

EVALUATION OF OVER-THE-COUNTER (OTC) EARBUDS TO IMPROVE HEARING AND COMMUNICATION

Nicky Chong-White, Joaquin Valderrama, Angela Wong,
Jorge Mejia, Brent Edwards

NICKY CHONG-WHITE, PhD

Principal Research Engineer

National Acoustic Laboratories

Sydney, Australia

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Introduction

- Millions of people are affected by hearing loss. Barriers, such as cost and inconvenience, prevent them from obtaining hearing treatment
- Growth in availability of earbud-style hearing devices: hearables, over-the-counter (OTC) hearing aids
- Uncertainty about performance of OTC devices, how will people self-manage them
- Need for evaluation of emerging direct-to-consumer hearing devices



Recent hearing features of AirPods Pro



Headphone Accommodations
Customise your headphones to your hearing needs.

Released Sept 2020



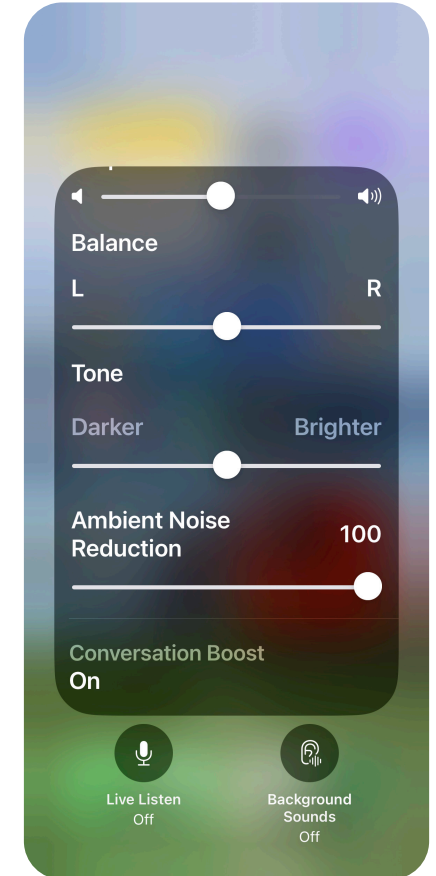
Conversation Boost
Make clearer connections.

Released Oct 2021



Ambient noise reduction

Released Oct 2021

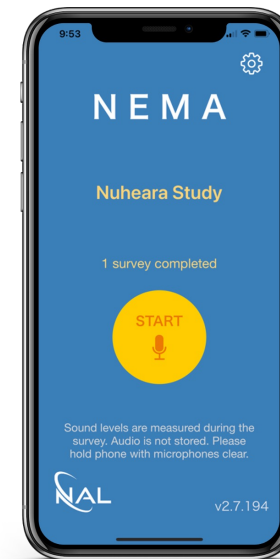


Hearing Control Panel on iPhone

Objective

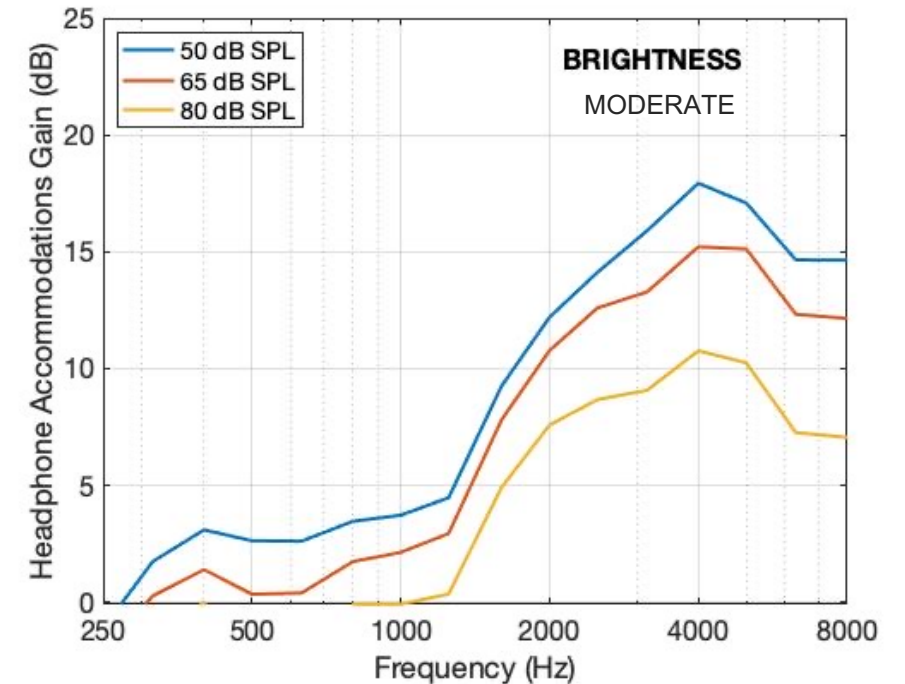
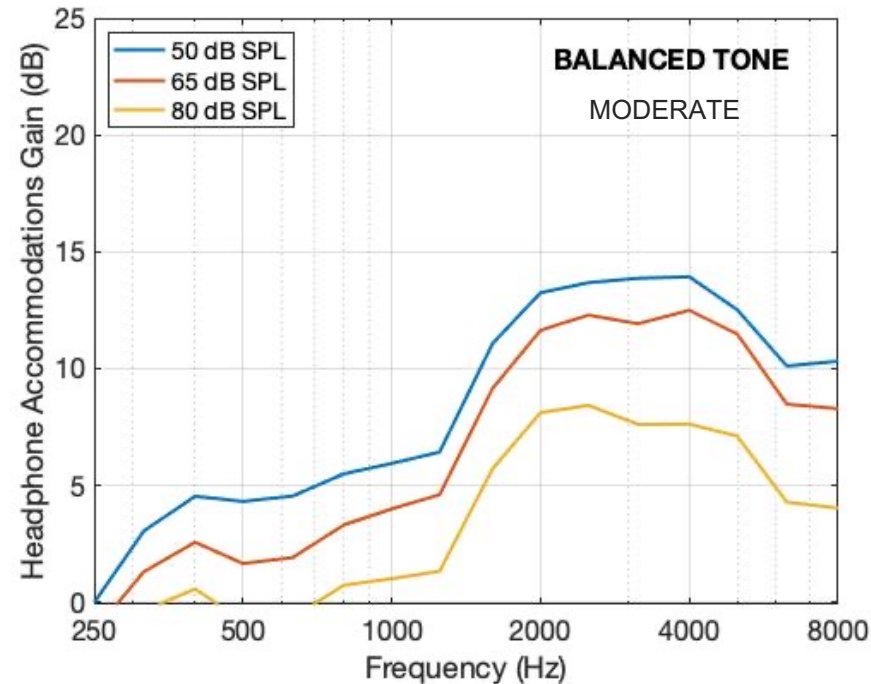
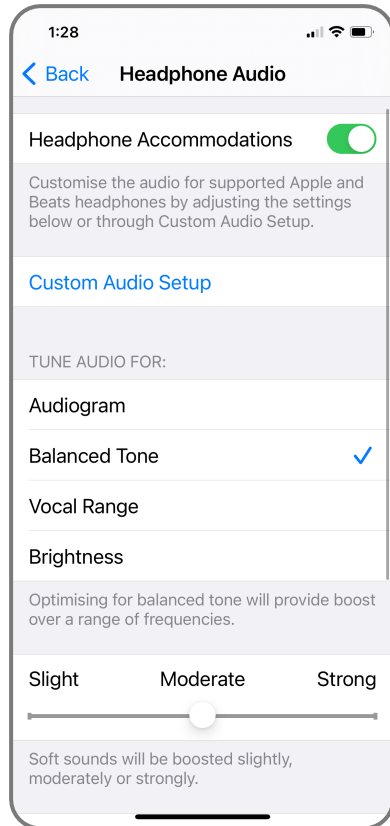
What is the effectiveness of AirPods Pro in improving hearing and communication for people with hearing loss or hearing difficulties?

Study Methods



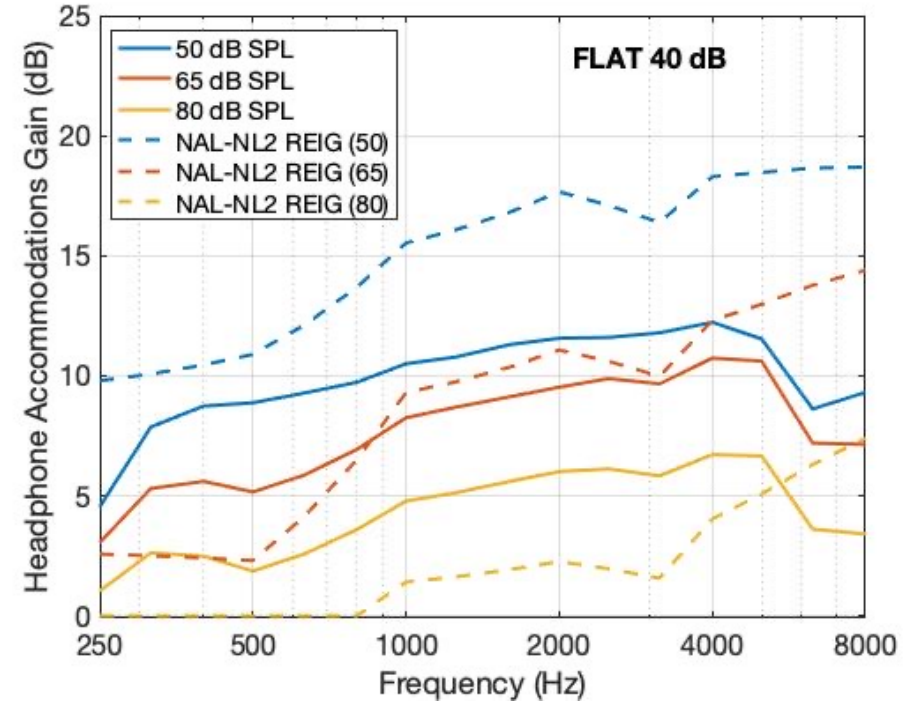
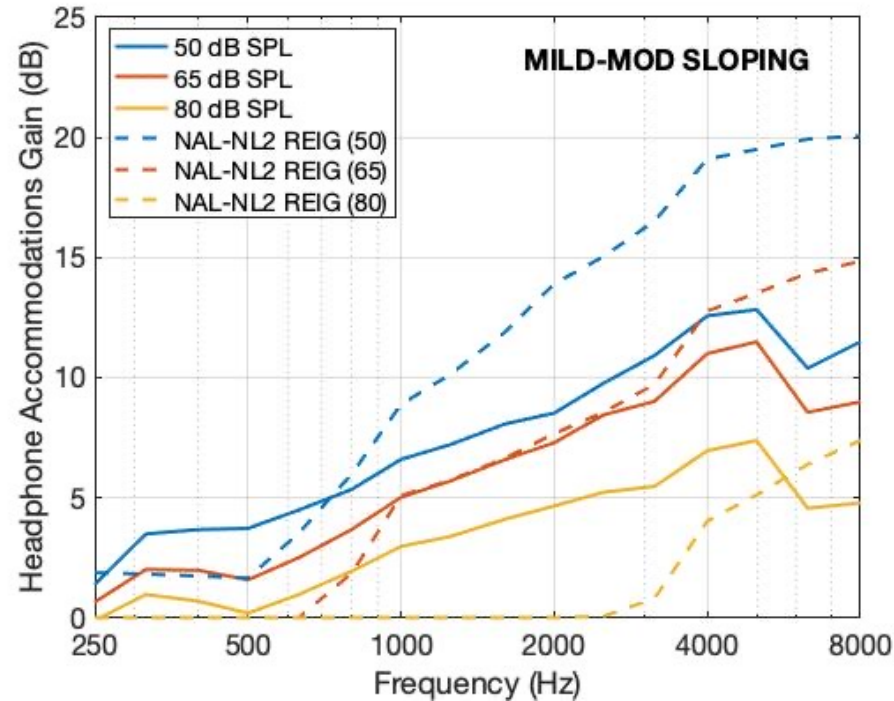
Acoustic Measures: Gain

FEATURE: HEADPHONE ACCOMMODATIONS



Chong-White et al. (Dec 2021) Hearing Review

Comparison to NAL-NL2 prescription

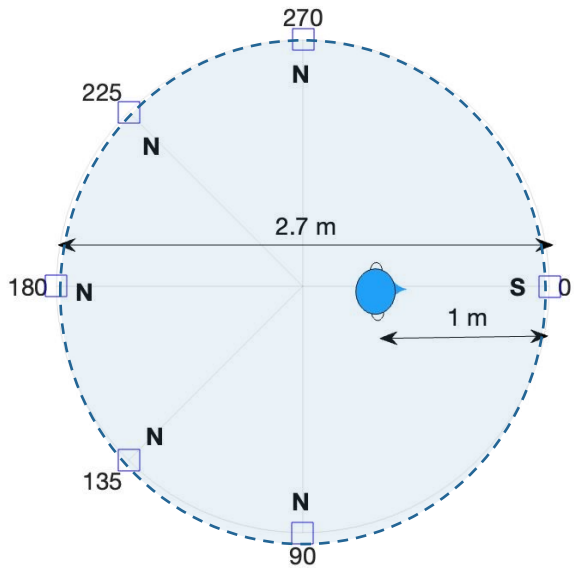


Headphone Accommodations provides

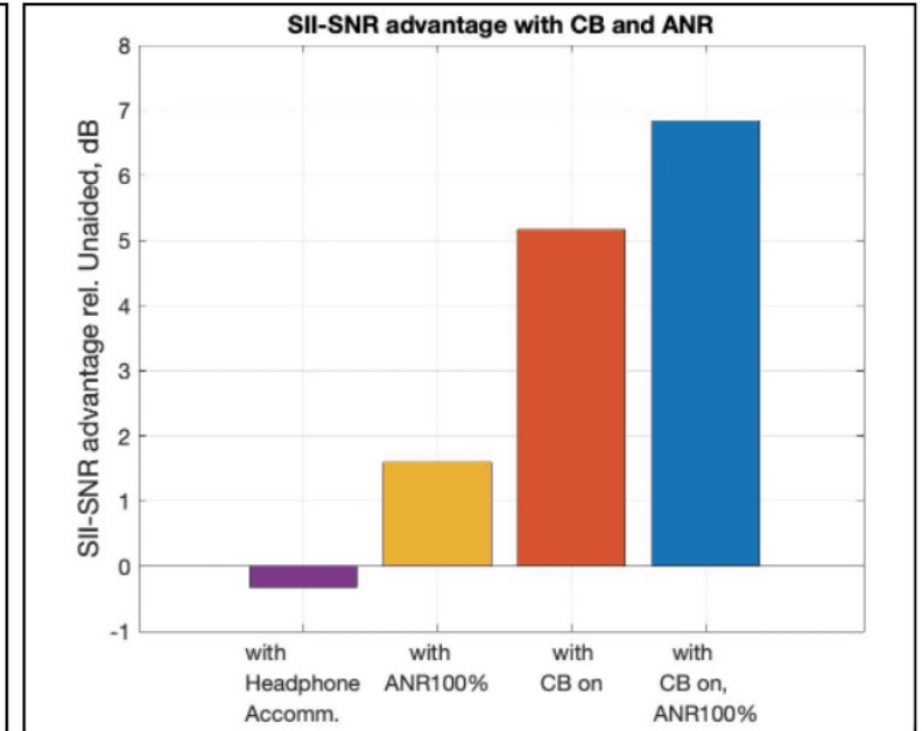
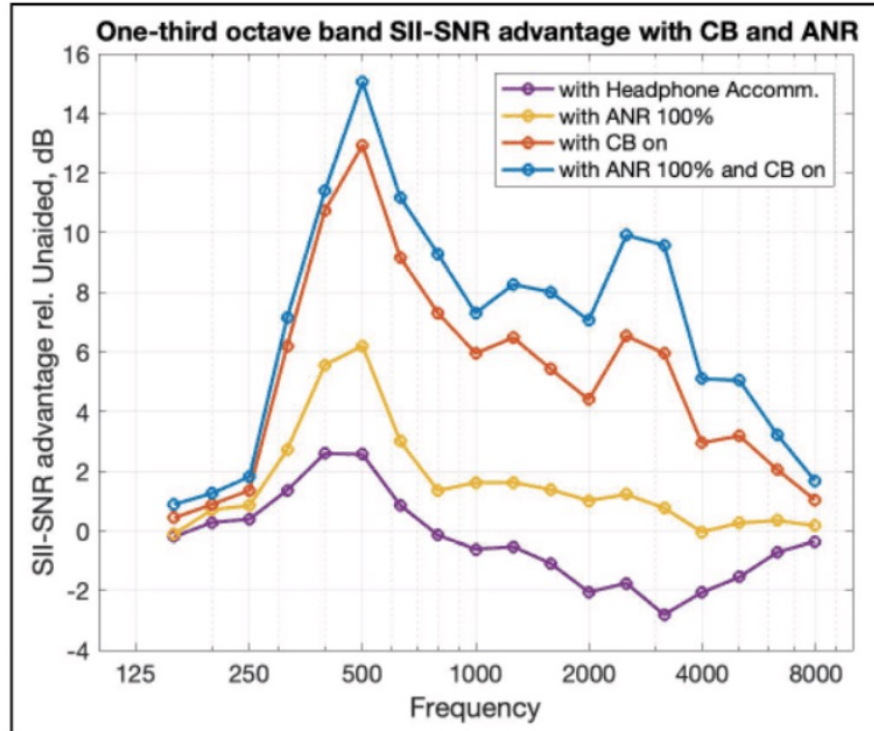
- close match at normal speech levels
- *greater* amplification at *loud* speech levels
- *less* amplification at *soft* speech levels

Directionality and Signal-to-Noise Ratio advantage

FEATURE: CONVERSATION BOOST (CB), AMBIENT NOISE REDUCTION (ANR)



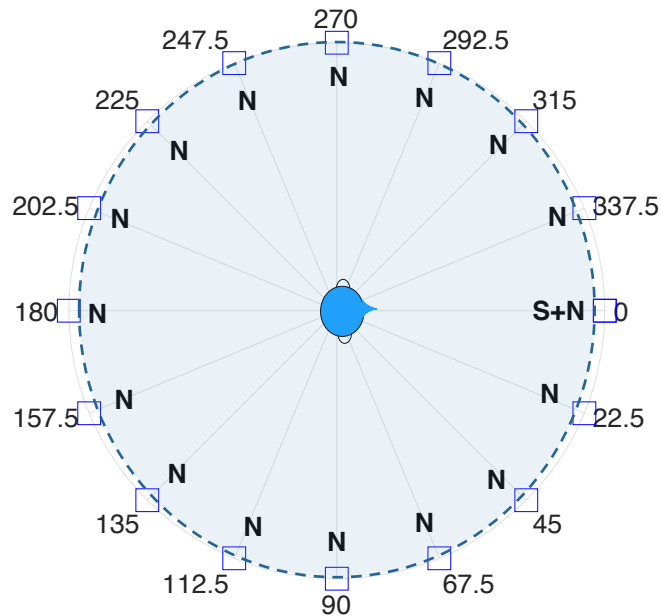
Arrangement 1



Chong-White et al. (Apr 2022) Hearing Review

Directionality and Signal-to-Noise Ratio advantage

FEATURE: CONVERSATION BOOST (CB), AMBIENT NOISE REDUCTION (ANR)



Arrangement 2

AirPods Pro tuned to a near-normal audiogram	SII-SNR advantage* (dB)
with ANR 100%	1.85
with CB on	3.20
with CB on, ANR 100%	5.36

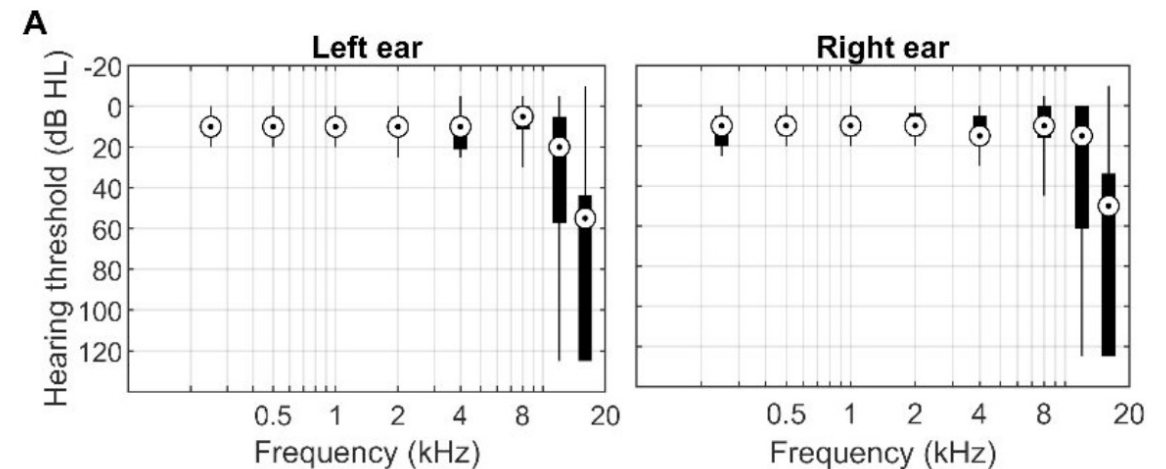
*relative to **Unaided** condition

2. Laboratory testing with participants



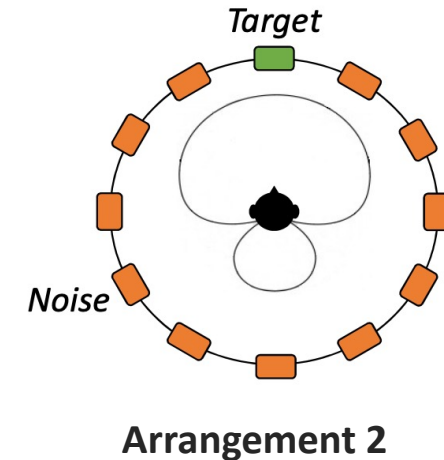
Joaquin Valderrama

- 17 participants (21—59 years, 9 female)
- Inclusion criteria: **Clinically normal hearing**, self-reported hearing-in-noise difficulties
- Large variability in thresholds at extended high frequencies (12 & 16 kHz)
- Participants were fitted with AirPods Pro tuned to their audiogram, and were instructed to keep CB and ANR turned on



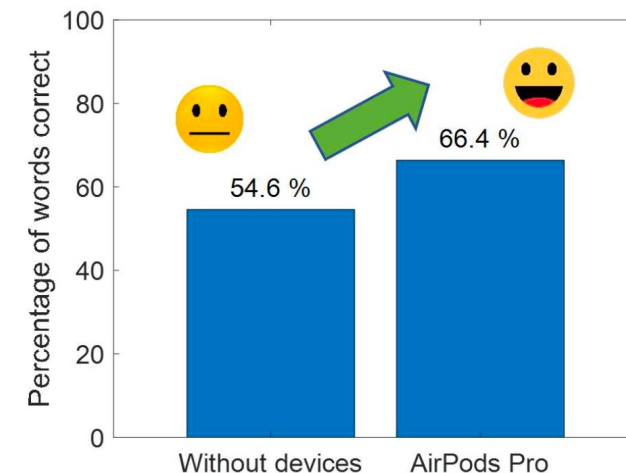
Speech-in-noise testing

- Sentences presented in diffuse babble noise at SNR corresponding to 50% intelligibility.
- 2 conditions: Unaided, wearing AirPods Pro
- NASA-Task Load Index questionnaire completed after each condition



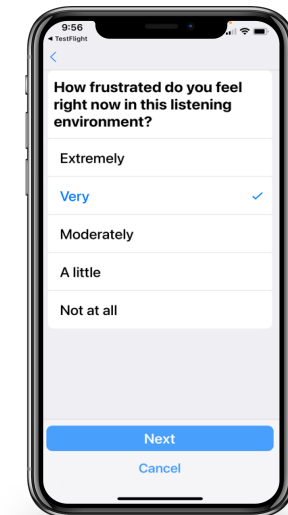
Results: With AirPods Pro, compared to unaided...

- 12% increase in speech intelligibility score
- less mentally demanding ($p=0.008$)
- improved performance ($p=0.04$)
- required less effort ($p=0.004$)

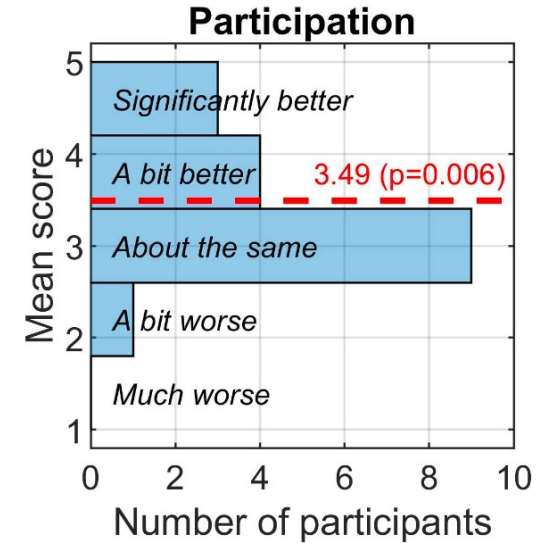
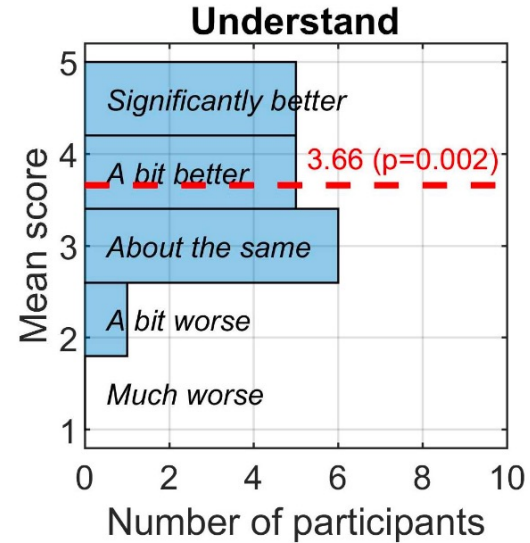
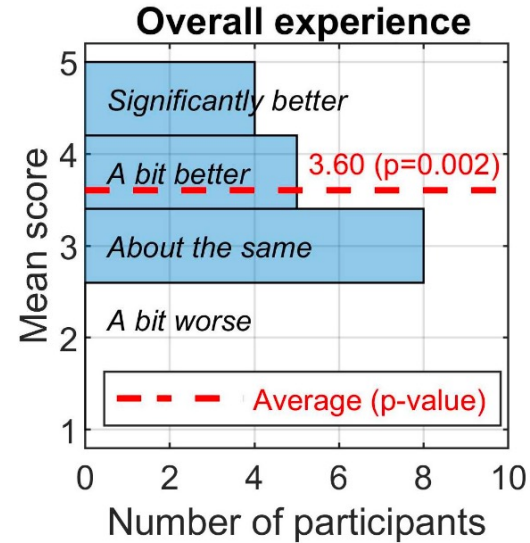
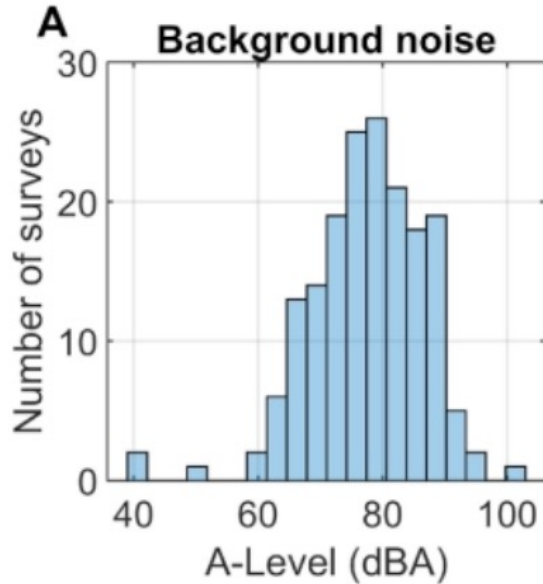


3. Real-world measures

- Outside-of-the-lab testing
- NAL Ecological Momentary Assessment (NEMA) app
- Participants were asked to complete 10 surveys in different noisy venues over a 4-week period. Have conversations unaided and while wearing AirPods Pro.
- Survey questions: speech understanding, participation, frustration, and overall experience.
- During surveys, acoustic features were measured, (e.g. sound level, reverberation, spectral and temporal features)



Real-world data (N=175)



- Café/restaurant 49
- Party/home gathering 35
- Shopping centre 33
- Bar/pub 12

Issues: explaining purpose of AirPods Pro, discomfort after extended period

Perceived benefit likely to vary depending on an individual's specific needs.

Benefits and Limitations

Benefits



- Improved audibility of sounds
- Improved SNR
(increased speech intelligibility)
- Reduced ambient noise
(improved listening comfort)
- Cost-effective
- Convenient to purchase
- Trendy, worn by all ages

Limitations



- Gain may not be optimised for intelligibility and loudness comfort
- Limited control over fitting parameters
- Lack advanced features, such as automatic activation of features based on environment
- Not perceived by others as hearing assistive devices
- Uncomfortable for extended periods of use

Summary and Key takeaways

1. Acoustic measures showed Apple AirPods Pro **increase audibility of sounds to individual needs**, and **significantly improve SNR** in noisy environments.
2. Participants with normal audiograms but speech-in-noise difficulties showed **improvements in speech intelligibility** and **reduced mental effort**. In real-world listening experiences, responses were mixed, with a slight overall improvement on average.
3. While barriers to regular use were reported, the results suggest that **AirPods Pro have strong potential as an alternative hearing device option**.
4. Further research is needed in larger and more diverse populations, and across a variety of self-fit hearing devices.

Thank you



Joaquin Valderrama



Angela Wong



Jorge Mejia



Brent Edwards



Nicky Chong-White

PRINCIPAL RESEARCH ENGINEER
NATIONAL ACOUSTIC LABORATORIES

 nicky.chong-white@nal.gov.au

 www.linkedin.com/in/nicky-chong-white