Towards a comprehensive assessment of unilateral hearing loss (UHL)

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- Today I will present a study conducted at the National Acoustic Laboratories in Sydney (Australia).
- In this study we evaluated the sensitivity of a broad range of measures to the unique characteristics of individuals with unilateral hearing loss.

UHL impacts (beyond pure-tone thresholds)

The Impact of Unilateral Hearing Loss on Adult Life

Individual perspectives on how UHL affects their daily lives, attitudes, and relationships

By JAMES GALLOWAY, MSc; VICKY ZHANG, PhD; VIVIENNE MARNANE; SANNA HOU, MClinAud; GREG STEWART, and FABRICE BARDY, PhD

There is a need to improve awareness and to better understand the impact and struggles of people who have unilateral hearing loss (UHL), the audiologists who treat them, and those who work, live, and socialize with them. With better awareness comes better understanding, so health professionals can refer them rather than dismiss them. Moreover, better understanding can fuel motivation and allow the person with UHL to be more proactive about managing the condition while reducing anxiety.

Unilateral hearing loss (UHL) has been defined as a HFA pure-tone average (PTA) above 20 dB HL or thresholds above 25 dB HL at two or more frequency above 2 kHz in the affected ear.[1] UHL in adults has an estimated prevalence of 7.2% of the overall population, with only 2% of people with UHL using a hearing aid or device.[2]

Some of the effects of UHL have been established in the literature, including difficulties to understand speech in background noise and reduced spatial awareness.[3] In our research, we wanted to explore *individual perspectives* of the impact of UHL on people's daily lives and the difficulties encountered, to provide a better understanding of the unmet needs of this population.

Methods

A 6-person research team at the National Acoustic Laboratories (NAL) explored this area using two qualitative approaches:

1) Semi-structured interviews were conducted in person or via phone/Skype with 14 adults who had unilateral hearing loss. They were either invited to participate from a volunteer research database or responded to a flyer invitation to participate. All interview participants provided written or verbal consent prior to taking part.

2) An open-ended survey consisting of questions that complemented those asked in the interviews was designed to capture responses from a wider audience. An invitation to complete the survey was posted on public forums specific to UHL, such as the Action on Hearing Loss forum and relevant Reddit threads.

The interview and survey questions were grouped into six main categories:

- Participant's background information;
- Awareness and the causes of UHL;
- The impact of UHL;
- Treatment decision-making (in this case, treatment refers to the use of a hearing device of any type);
- The implications of treatment or no treatment, and
- Suggestions and needs.

Information from interviews and surveys were combined and main (No Title) fitted, which are discussed below.

Results

Demographics. A total of 14 adults with UHL participated in interviews, and 80 adults (34 females, 46 males) responded to the survey, including 17 from the Australian Hearing database, 31 from reddit, and 12 from the Action on Hearing Loss forum. Participant ages ranged from 18-71 (mean: 34.9). Among these participants, 53% were located in the United States/Canada, 31% were from Australia, and the other 16% were from other countries (eg. Netherlands, Vietnam, and India).

The causes for the UHL were diverse including meningitis, head trauma/accident, absence of auditory nerve, tumor, otosclerosis, micortia atresia, Ménière's disease, virus, mumps, noise exposure, and measles. Among these participants, 44% reported currently using a hearing device, and 32% reported that hearing loss was identified since birth.

James Galloway, MDesSc (Audio & Acoustics), is a Research Engineer, Vicky Zhang, PhD, is a Research Pediatric Audiologist; Vivienne Marnane is a Research Speech Pathologist; Sanna Hou, MClinAud, is a Research Pediatric Audiologist; Greg Stewart is a Technical Support Officer; and Fabrice Bardy, PhD, is a Research Scientist at the National Acoustic Laboratories (NAL) in Sydney, Australia.

Listening in noise: *Conversations can be unbearable, especially in loud places.*

Localization: *I have a hard time telling what direction sound comes from if I can´t see the source of the noise.*

Auditory blind spots: *I feel almost like I'm blind on the left.*

Fatigue: *By the end of the meal, my brain is usually exhausted from trying to hear everyone.*

Anxiety: *I wish I could feel less anxious about being judged for misunderstanding or not hearing people.*

Self-steem: *It makes me feel broken, like I can't get simple instructions at work.*

Reduced social engagement: *I think the social isolation is the worst. I very rarely socialise in noisy environments as it´s just too stressful and difficult.*

Fear: *I fear my good ear getting bad and all my friends and family slowly dropping me out of their lives.*

Stigma in the workplace: *I only wear my hearing aid on weekends. I don´t want my work to know about my disability.*

Galloway et al. (2019) The Hearing Review 26, 10—14.

- The study was motivated by previous research led by Dr Fabrice Bardy, also at NAL, in which they used design thinking methodologies based on surveys and personal interviews to better understand individual impacts of unilateral hearing loss.

- The study revealed that UHL imposes important challenges in a broad range of dimensions that affect everyday communication, including (1) listening in noise, (2) localisation of sound sources, (3) mental effort and fatigue, (4) anxiety, (5) self-steem, (6) fear, (7) reduced social engagement, and (8) stigma in the workplace.

- The study found a mismatch between the complexity of the hearing challenges experienced by individuals with UHL and the simplicity of the audiological measures used by hearing clinicians, mostly based on the audiogram.

- These results motivated novel research aimed at characterising UHL deficits in real-world environments.

Methods

16 normal-hearing
18—70 yr, 12 female

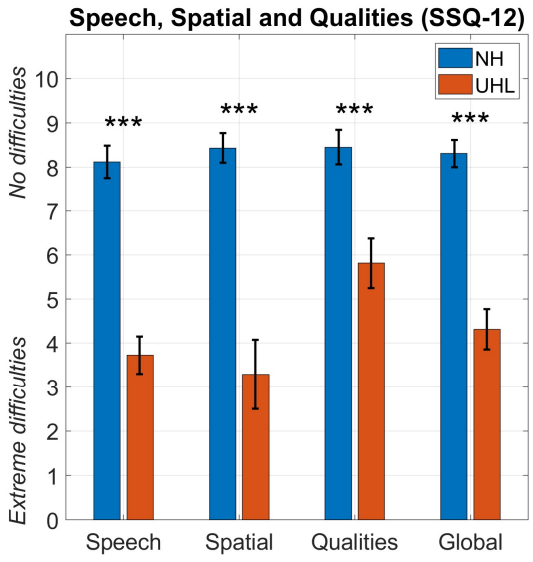
16 UHL
25—75 yr, 6 female
14 severe-to-profound HL +
2 moderate HL

Anechoic chamber, Australian Hearing Hub (Sydney, Australia)

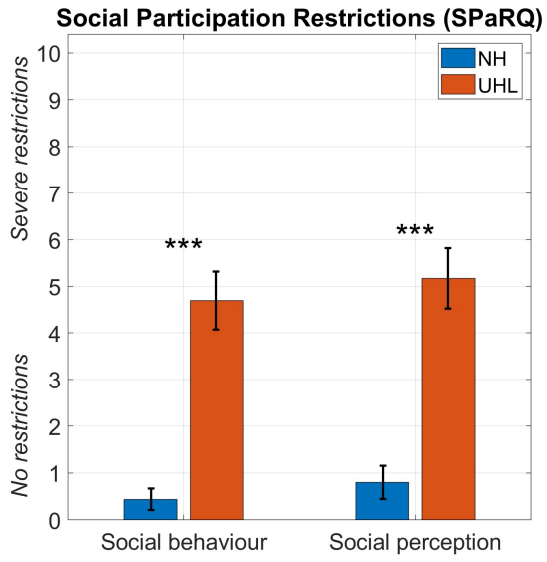
Validated questionnaires → Speech-in-noise comprehension → Head movement → Self-perceived handicap → Listening effort

- Our study compared 16 normal-hearing individuals with 16 participants with unilateral hearing loss (UHL), the majority of whom had severe-to-profound hearing loss in the affected ear.
- Testing was conducted in the anechoic chamber at the Australian Hearing Hub, Sydney, using a 41-speaker Ambisonics array arranged spherically.
- We employed validated questionnaires, measured speech-in-noise comprehension, tracked head movement, assessed self-reported hearing experiences during the speech-in-noise task, and evaluated listening effort.

Standardised questionnaires



Noble et al. (2013)



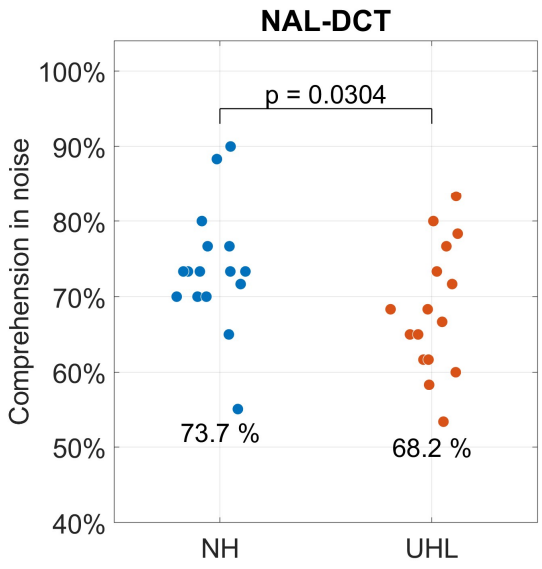
Heffernan et al. (2018)

- Participants were asked to assess their hearing experience using the Speech, Spatial and Qualities (SSQ) questionnaire and the Social Participation Restrictions Questionnaire (SPaRQ).
- SSQ results indicated that UHL participants face greater challenges than their normal-hearing peers in (1) understanding speech in various settings, (2) perceiving sound direction, localisation, and distance, and (3) hearing clarity, naturalness, and effort.
- SPaRQ data revealed that UHL participants encounter more difficulties (1) performing tasks in social contexts due to their hearing and (2) with emotional comfort and confidence.

Speech-in-noise comprehension

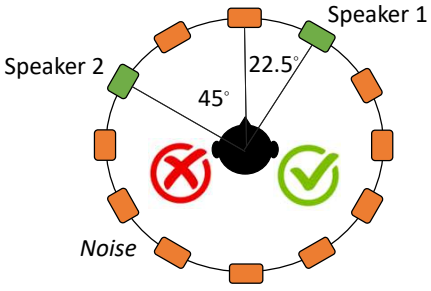
National Acoustic Laboratories Dynamic Comprehension Test
(NAL-DCT, Best et al. 2016)

- Speech comprehension test
- **Target speech:** A dynamic conversation between 2 Australian-speaking talkers, IELTS English Test
- **Background:** Realistic café noise at 72 dB SPL, ARTE database (Weisser et al., 2019)
- **SNR:** 0 dB (ecologically valid scenario)
- 6 runs (3-4 mins each)
- 10 multiple-choice questionnaire
- Performance in terms of %-correct



- We assessed whether UHL participants had lower comprehension than normal-hearing individuals using the Dynamic Comprehension Test (NAL-DCT) developed by the National Acoustic Laboratories.
- Instead of presenting isolated words or sentences in noise, the NAL-DCT uses 2-3 minute conversations between two Australian speakers in realistic cafeteria noise at a challenging 0 dB SNR, and participants answer questions to generate a comprehension score as a percentage of correct responses.
- The figure shows normal-hearing (blue) and UHL participants (red), with NH participants averaging 74% correct responses compared to 68% for UHL, a statistically significant difference.
- While the comprehension difference may seem small, the following slides will show that achieving this performance level for UHL participants came at a cost.

Head movement



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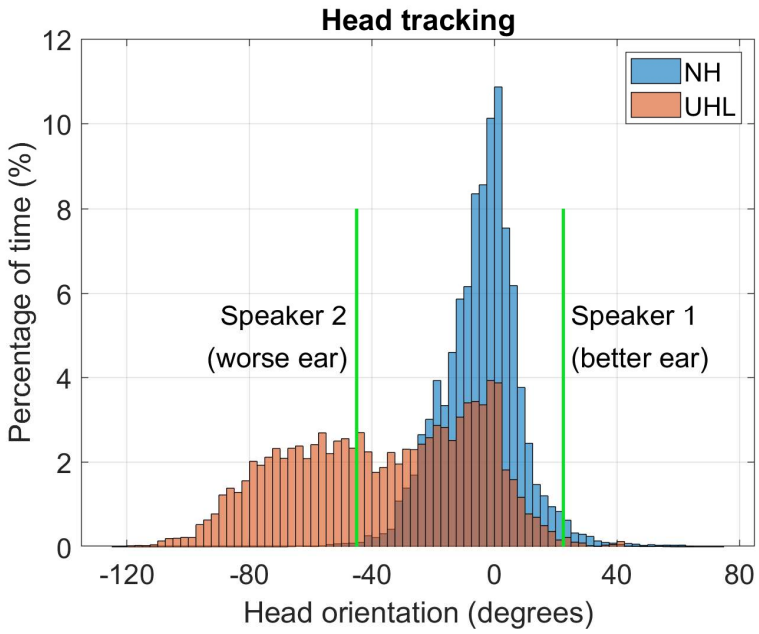
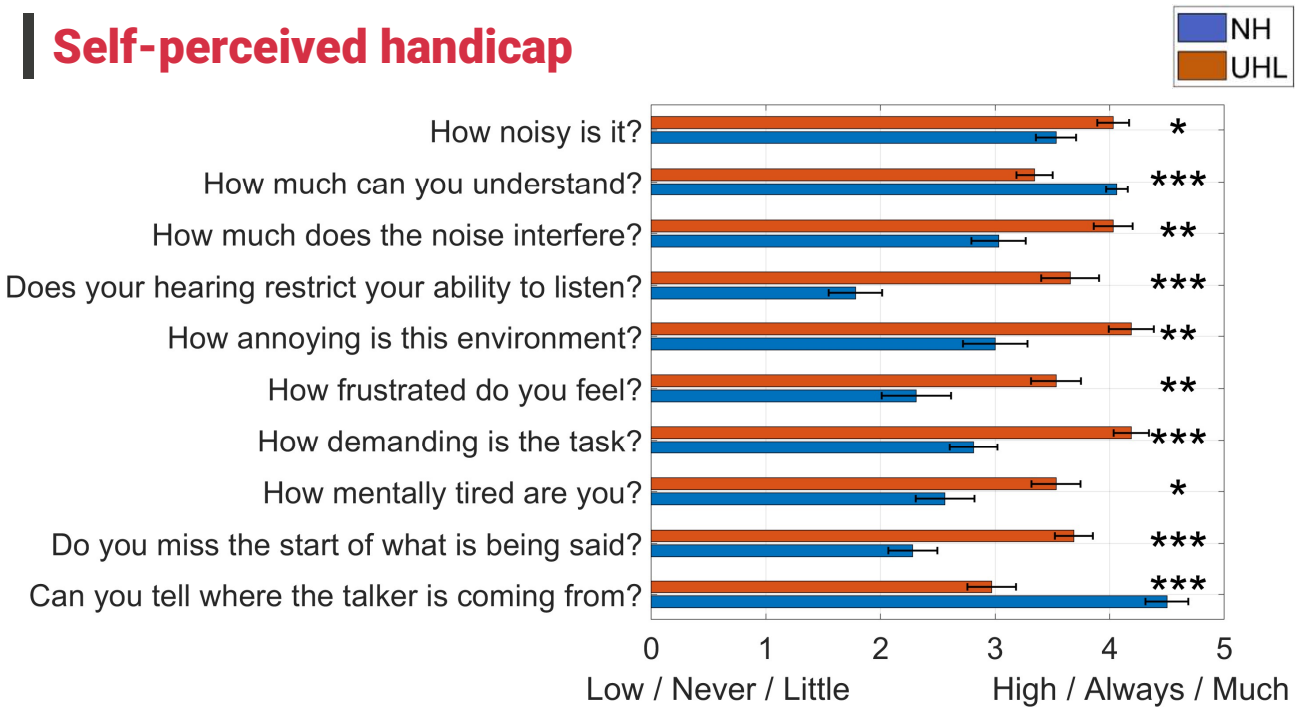


- The position of the speakers in the NAL-DCT test were positioned asymmetrically, with one speaker situated at 22.5º azimuth on the good ear and 45º on the bad ear.
- Results showed that, despite the asymmetric positioning of the speakers, normal-hearing individuals predominantly kept their head centred, as their binaural hearing allowed them to follow the conversation with minimal head movement.
- In contrast, UHL participants exhibited more pronounced head tilting towards their poorer ear and had to orient their better ear towards each speaker, resulting in greater head movements.
- Understanding these head movement patterns might be relevant for designing more effective beamformers for individuals with UHL.

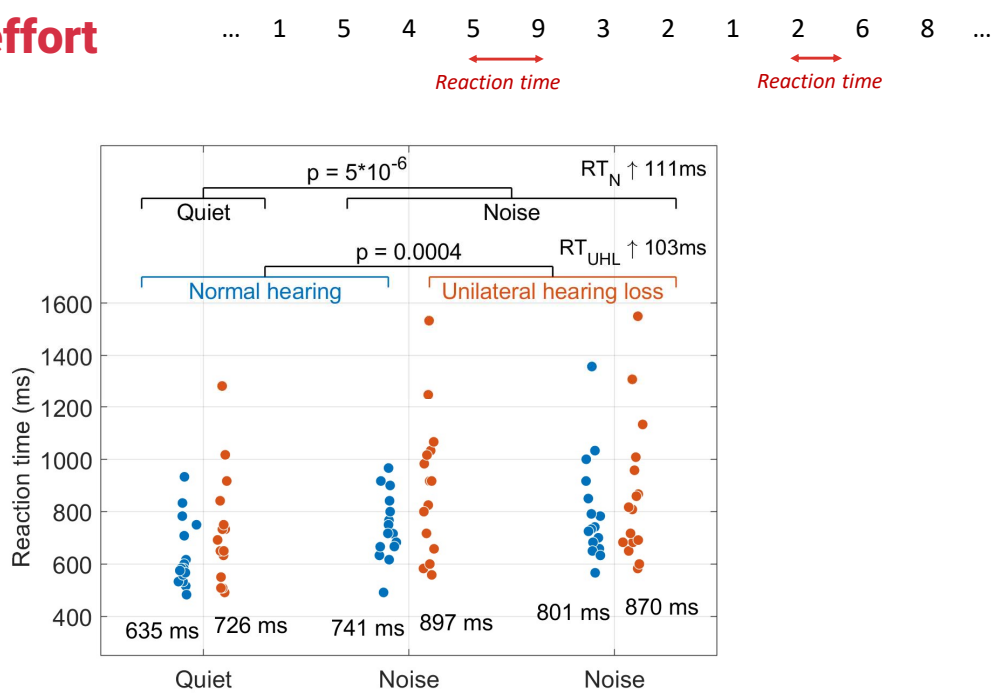
Self-perceived handicap



- We also asked our participants about how they felt on different aspects while they were performing the speech-in-noise comprehension task.

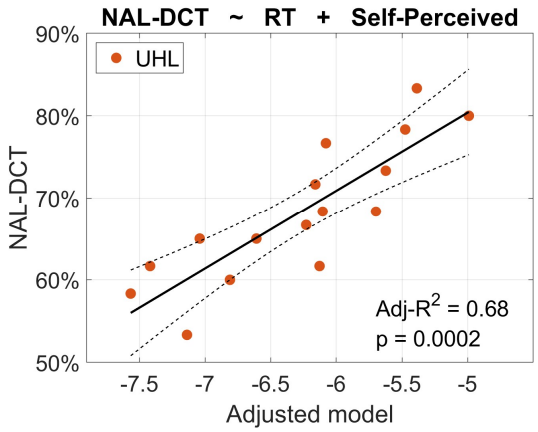
- Relative to NH, UHL participants reported
    1. to find the acoustic scenario noisier,
    2. to understand less,
    3. to perceive greater interference from the noise,
    4. to experience greater restrictions from their hearing,
    5. to feel more annoyed by the noise,
    6. to have to dedicate much more cognitive resources,
    7. to feel more mentally tired,
    8. to miss the start of the conversations more often, and
    9. to have greater difficulties positioning the talker.

Listening effort



- In addition to measuring speech-in-noise comprehension, we assessed participants' listening effort by evaluating their reaction time in a Single Task.
- The acoustic stimuli consisted of monosyllabic digits presented every 1.5 seconds, and participants were instructed to press a button as soon as they heard two consecutive ascending digits (e.g., 4 after 3 or 9 after 8).
- This task was completed once in quiet (no background noise) and twice in 8-talker babble noise at 0 dB SNR.
- Listening effort was measured by the reaction time between the onset of consecutive digits and the button press.
- The figure presents the median reaction times for NH (blue) and UHL participants (red) across the three conditions, showing notable inter-subject variability.
- The mean of the median RT across participants is displayed at the bottom, confirming that RT increased in noise compared to quiet conditions.
- Importantly, UHL participants exhibited significantly longer reaction times, indicating a greater listening effort compared to normal-hearing participants.

Prediction of speech-in-noise comprehension



Selected questions from Self-Perceived difficulties

- Q1. Noise interference
- Q2. Frustration
- Q3. Missing the start of sentences

Test battery sensitive to UHL

- ✓ Hearing diagnosis
- ✓ Assess efficacy of interventions

- Interestingly, we observed a strong correlation between UHL participants' comprehension in noise and a linear combination of their reaction times and specific self-reported hearing difficulties.
- This model explained 68% of the variability in NAL-DCT scores. These findings suggest the potential to predict UHL comprehension in noise using a relatively simple cognitive test and a brief questionnaire.
- Overall, the study presents a test battery sensitive to the unique hearing challenges faced by individuals with UHL, which could support more comprehensive hearing assessments and evaluate the efficacy of interventions such as hearing aids and cochlear implants.
- In fact, my colleagues Amparo Callejón, Ángel Ramos, and I are currently editing a special issue on cochlear implantation challenges and prospects in the *Journal of Clinical Medicine*, and we would be keen to learn about any research you may have conducted on cochlear implants in UHL populations.

Take-home & Acknowledgements

- Individuals with unilateral hearing loss (UHL) face significant hearing challenges that adversely affect their quality of life.
- The proposed test battery is sensitive to the specific hearing handicaps experienced by those with UHL, including difficulties with speech-in-noise perception, greater social participation restrictions, increased cognitive effort, fatigue, and frustration.
- Given the complexity of UHL impacts, a comprehensive test battery may help provide more accurate hearing assessments and evaluate the efficacy of hearing interventions.

SLIDES & NOTES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- To take home… (read take-home messages)
- Should you be interested, the slides of the presentation are available on this QR-code.
- To conclude, I would like to acknowledge the full research team.
- And I thank the sponsors of this research: (1) the Australian Government through the Department of Health and (2) the Spanish 'Ramón y Cajal' fellowship, funded by the Ministry of Science, Innovation and Universities of the Spanish Government, the National Agency for Research and the European Social Fund Plus.
- Thank you for your attention.