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Acclimatization to hearing aids

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Manchester Academic Health Science Centre

- Research overview

- Background
- Starkey acclimatization study
- Patient focus groups
- Attention study

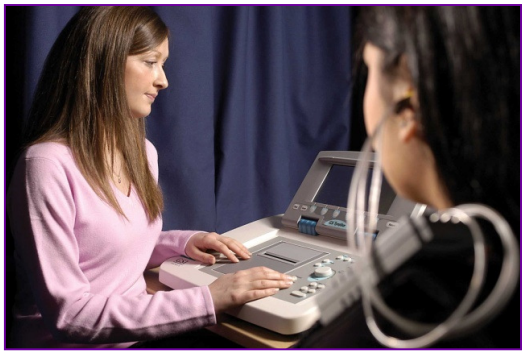
Manchester Audiology and Deafness Research Group

- Ellis Llwyd Jones
- Son of Rochdale cotton millionaire
- Born deaf, educated at Oxford
- Killed in WW1
- Father donated his son's fortune (£5m) to founding our group (1919)
- Led by Irene and Alexander Ewing, established the principals of paediatric audiology and deaf education (early identification and intervention, involvement of family, hearing assessment)

….100 years on

- Developed and implemented universal newborn hearing screening
- Modernisation of hearing aid services in the NHS
- Leading centre for audiology training in the UK

- Current research: Translating basic research into direct benefit to people with hearing loss. Delivering improved services in health care and education for adults and children with hearing loss



- Multidisciplinary team: audiology, deaf education, medicine, psychophysics, electrophysiology, signal processing, cognitive psychology, genetics and imaging

Current projects

1. **Epidemiology of hearing loss: UK Biobank**
2. Genetics of age-related HL (UCL, KCL, Harvard)
3. 'SENSE-Cog' EU study: mental well-being in older adults with hearing and vision impairment
4. Facilitation & measurement of hearing aid uptake, use & benefit
5. **Acclimatization to hearing aids**

Background: Acclimatization

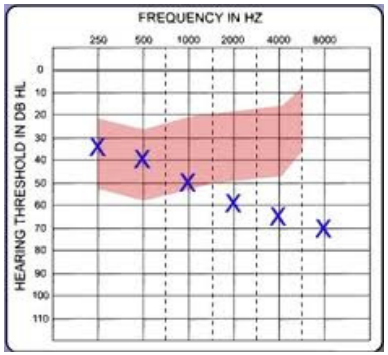
"Improvement over time as users learn to make optimal use of altered patterns of auditory input"

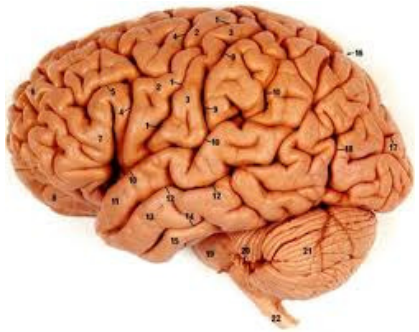
→Explain individual differences & boost benefit from hearing aid?

- Optimizing first-fitting programs for hearing aids
  - Incremental gain/other HA settings
- Informing counseling for first time users
  - HA users more likely to be satisfied with HA and persist if they know what to expect
- Helping select management strategies
  - Eg behavioural training
- Individualizing fitting for hearing aids
  - Eg acclimatization depend on cognitive capacity

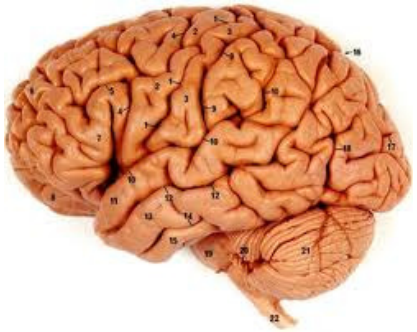
Hearing aid model

Deprivation → plastic changes





Restoration of input → secondary changes



Acclimatization studies

√	X
Gatehouse, 1992, 1993 Cox & Alexander, 1992 Cox et al., 1996 Horwitz & Turner, 1997 Kuk et al, 2003 Munro & Lutman, 2003 Yund et al., 2007	Taylor, 1993 Bentler et al., 1993a, 1993b Humes, Wilson, & Barlow, 2002 Saunders & Cienkowski, 1997

X : acclimatization effect is either non-existent or trivially small

√ : acclimatization effects are real, lack of detection can be explained by design factors (though unclear if clinically relevant)

Acclimatization studies

- Mixed findings. Due to design factors?

→Starkey funded acclimatization study (2009-2011)

Rolls Royce acclimatization study

-prospective, longitudinal, controlled

-physiological, perceptual and real life measures

Starkey acclimatization study

Aims

1. Rate & extent of perceptual & physiological changes

2. Relationship between perception & physiology and real life benefit

3. Unilateral vs bilateral fitting (vs control group)

4. Predict individuals (or environments) showing changes. Possible to boost rate/extent of acclimatization & benefit?

Design

New users (no prior HA experience)

- New Unilateral (N = 25)
- New Bilateral (N = 17)

Controls (at least 1 year HA experience)

- Experienced (N = 17)

- Mean age ~70 yrs
- HL severity (At least 40 dB HL at 2 kHz)
- Two test occasions:
  - Fitting (T1)
  - After 12 weeks use (T2)

Hearing aids

- circuitry (all same)
- gain (real-ear measures)
- usage (data logging)
- quality of use (input level)

Measurement

- Aids in sound field (not headphones)
- Measures tap freqs/intensities where aids are expected to make a change
- Reliable measures
- Real-life relevance (SRM and listening effort)
- Predictors of acclimatization
  - RT, WM, Age (neural integrity)
  - Gain, HA use, input level (stimulation)
  - HL (initial deprivation)

Measures

Cognitive measures: reaction time, verbal memory

Environmental measures: data logging

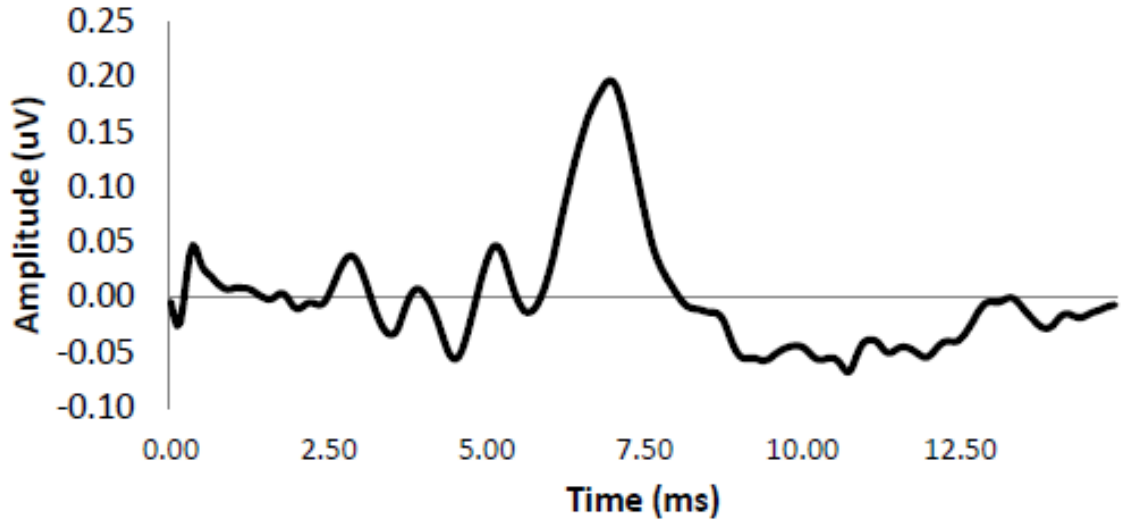
Behavioural measures: **Speech in noise**, loudness balancing, **Spatial release from masking**, listening effort

Electrophysiological measures: Acoustic reflex, **click-ABR**, FFR, **cortical ERPs**, ERP measure of plasticity

Real-world benefit: **Spatial, Speech and Qualities of Hearing questionnaire**

Click ABR

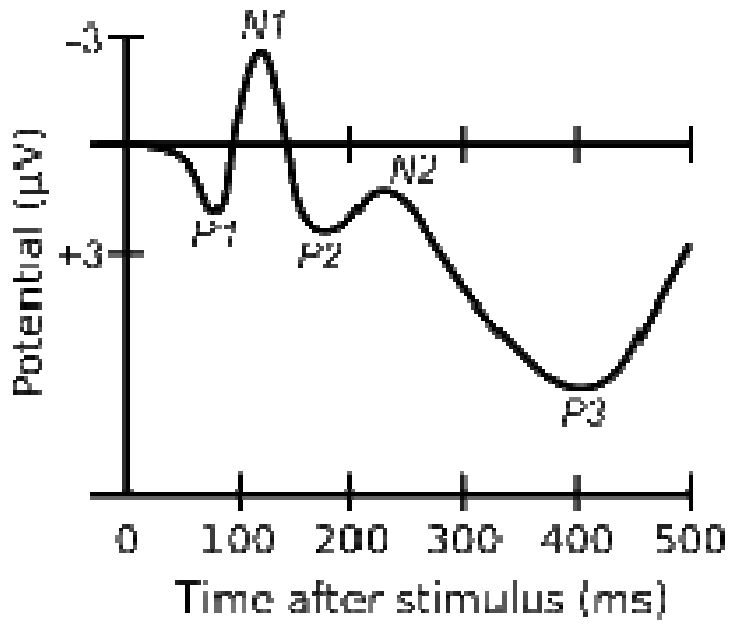
- Clicks at 80 dB nHL to L & R ear
- **No change** in wave V amplitude or latency in any ear/group



Dawes et al. (2013). Brainstem processing following unilateral and bilateral hearing-aid amplification. *NeuroReport* **24**, 271-275.

Cortical ERP

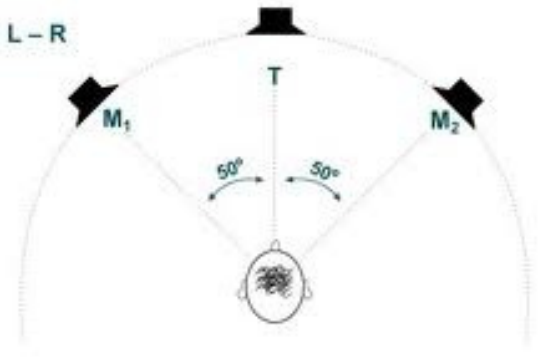
- 3000Hz and 500Hz tones to L & R ear, 65, 75, 85 dB SPL
- **No significant change** over time in latency/amplitude of N1/P2



Dawes et al (2014). Hearing aid use-related auditory acclimatization: Late auditory evoked potentials and speech recognition following unilateral and bilateral hearing-aid amplification *Journal of the Acoustical Society of America*.

Spatial release from masking

- Marrone et al (2008), aided & unaided; CRM stimuli
- SRM = 50% speech recognition threshold advantage when maskers and target are spatially separated at 90 azimuth vs co-located condition
- No improvement over time in familiar aided listening conditions
- Bilateral aids facilitated better SRM performance than unilateral aids.



Dawes et al (2013). Unilateral and bilateral hearing aids, spatial release from masking and auditory acclimatization. *Journal of the Acoustical Society of America* **134**, 596-606.

Speech-in-noise

- Four alternative auditory feature test (FAAF)
- Fixed SNR
  – Separate ear testing
  – Aided & unaided
  – 65 and 75 dB SPL target
  – 50% SNR for each condition set at T1
  – Change in % correct between T1 and T2

THOUGHT

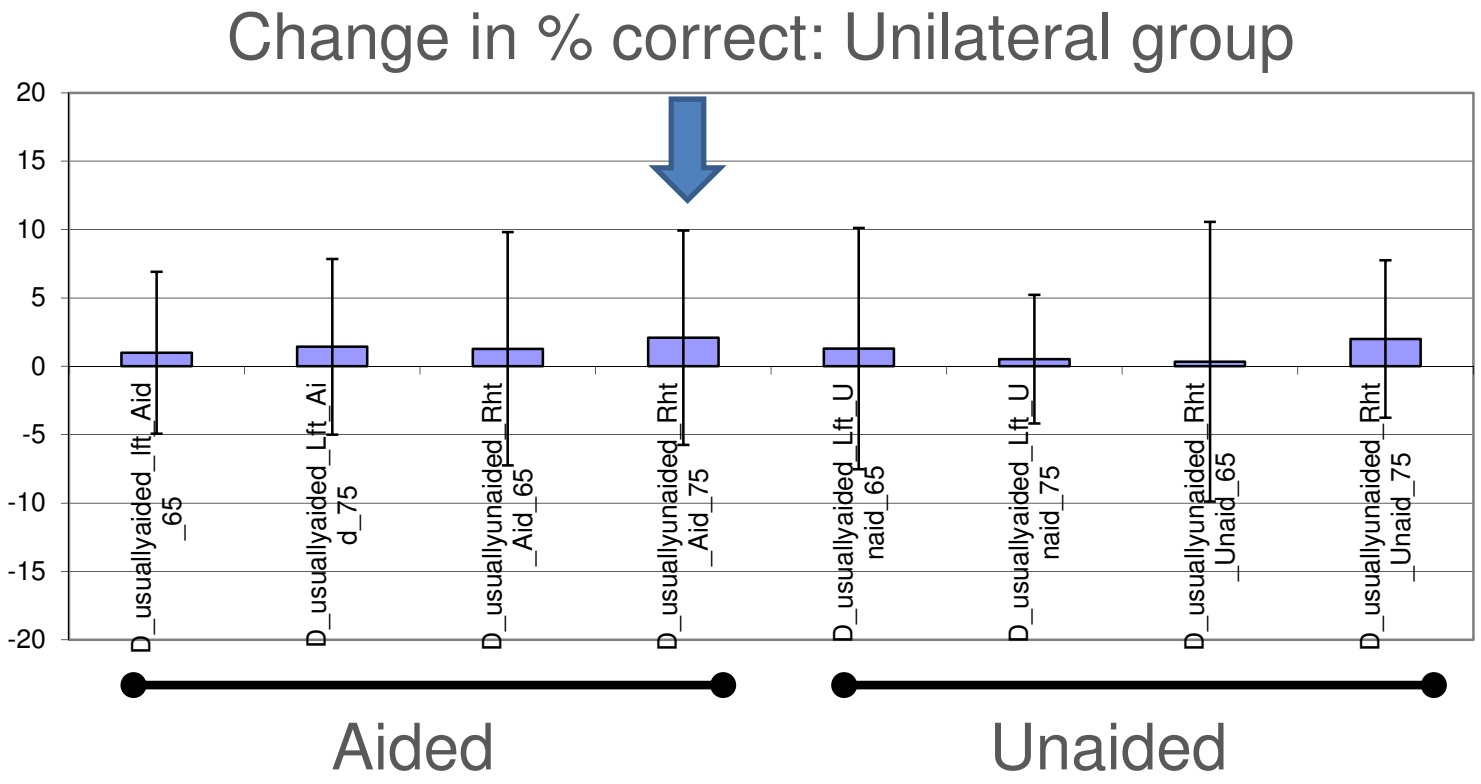
FOUGHT

TAUGHT

CAUGHT

20

Speech-in-noise (fixed SNR): No change



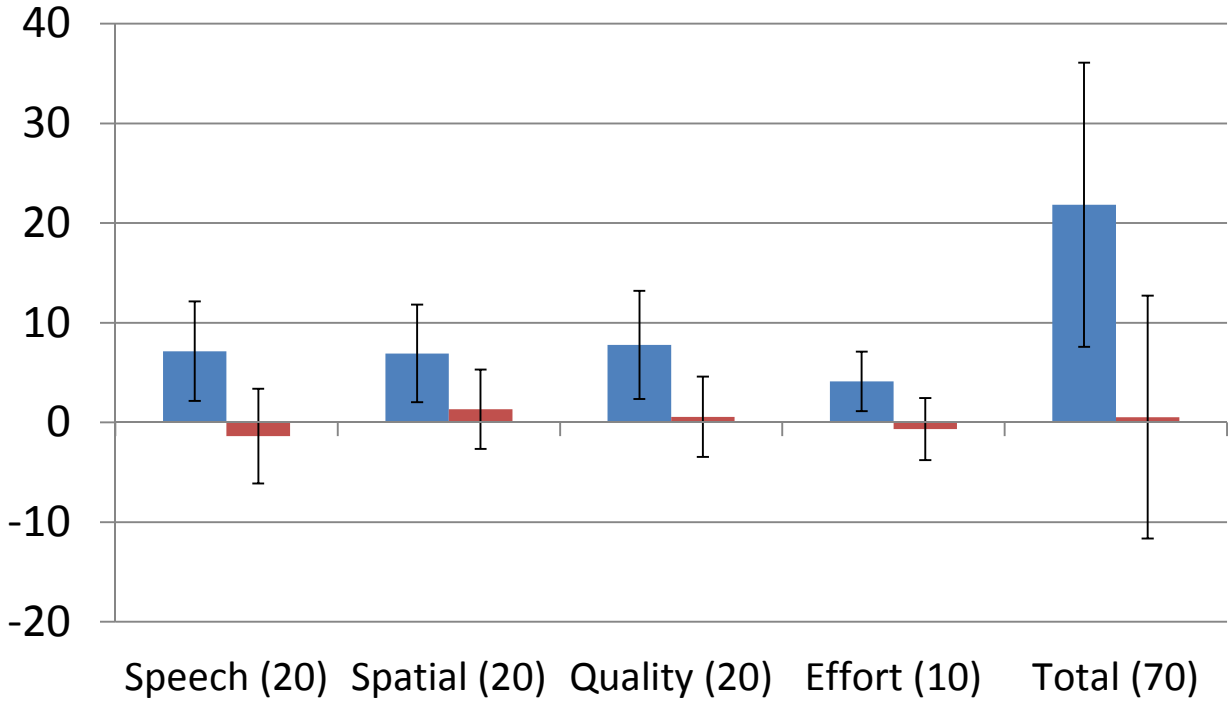
Dawes et al (2014). Acclimatization to hearing aids. *Ear & Hearing* **35**, 203-212.

Speech-in-noise

- No improvement in aided SIN consistent with acclimatization

- Control group?
- Non-linear vs linear aids?

Spatial, Speech and Qualities of Hearing Questionnaire



- New users report big improvement

Conclusions from study

- Didn't see expected acclimatization effects

→Acclimatization effects not very robust, small on average and clinically insignificant (at least for standard non-linear aids)?

However…

'Acclimatization' is recognised by users and audiologists; consistent use likely to lead to greater benefit.

Could we have been looking in the wrong places?

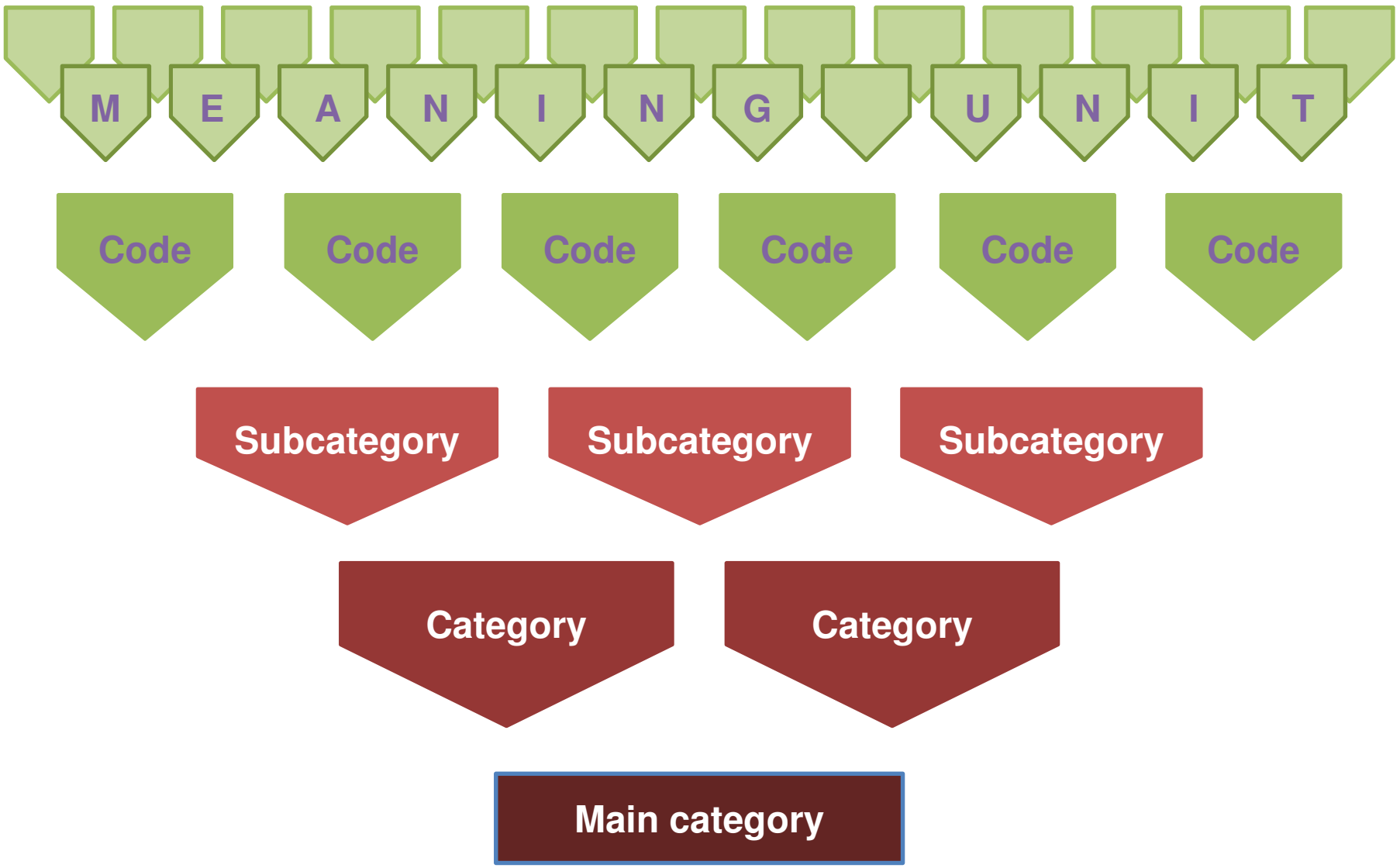
Interview new hearing aid users

- Aim to describe ‘getting used to hearing aids’ from the perspective of users
- New hearing aid users (3 groups, 18 in total)
- What is most significant from the point of view of users? Will they report acclimatization effects?

Dawes, P., M. Maslin, et al. (2014). "Getting used to hearing aids from the perspective of adult hearing aid users." International Journal of Audiology.

Mary has just got new hearing aids

What might Mary experience over the next few days, weeks and months as she starts using her new hearing aids?


MEANING UNIT
Code
Code
Code
Code
Code
Code
Subcategory
Subcategory
Subcategory
Category
Category
Main category

Analysis

Meaning unit "*At the beginning I definitely had that. It was a couple of days and I thought 'I'm not going to cope with this'. It was a foreign body literally in my ear which didn't feel awfully comfortable*"

Code: 'Hearing aid comfort' (concrete content)

Supercategory: 'Practical use'(thematic content)

Primary category	Secondary category
Annoying sounds	-
Occlusion	Occlusion effects Unnatural Sound
Practical use	Cleaning hearing aid Hearing aid comfort Managing batteries Manipulating hearing aid Remembering hearing aid
Experimenting with use	Listening strategies Cinema Music Telephone Trying 1 or 2 hearing aids
Psychological factors	Re-defining self-image Subcategory: Managing stigma Subcategory: Increased confidence Broadened experience Re-negotiate communicative interactions

Getting used to hearing aids

- A challenging multi-factorial process
- Both practical and psychological difficulties besides demands of adjusting to hearing aid input.
- Do not report improvement over time consistent with acclimatization
- ‘Annoying sounds’ the most prominent issue

Most prominent experience: "Annoying sounds"

"*The battery of noise. My first experience was walking out of* XXX *Hospital and hearing very, very strange noises that I realised were my feet. And my car, which I thought was as good as a Rolls Royce, was making one hell of a racket. Switches going click, indicators going - terrible. It was a bombardment of noise*"

"*oppressive*", "*weird*", "*a dreadful cacophony*" and "*overwhelming*"

“I think it’s getting used to small sounds. … we have a very old fridge that even without my hearing aids I could hear it knock itself on and knock itself off again. What I didn’t realise is that after it knocks itself off I could hear a hissing sound, and it drove me mad. I was really looking round. And then it dawned on me that sound must have always been there. I just hadn’t heard it.

At first it was really frustrating because I didn’t associate it with my hearing, I associated it with a noise that’s coming from somewhere. As I say, when it dawned on me that the small things were because I hadn’t heard them before then it was fine”

“I’m sure my brain filters out noise. I’m sure it does. ‘Cause otherwise I wouldn’t have got used to them to the point where I sometimes wonder if they’re working”

Consistent HA use

"If he's not wearing them, when he puts them in he's going to find the noise and things that we found at the beginning and it's going to take him a lot longer"

"then it's the whole thing of the noise again, the whole noise issue which you sort of – you get used to"

Acclimatization: attentional tuning?

1. Report of ‘annoying sounds’
2. Research evidence for importance of attention in auditory training

→Acclimatization a process of screening out background sounds that have an impact via informational masking?

Attentional tuning

- Normal hearing
  - Audible background sounds ignored
- Long-standing HL
  - Background sounds are inaudible/very quiet
- New Hearing aid
  - Audibility restored; background sounds intrude on conscious attention → informational masking
- Acclimatized HA
  - Audible background sounds ignored (reduced informational masking)

Study 1: Normally hearing

Aim: Test ‘attentional tuning’ and trial experimental paradigms

(view to extension to HI people)

Attentional tuning: Normally hearing

Aim: Test ‘attentional tuning’ and trial experimental paradigms

12 normal hearing participants

Wear low gain hearing aid for 1 week
(control group with no-gain hearing aid)

Periodic testing

Tests

i) Distraction
ii) Adaptive speech in noise
iii) Subjective ratings
iv) Qualitative diary of experience

→ Changes over time?

i) Distraction

Serial recall 8 digits

8s delayed recall

In Quiet (HA off) and in noise (HA on)

Distraction = Quiet - Noise

Distracting low background noise 50 dB(A)

Cassidy and MacDonald (2007) showed that everyday background noise impaired performance in a number of cognitive tasks; biggest effect on memory

Cassidy, G., & MacDonald, R. A. R. (2007). The effect of background music and background noise on the task performance of introverts and extraverts *Psychology of Music, 35*(3), 517-537.

Based on Jones auditory distraction research paradigm

Jones, D. M., R. W. Hughes, et al. (2010). "Auditory distraction and serial memory: The avoidable and the ineluctable." Noise and Health **12**(49): 201-209.

What were the numbers?

Answer:

6 8 1 5 7 3 2

What were the numbers?

Answer:

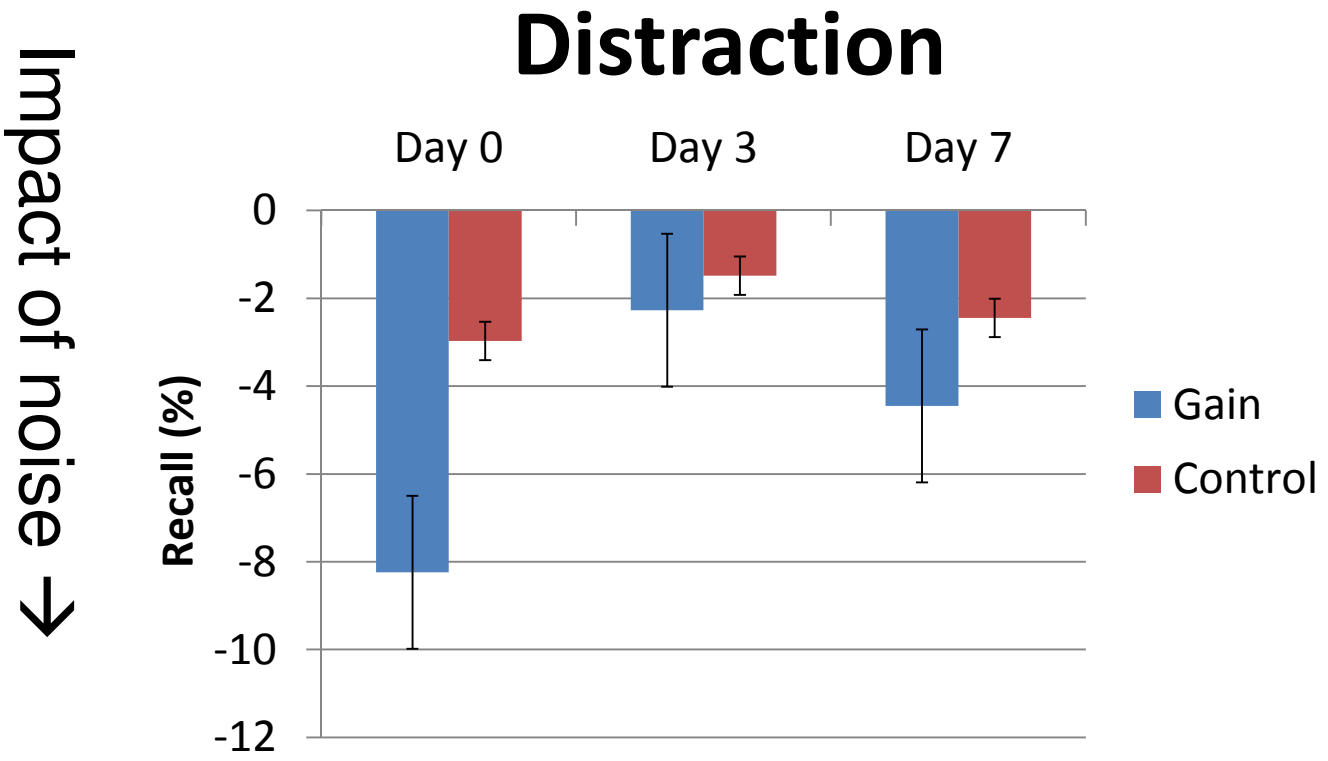
5 7 1 3 6 4 8

Distraction = Quiet - Noise

Speech in noise

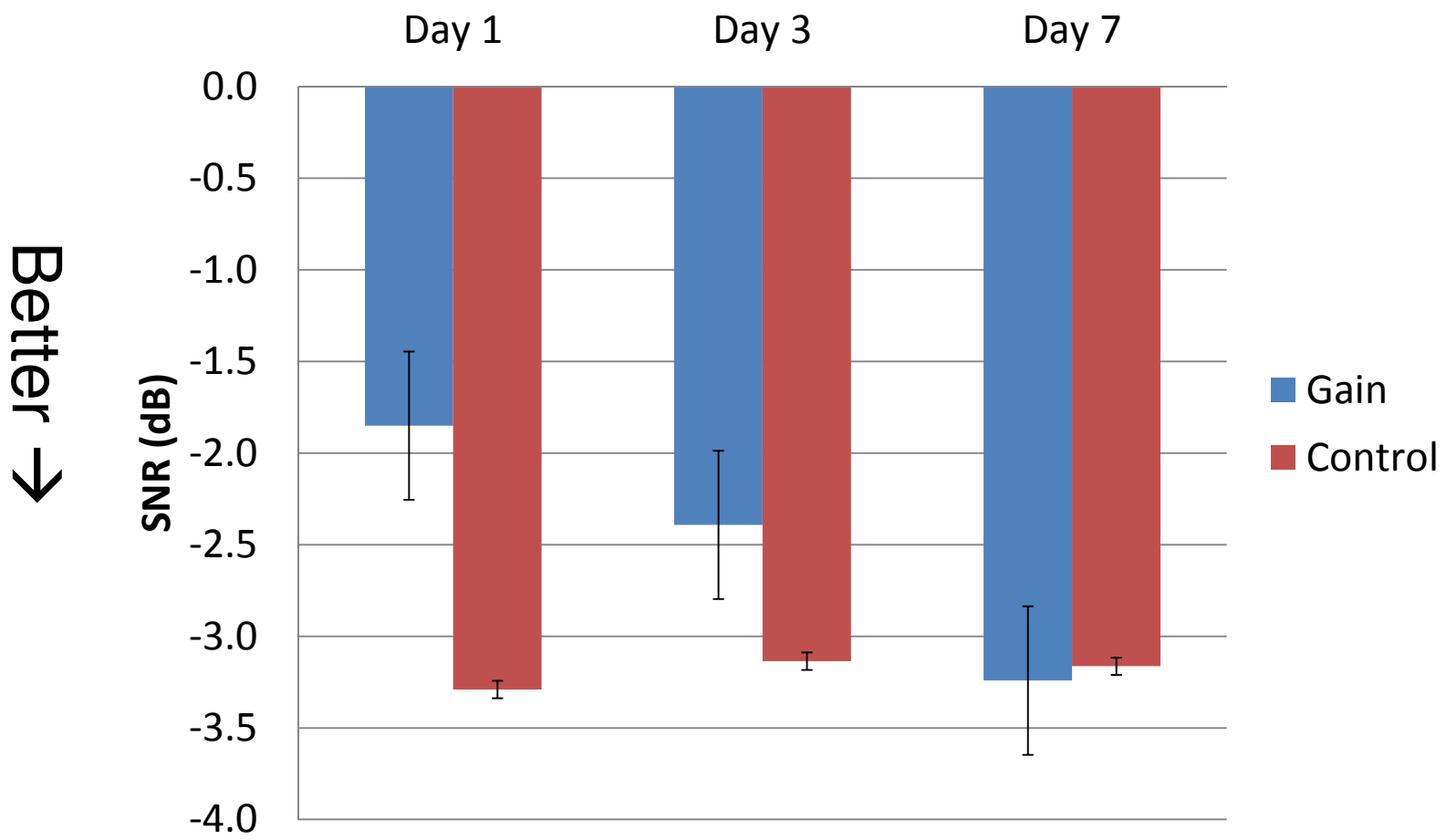
- Adaptive tracking procedure; level of noise varies. IEEE sentences in background noise recorded from realistic everyday environments (eg supermarket, office).
- Target speech and background noise was spatially separated to give more ecologically valid test of speech intelligibility in noise.

Results



Effect of noise for Gain group, reducing with time

Speech-in-noise



Acclimatization

"Improvement over time as users learn to make optimal use of altered patterns of auditory input"

Previously: focus on amplified target

Now: focus on noise

Acclimatization=ignoring background noise

Could explain why consistent use is helpful (why occasional users don't benefit as much)

Auditory attention

- Industry Research Consortium grant
- New hearing aid users vs experienced users

- Can we measure acclimatization related to attentional tuning?

- New hearing aid users vs experienced users

If acclimatization results in improved ability to ignore background sounds, then:

1. Speech recognition thresholds will improve post HA fitting for new users
2. New users will show reduced distractibility over time
3. Improved SIN will be associated with reduced distractibility
4. Improvements in SIN and distraction will be accompanied by self report of reduced annoyance
5. Improvements in speech recognition and distraction will be associated with consistent hearing aid use

Methods

- Participants

Control group: n=20

New users n=35

- Testing:

Day of fitting, +1, +7, +30 days

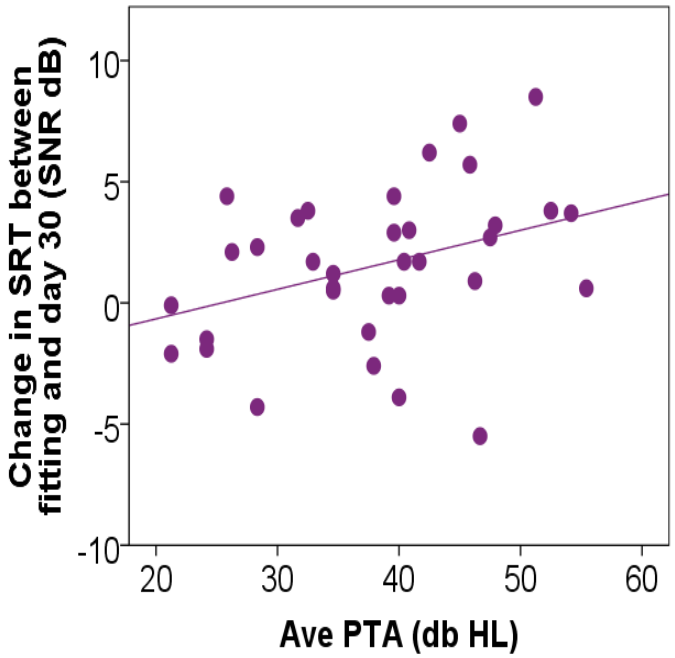
REIG and audiogram at day of fitting and day 30

Measures

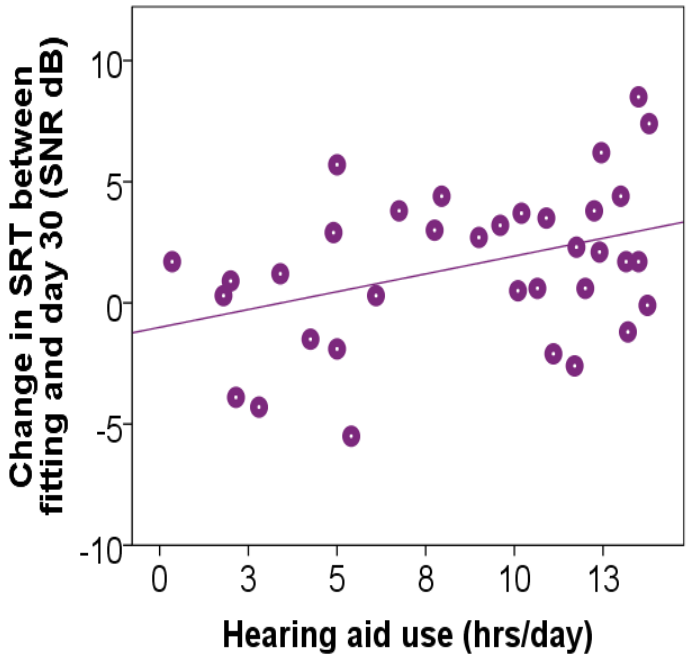
- Distraction
- SIN
- IOI-HA
- Self-report questions (eg *When using the hearing aid, how annoying in general do you find background sounds when you are focusing on a task (e.g. reading or studying*)?)
- Hearing loss
- Hearing aid use

Correlation: SIN and HA use, PTA

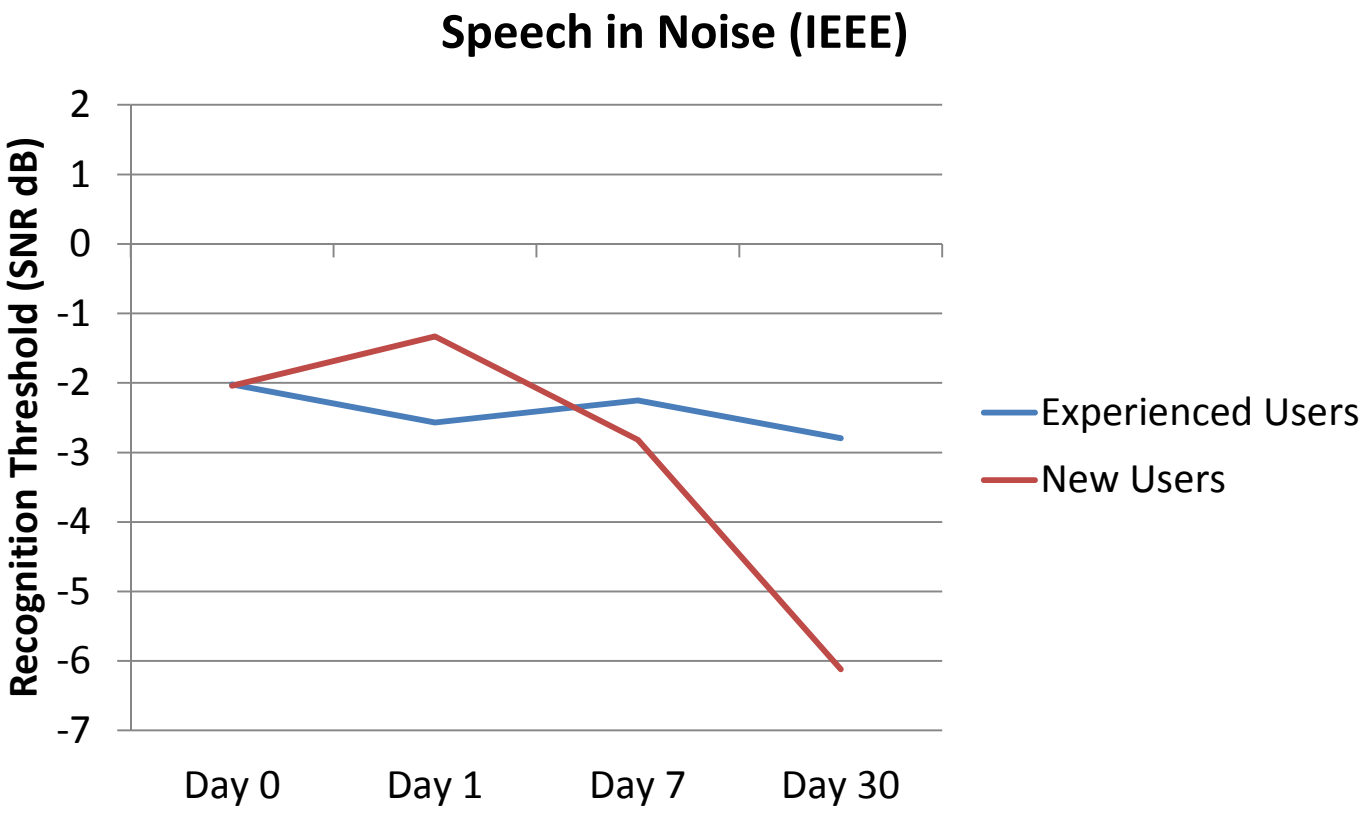
r2 = 0.36, *p* = 0.02



r2 = 0.39, *p* = 0.02

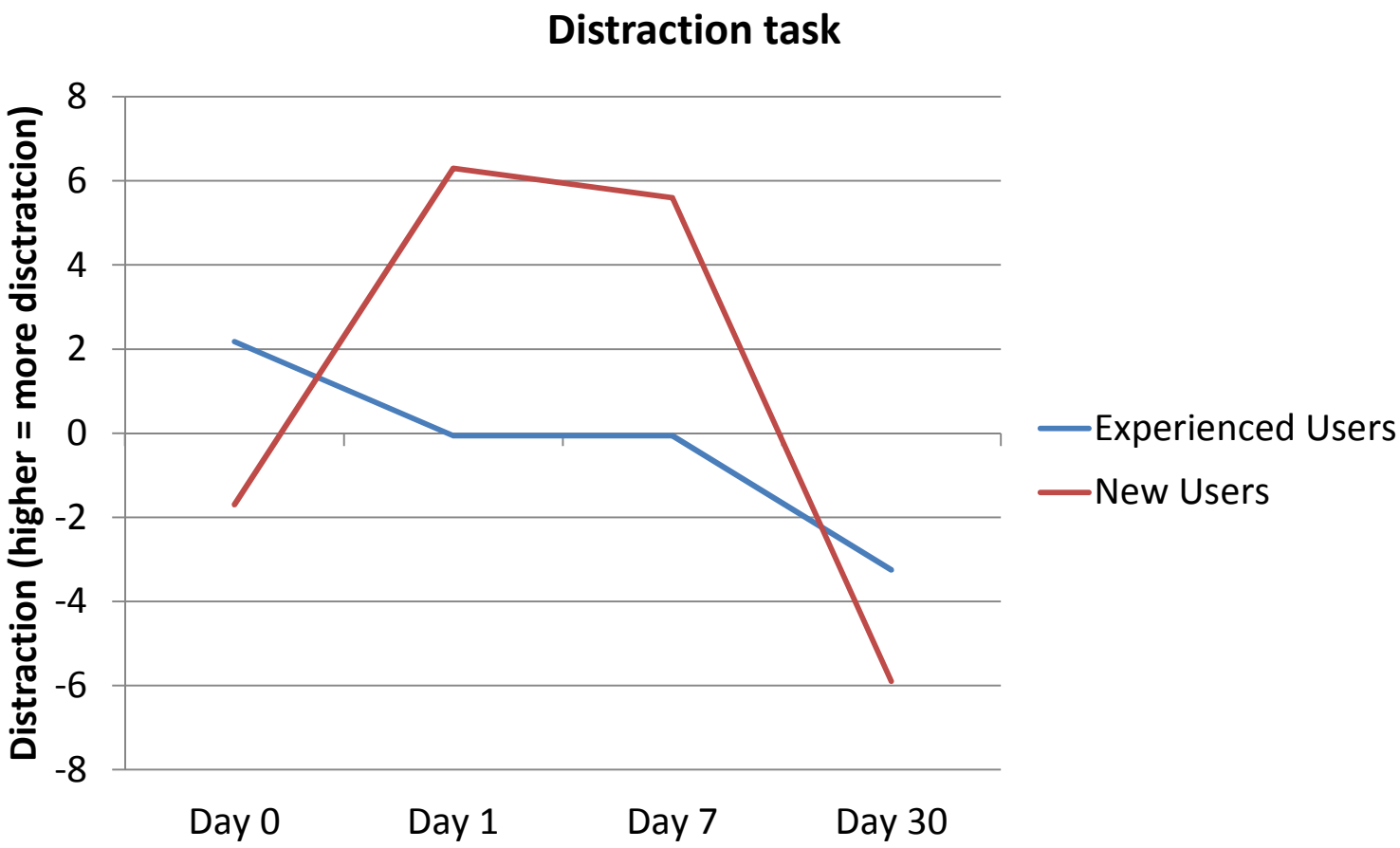


Speech recognition

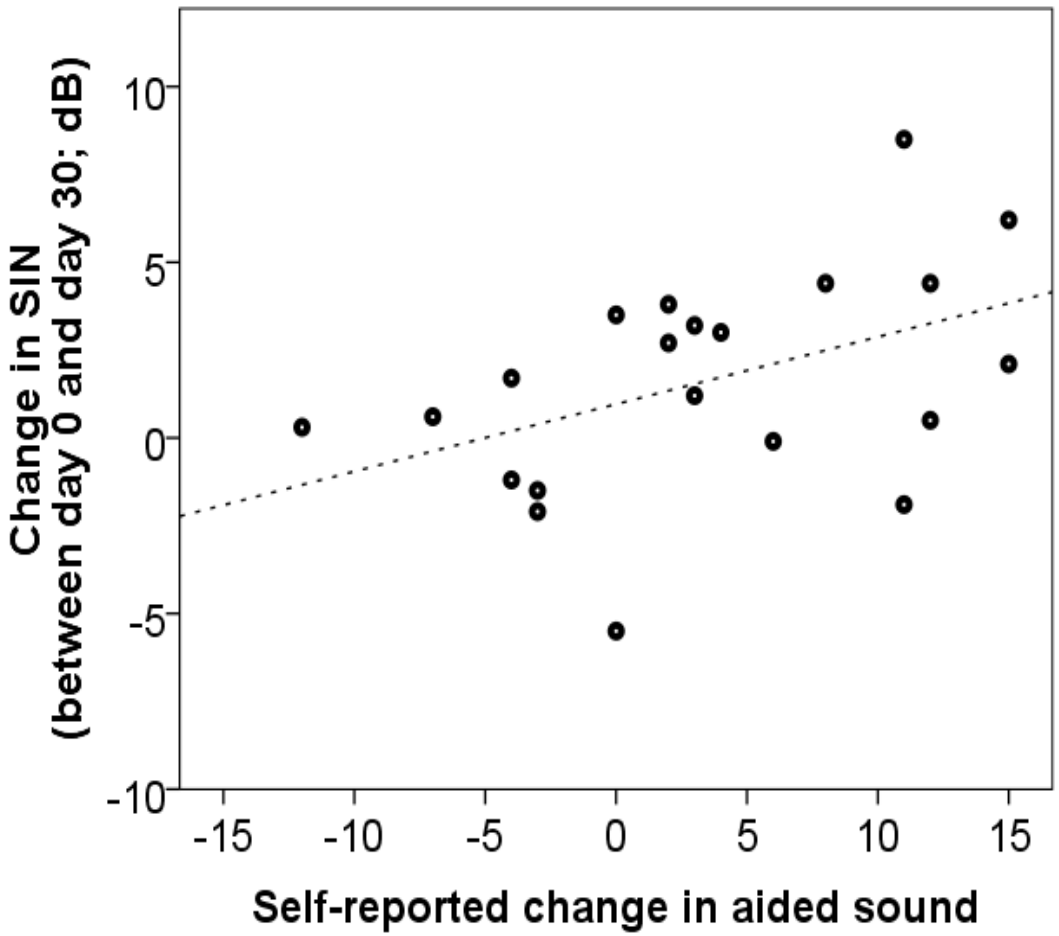


- Selecting new users with PTA>40 dB HL and HA use >6hrs/day (n = 10), a significant improvement in SRT over time (RM ANOVA, Group*SRT $F(3,22) = 4.5$, $p = 0.01$)

Distraction



Correlation: SIN and self-report



eg *When using the hearing aid, how annoying in general do you find background sounds when you are focusing on a task (e.g. reading or studying*)?

$r2 = 0.39$, $p < 0.05$

1. Speech recognition thresholds will improve post HA fitting for new users YES
2. New users will show reduced distractibility over time NO
3. Improved SIN will be associated with reduced distractibility NO
4. Improvements in SIN and distraction will be accompanied by self report of reduced annoyance YES
5. Improvements in speech recognition and distraction will be associated with consistent hearing aid use YES

- Evidence of improvement in speech recognition in noise in new HA users.
- Improvement was associated with self-reported less distraction/annoyingness of background sound.
- Improvement in SIN may be predicted by HL and HA use.

- Some support for acclimatization related to distracting background sounds
- problem with distraction measure

→ Alternative measure of distraction/auditory attention

‘acclimatization’ summary

- Patients go through a process of ‘adjustment’; multifactorial; HA benefit affected by multiple factors; practical, motivational, psychosocial

- Attentional/cognitive component

Acknowledgements

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Technical support: Keith Wilbraham

Funding: Deafness Research UK, Starkey Hearing Research Centre, Hearing Aid Industry Research Consortium

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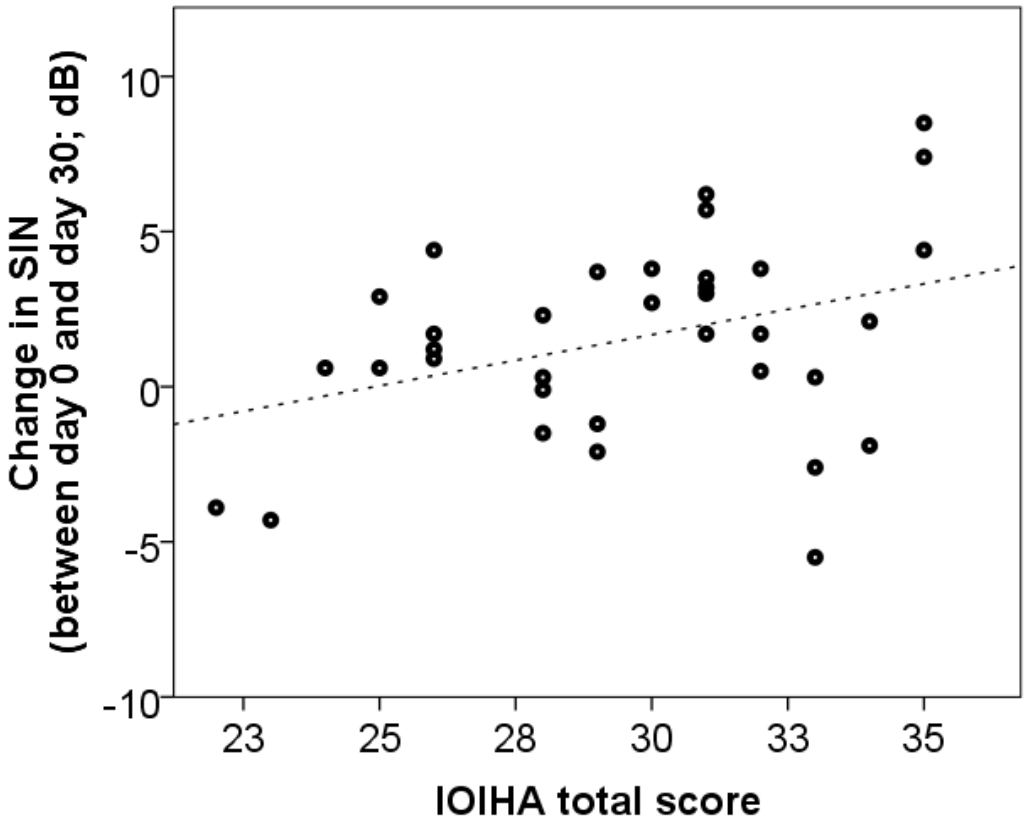
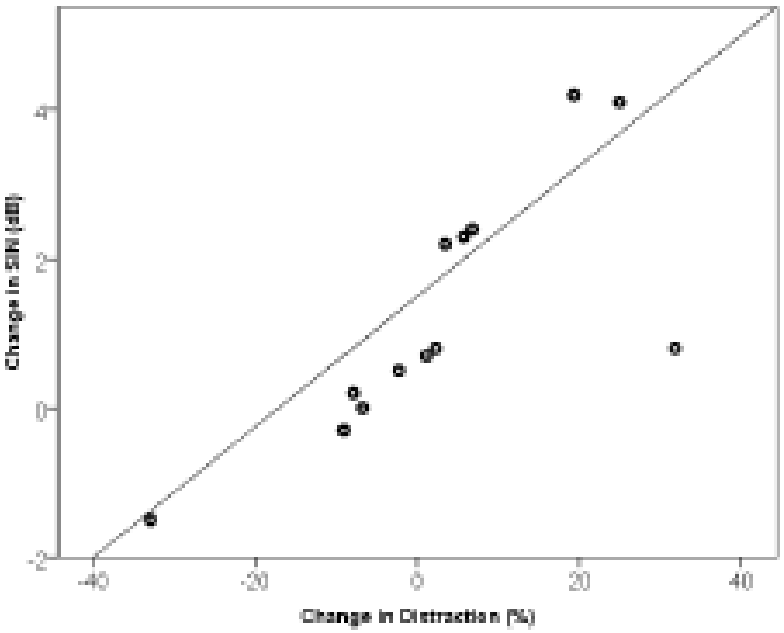
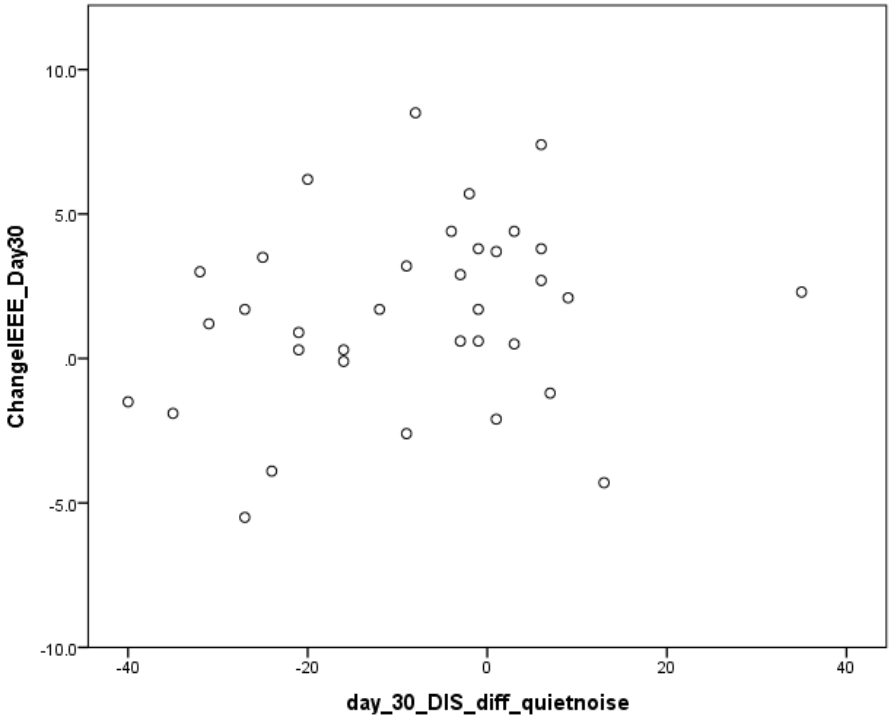
Correlation: SIN and IOI-HA





Normal hearing
(2012 pilot)



New HA users
(present study)

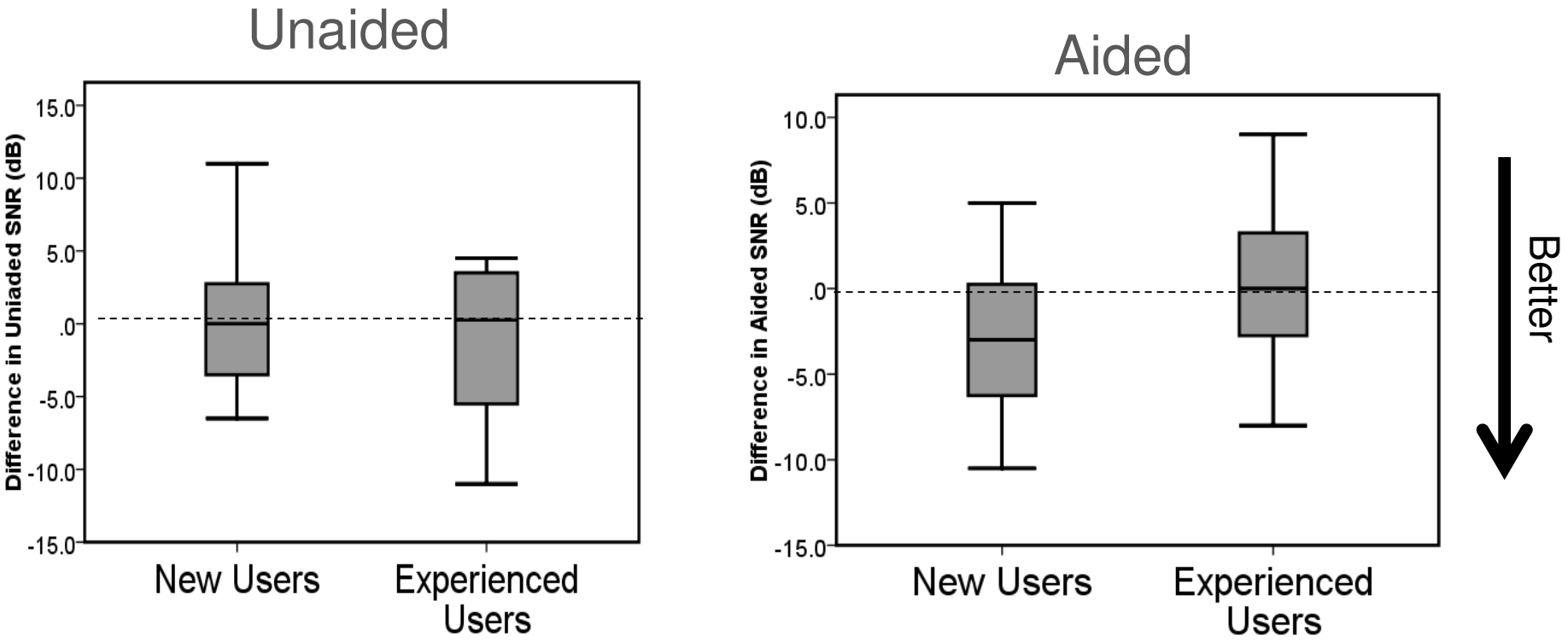
Speech-in-noise

Adaptive SNR

- 1 run
- Target at 65 dB SPL
- SNR required for 50% correct
- Normally aided configuration and unaided
- Change in 50% SNR between T1 and T2

*only a subset of participants

Adaptive SNR Speech-in-noise



Trend for greater improvement for new users