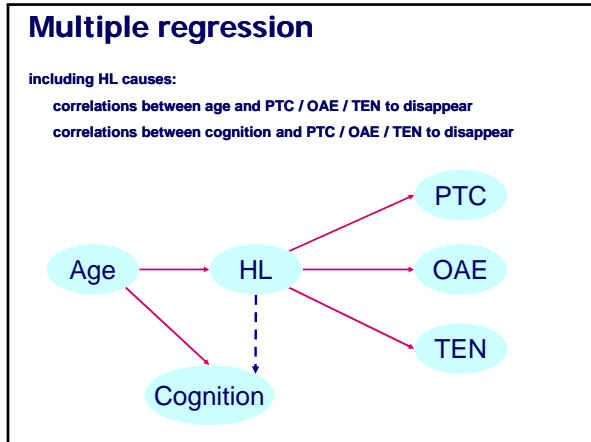
But not once we fully build HL into the SII prediction

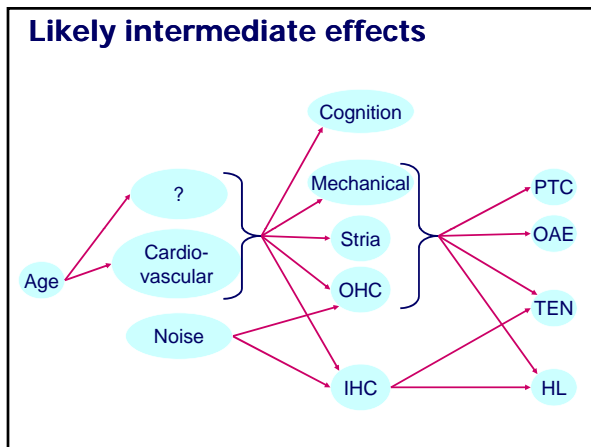
Correlations

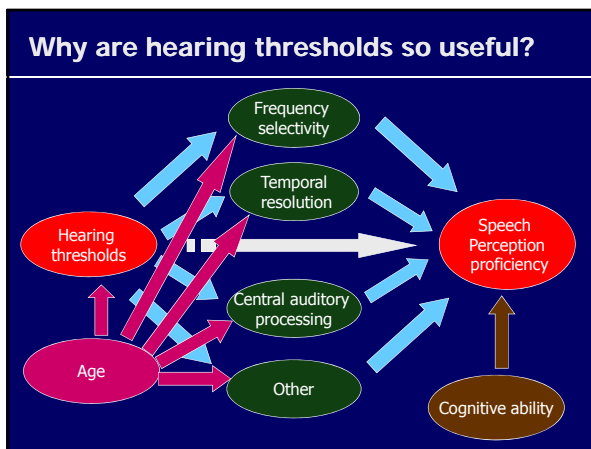
500 Hz							1 kHz						
HL 500	PTC5_Q10	OAE 500	TEN 500	Cognit	Age		HL 1k	PTC1k_Q10	OAE 1k	TEN 1k	Cognit	Age	
--	-0.70	0.04	0.56	-0.38	0.26		HL 1k	--	-0.63	0.36	0.46	-0.38	0.30
-0.70	--	-0.06	-0.48	0.33	-0.17		PTC1k_Q10	-0.63	--	0.20	-0.10	0.23	-0.17
0.04	-0.06	--	-0.10	-0.05	-0.05		OAE 1k	-0.36	0.30	--	-0.18	0.20	-0.20
0.56	-0.48	-0.10	--	-0.35	0.04		TEN 1k	0.46	-0.10	-0.18	--	-0.13	0.10
-0.38	0.33	-0.05	-0.35	--	-0.45		Cognition	-0.38	0.23	0.20	-0.13	--	-0.45
0.26	-0.17	-0.05	0.04	-0.45	--		Age	0.30	-0.17	-0.20	0.10	-0.45	--

2 kHz						4 kHz						
HL 2k	PTC2k_Q10	OAE 2k	TEN 2k	Cognit	Age	HL 4k	PTC4k_Q10	OAE 4k	TEN 4k	Cognit	Age	
--	-0.79	-0.65	0.53	-0.40	0.35	HL 4k	--	-0.84	-0.60	0.58	-0.43	0.41
-0.79	--	0.49	-0.47	0.36	-0.25	PTC4k_Q10	-0.84	--	0.59	-0.49	0.33	-0.23
-0.65	0.49	--	-0.36	0.35	-0.36	OAE 4k	-0.60	0.50	--	-0.31	0.44	-0.40
0.53	-0.47	-0.36	--	-0.38	0.15	TEN 4k	0.58	-0.49	-0.31	--	-0.45	0.38
-0.40	0.36	0.35	-0.38	--	-0.42	Cognition	-0.43	0.33	0.44	-0.45	--	-0.45
0.35	-0.25	-0.36	0.15	-0.42	--	Age	0.41	-0.23	-0.40	0.38	-0.45	--

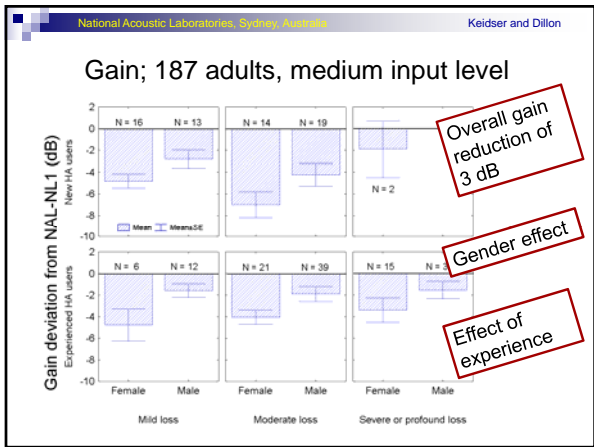


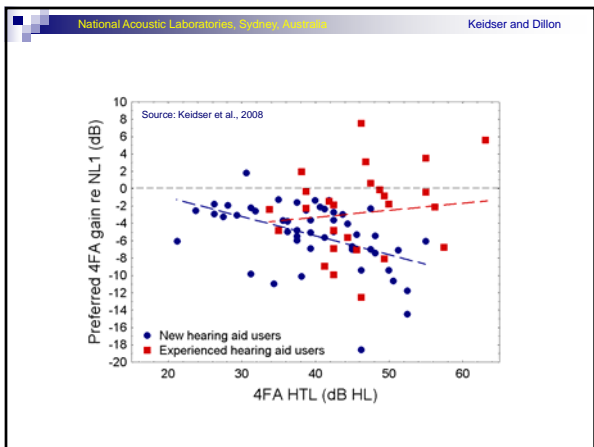


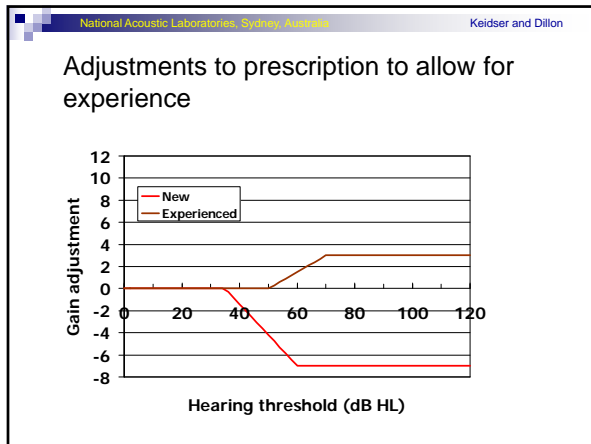


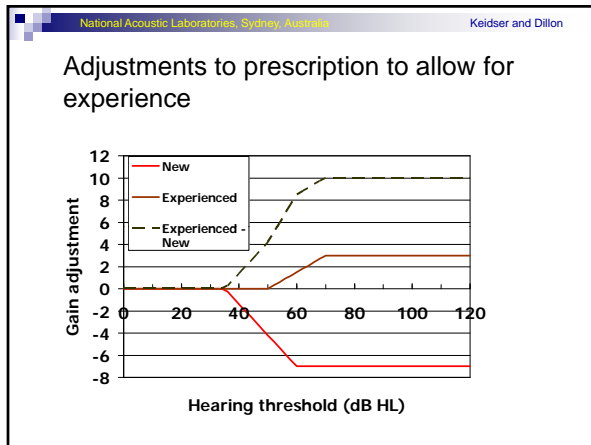


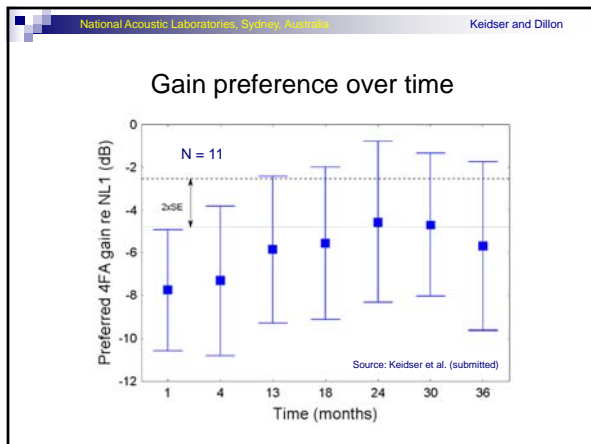
Factors affecting prescription

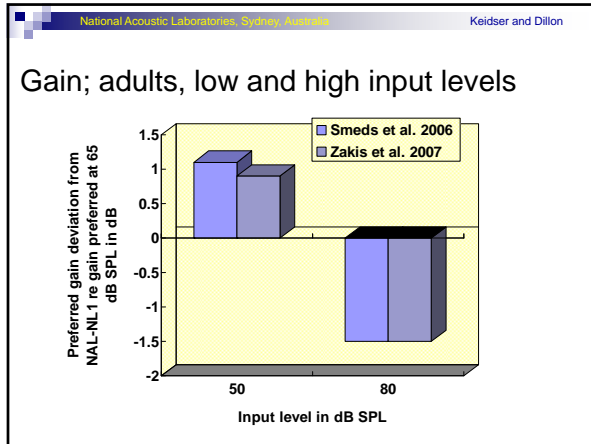


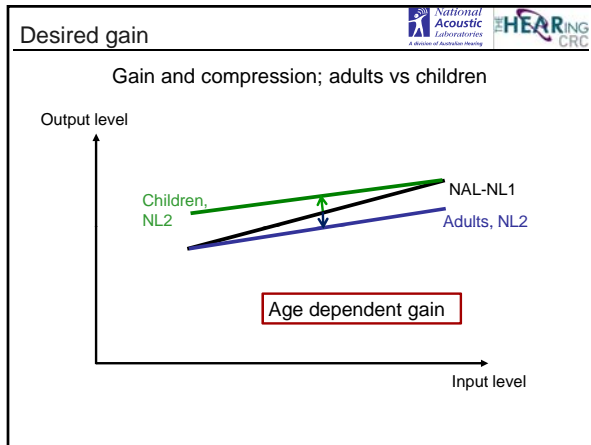


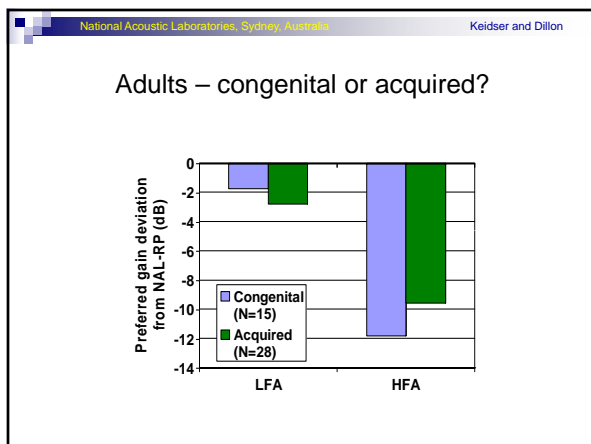


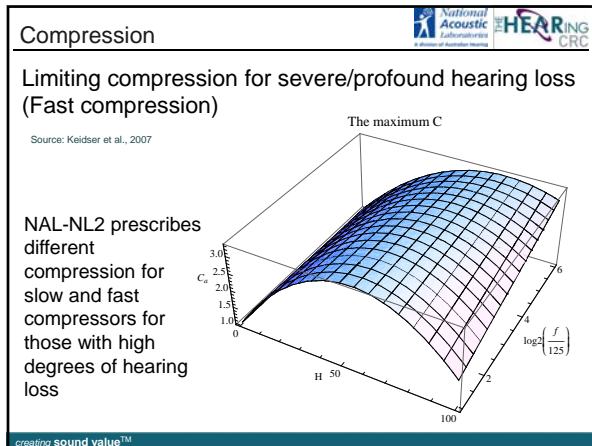


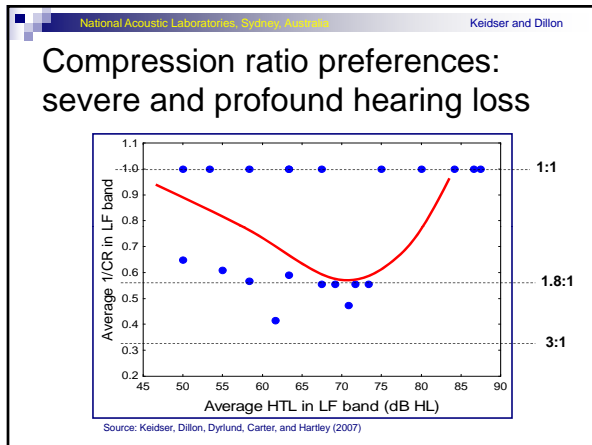


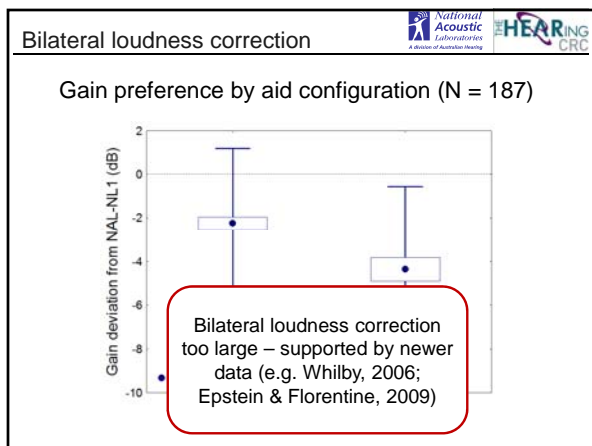


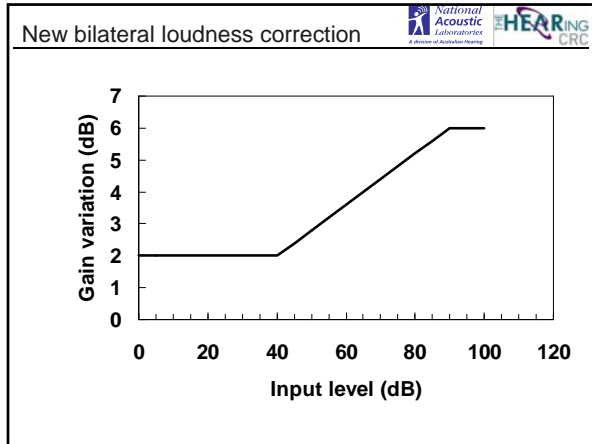








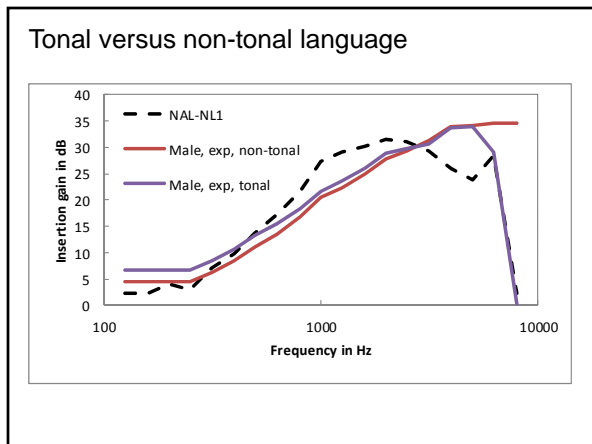


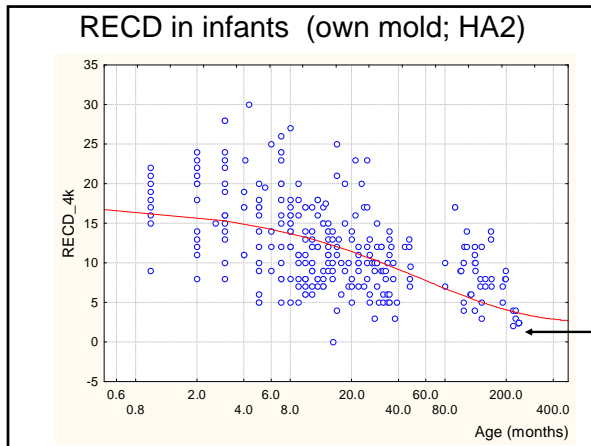


National Acoustic Laboratories, Sydney, Australia
Keidser and Dillon



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



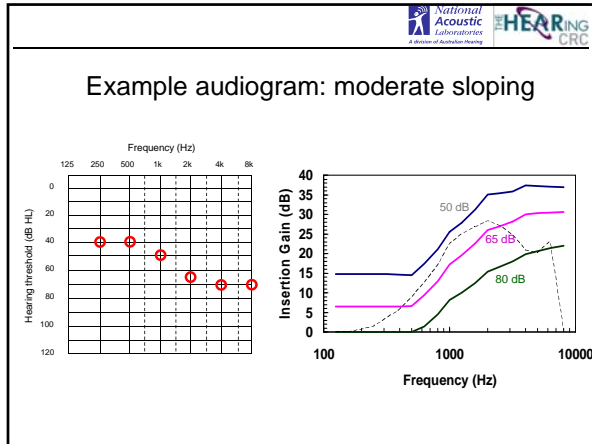


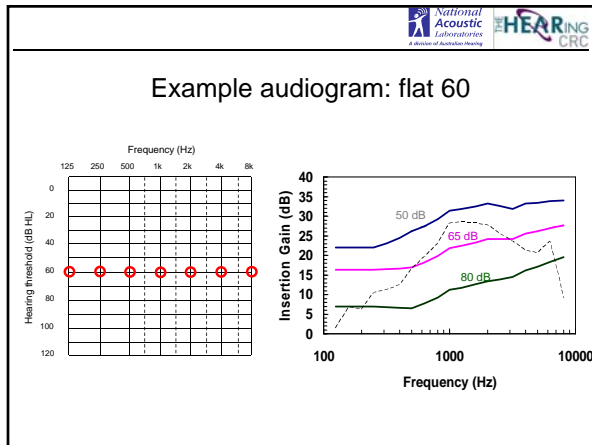
Summary

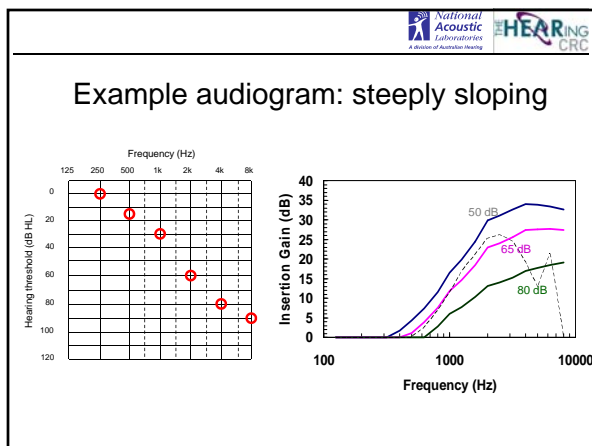
 

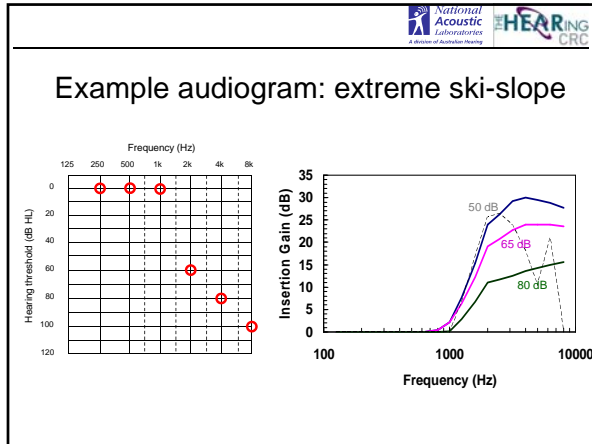
- New features in NAL-NL2
 - Different gain-frequency response shape and higher compression ratios
 - Different compression ratios for fast and slow compressors (severe/profound hearing loss)
 - Gender dependent gain
 - Age dependent gain
 - Gain adaptation for new hearing aid users
 - Language dependent gain (tonal vs non-tonal)

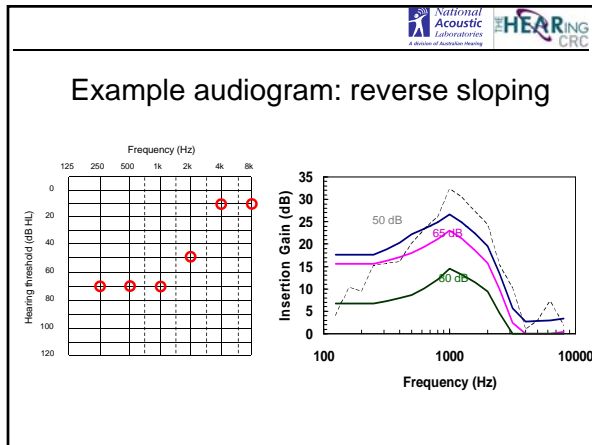
Examples of prescriptions

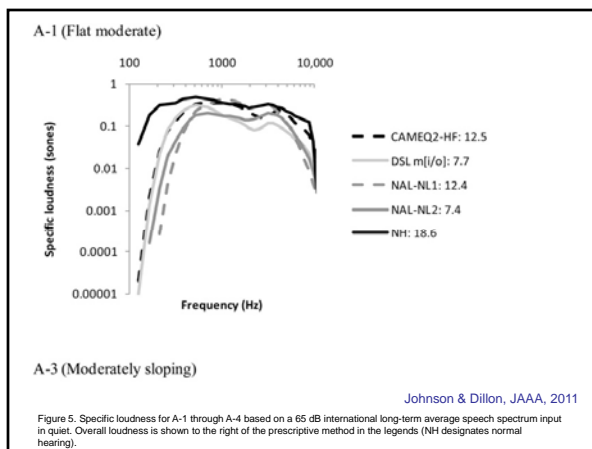












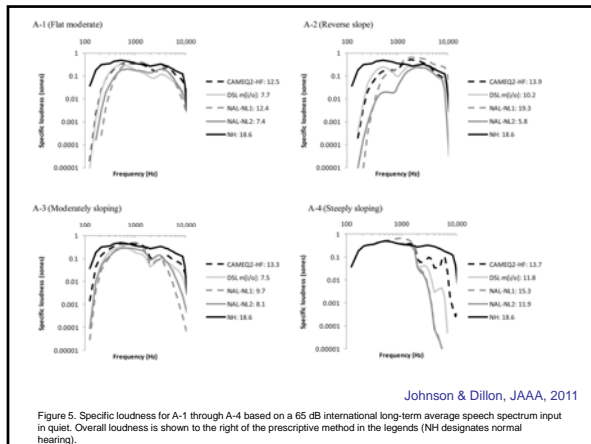


Figure 5. Specific loudness for A-1 through A-4 based on a 65 dB international long-term average speech spectrum input in quiet. Overall loudness is shown to the right of the prescriptive method in the legends (NH designates normal hearing).

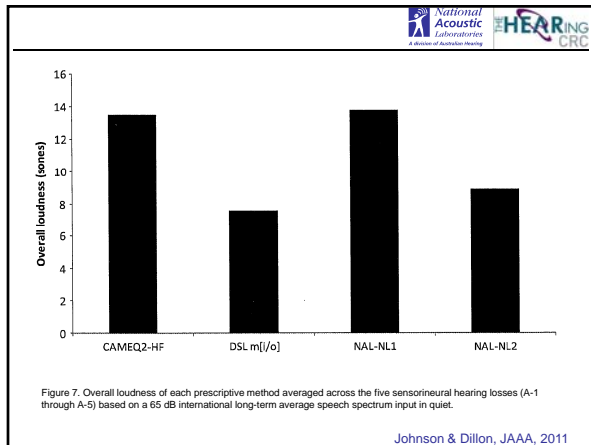


Figure 7. Overall loudness of each prescriptive method averaged across the five sensorineural hearing losses (A-1 through A-5) based on a 65 dB international long-term average speech spectrum input in quiet.

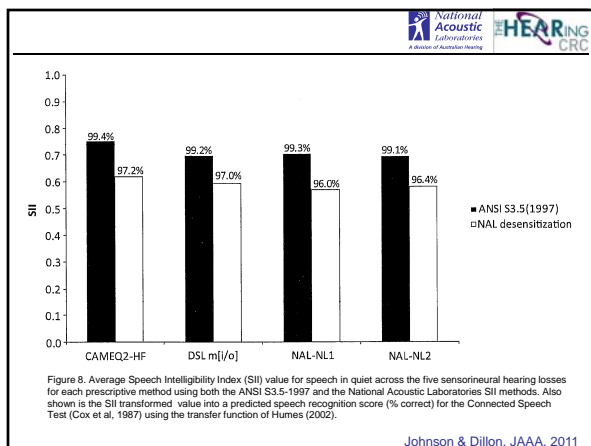
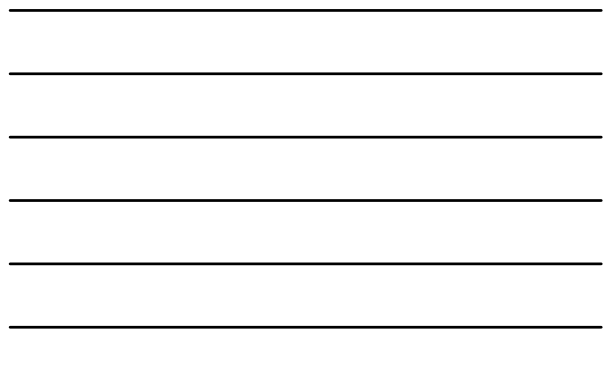
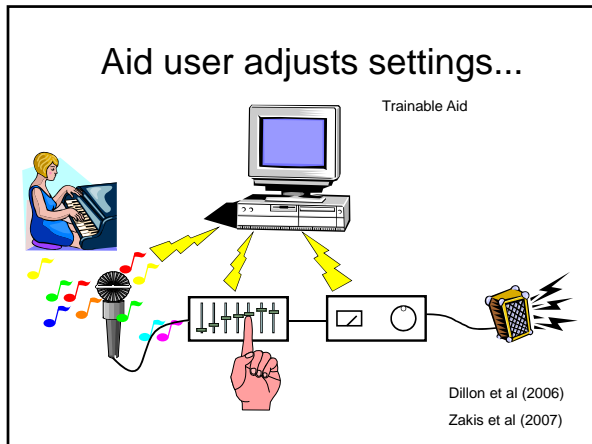
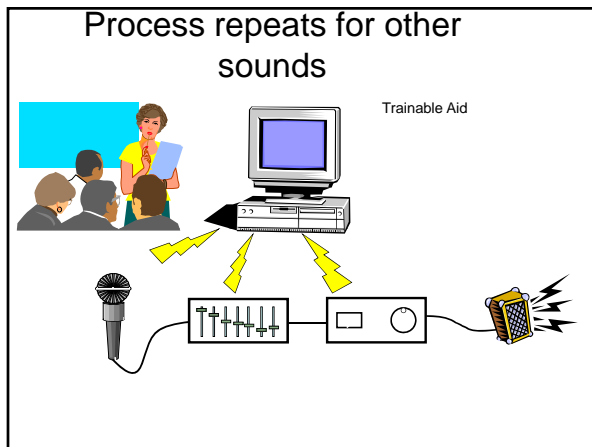
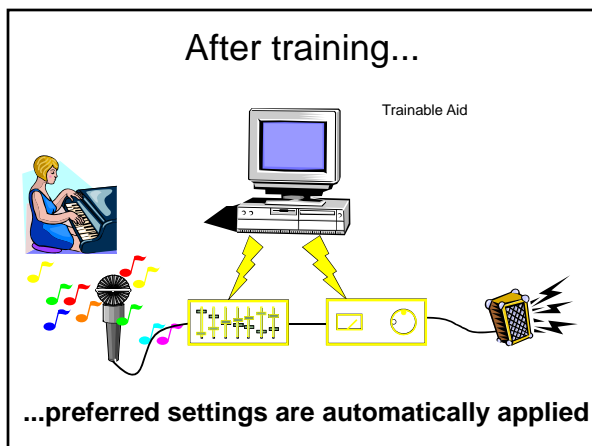


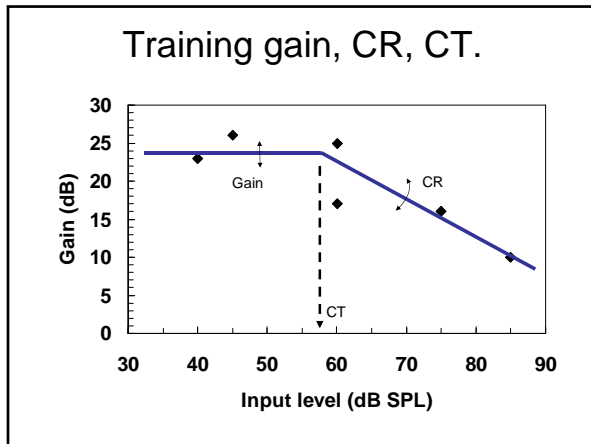
Figure 8. Average Speech Intelligibility Index (SII) value for speech in quiet across the five sensorineural hearing losses for each prescriptive method using both the ANSI S3.5-1997 and the National Acoustic Laboratories SII methods. Also shown is the SII transformed value into a predicted speech recognition score (% correct) for the Connected Speech Test (Cox et al., 1987) using the transfer function of Humes (2002).











“A challenge for the profession is to devise fitting procedures that are scientifically defensible and the challenge for the individual audiologist is to choose the best procedures from whatever are available”
Denis Byrne, 1998

Thanks for listening

Acknowledgements www.hearingcrc.org
www.nal.gov.au

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creating sound value™
