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- Click Print
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- Click layout
- Choose # of pages per sheet from dropdown menu
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- Click Print
- Choose # of pages per sheet from dropdown menu
- Choose Black and White from "Color" dropdown

Innovations and Clinical Tools with AI from the National Acoustic Laboratories

Matt Croteau, MS; Vicky Zhang, PhD; Jessica Monaghan, PhD

Matt Croteau, MDesSc, MClinAud

Matt Croteau is a research audiologist with a science and technical background who has worked in the areas of hearing assessment, diagnosis, and rehabilitation for adult, paediatric, and complex clients. Much of the research he undertakes at NAL is in understanding individual impacts of hearing loss and the evaluation and development of new solutions and technologies.

Vicky Zhang, PhD

Dr. Zhang is a Senior Researcher with over 20 years of experience in the area of hearing assessment and rehabilitation for children with hearing loss. Her main research has focused on investigating the efficacy of early intervention for populations of children with bilateral hearing loss or unilateral hearing loss, and evaluation of sound detection and discrimination in children with hearing loss. Additionally, she is passionate about exploring the applications of telehealth and AI technology in the field of audiology.

Jessica Monaghan, PhD

Dr Jessica Monaghan is a Senior Research Scientist at the National Acoustic Laboratories in Sydney, specializing in the application of machine learning to hearing healthcare. Her experience encompasses work on automatic speech recognition, cochlear implant algorithms, and noise-reduction techniques. Her current research focuses on leveraging the power of machine learning to develop new approaches for identifying hearing loss, as well as improving the performance and personalization of hearing devices.

Disclosures

- **Presenter Disclosure**: Financial: Vicky Zhang is employed by NAL. Non-financial: Vicky Zhang has no relevant non-financial relationships to disclose. Financial: Jess Monaghan is employed by NAL. Non-financial: Jess Monaghan has no relevant non-financial relationships to disclose. Financial: Matt Croteau is employed by NAL. Non-financial: Matt Croteau has no relevant non-financial relationships to disclose. In lieu of honorarium, a donation has been made to the NAL student internship program.
- **Content Disclosure**: This learning event does not focus exclusively on any specific product or service.
- **Sponsor Disclosure**: This course is presented by the National Acoustics Laboratories in partnership with AudiologyOnline.

Learning Outcomes

After this course, participants will be able to:

- Describe the barriers to widespread hearing screening of children between the newborn period and starting school and identify potential differences in the speech of children with and without hearing loss.
- Describe traditional methods for assessing speech intelligibility performance and assess the reliability and validity of AI-based method compared to results obtained from human listeners and discuss the potential implication for early intervention.
- Discuss how to locate, share, and use the NALguide as a resource or counselling tool.

An Introduction to NALguide: Hearing Aid Features Explained

Matt Croteau MDesSc, MClinAud

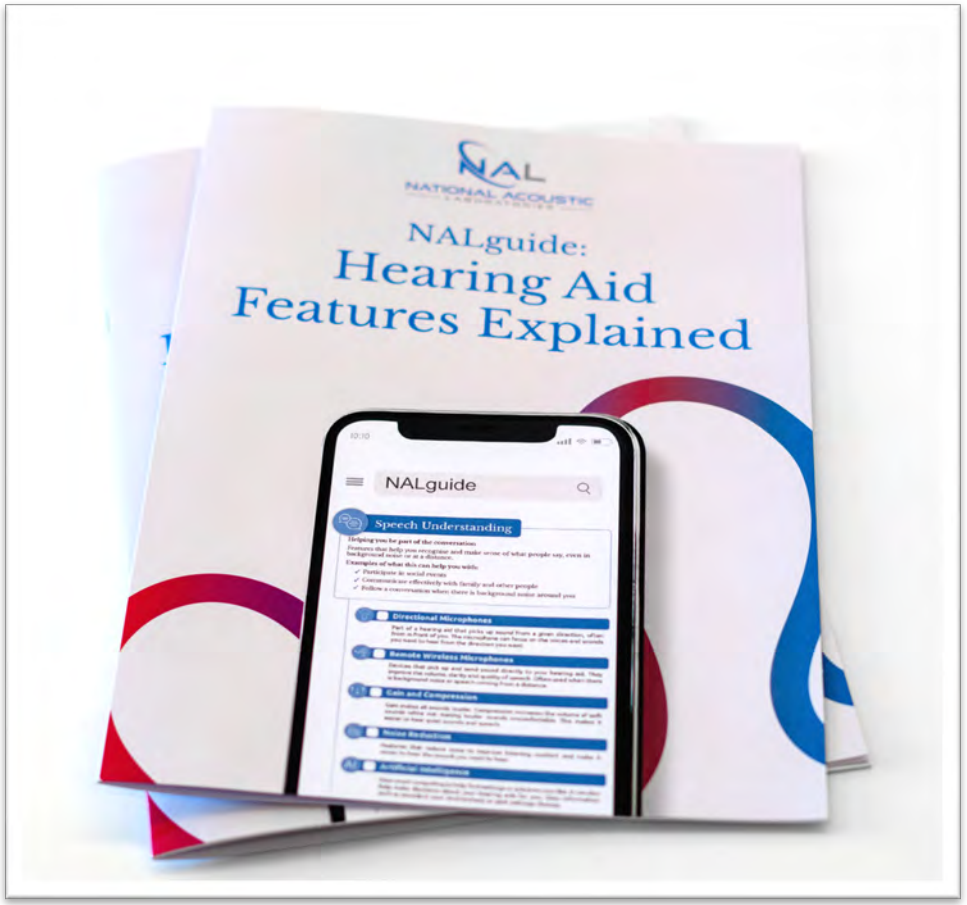
Research Audiologist

Course Overview

- What is NALguide?
- Why did we create this?
- How did we go about it?
  - Using the Guide:
    - Where to find it.
    - Overview of the interactive online version.
    - Overview of the pdf version.
    - Printable booklet.
    - Examples of use.
  - What's next?

What is NALguide?

- NALguide: Hearing Aid Features Explained
- An easy-to-understand guide that helps simplify and explain hearing aid technologies and features.
- Based on a comprehensive scoping review of current hearing devices.
- Starting with high-level over-arching categories down to finer detail and descriptions.

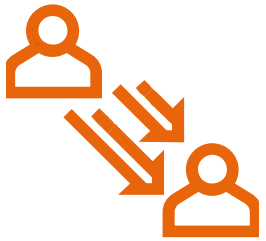


Why have a guide at all?

- It all comes down to making information accessible.

40-80%

of information given verbally in clinical appointments is forgotten.



25-49%

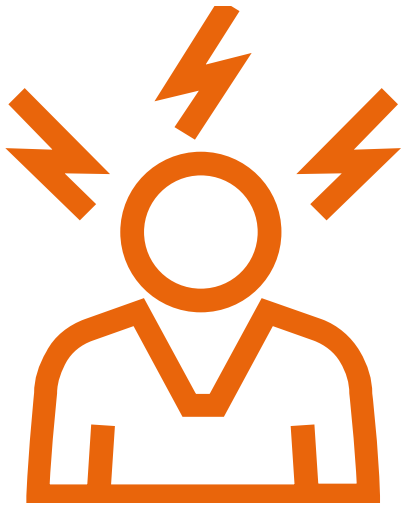
of information given during a first fitting appointment is forgotten.

69%

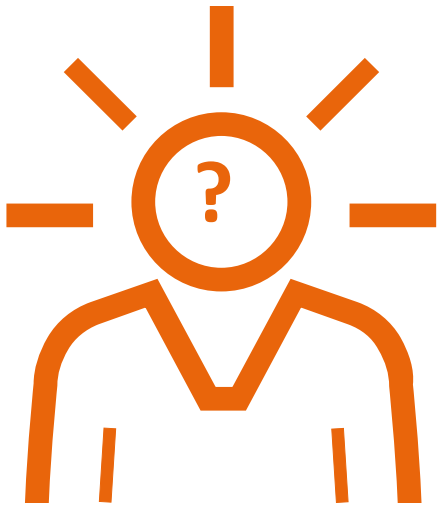
of printed hearing aid guides rated not suitable, with 31% rated as adequate.

Bennett et al, 2020, Caposecco et al., 2014 & 2016; Ferguson et al., 2015;Kessels, 2003; Laplante-Lévesque, et al., 2012; Maidment et al., 2020; Reece et al., 2006., Young et al 2022.

Inaccessible Information: Too much, too little, or incomprehensible.

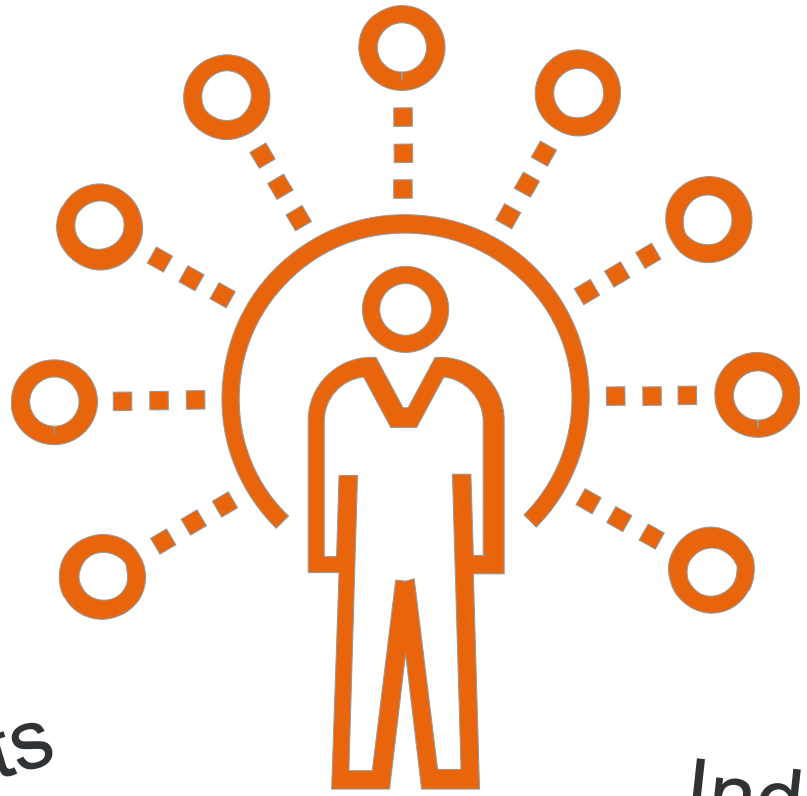


Information Overload



Information Underload

Where do patients get their information?



Online Reviews

Marketing Materials

Friends & Family

Advertisements

General Practitioners

Industry Websites

Hearing Care Professionals

Government Programs

Manufacturers

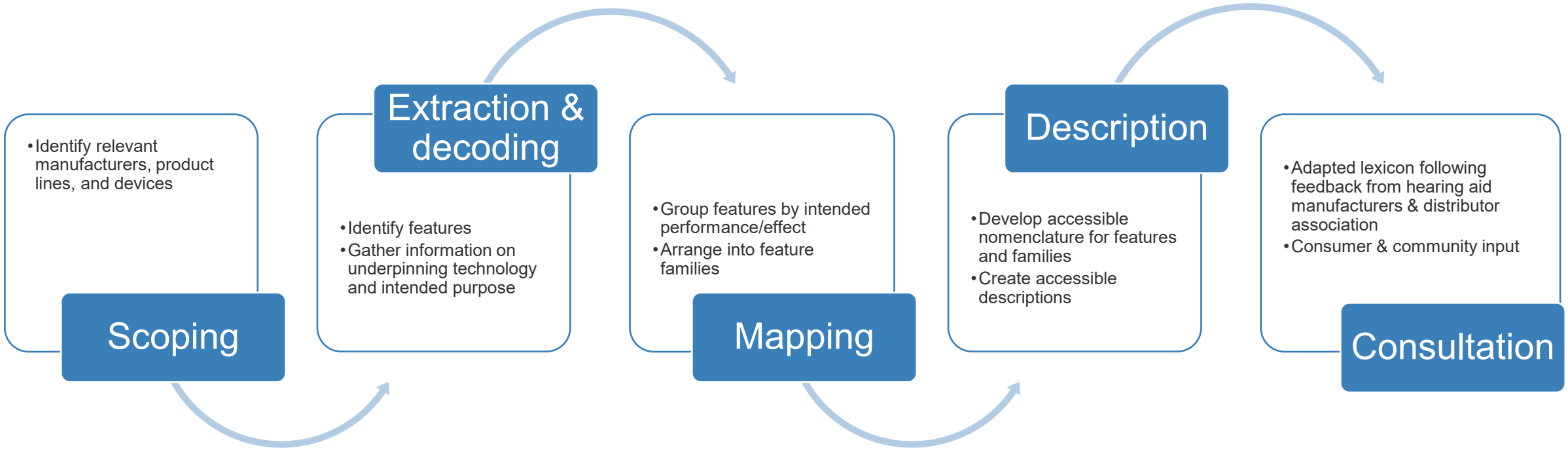
Let’s demystify and make this easy…

- NAL recognised an opportunity to begin a scoping review of current hearing aid technology and identify a number of potential outputs and uses for this review.

Let’s demystify and make this easy…

- Clarify the current landscape of hearing aid technology in a condensed form as a reference for stakeholders.
- Create a rolling inventory of features and technology that is both future-proof and easily updated.
- Identify and track emerging and niche technologies.
- Provide an easy-to-understand guide for individuals to learn about, consider, and discuss hearing aids.

Overview of the process:



Overview of the process:

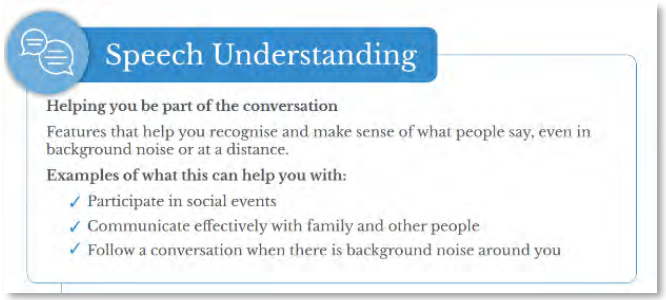
- Key takeaways of how we did it:
- A team of engineers, audiologists, and researchers extracted over 350 individual hearing aid features entirely from publicly available sources (data sheets, marketing materials, white papers, etc).
- These features were grouped into several feature families (groups of similar technology or technologies with a similar intended effect)
- These feature families were then assigned an overall benefit-based intended purpose.

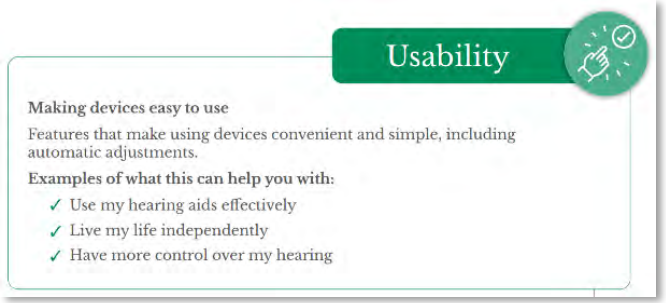
Overview of the process:

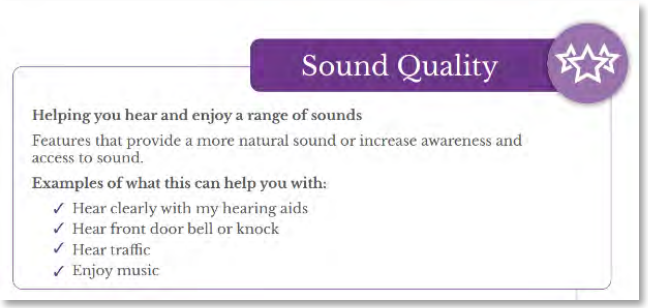
- Key takeaways of how we did it:
- After the scoping and mapping processes were completed, care was taken to consult with important stakeholders – including manufacturer associations and advocacy groups (namely HAMADAA and Deafness Forum Australia) to ensure fair categorisation of features and general accessibility in terms of clear language and avoiding technical jargon.

The Guide

- The end result is a comprehensive guide of hearing aid features with:
- Clear descriptions.
- Broadly categorised with intended purpose.
- Manufacturer agnostic.
- Easy to understand.
- Easy to follow and engage with.







Overview of NALguide

- Three main versions:
- Interactive Online Version
- Downloadable and Printable PDF Version
- Downloadable Booklet (for professional printing services)

Available at:

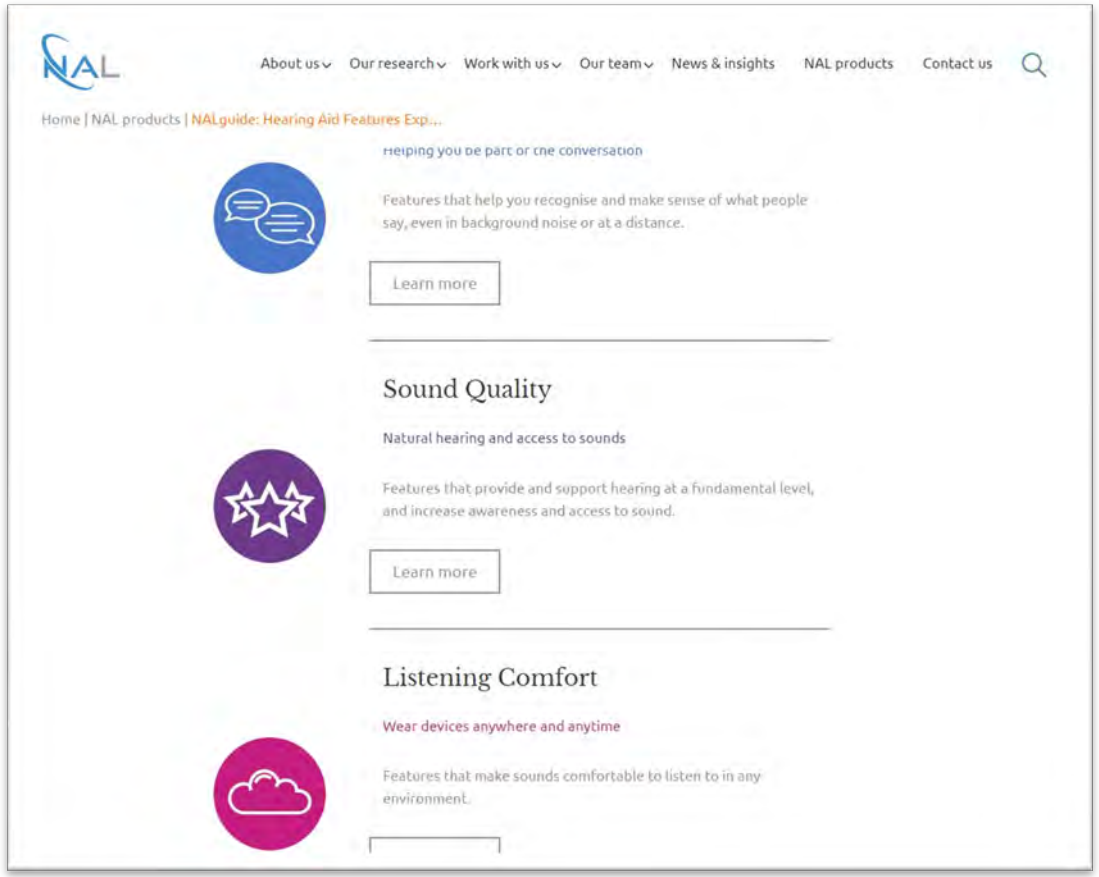
https://www.nal.gov.au/nal_products/nalguide-hearing-aid-features-explained/

Note that a simplified version is also available on the Australian Hearing Services Program Website

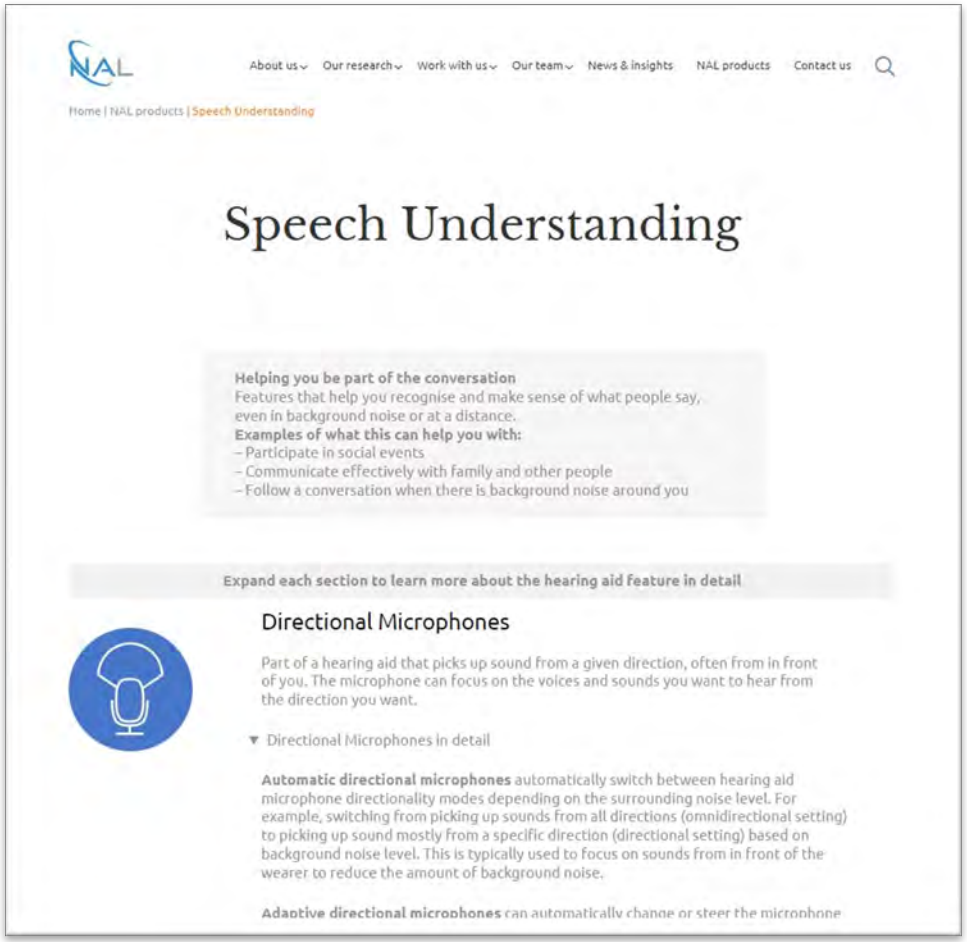
Interactive Online Version

- Contains the greatest level of detail.
  - Category
  - Feature Family with descriptions
  - Individual Features with definitions
- Navigable drop-down menus .

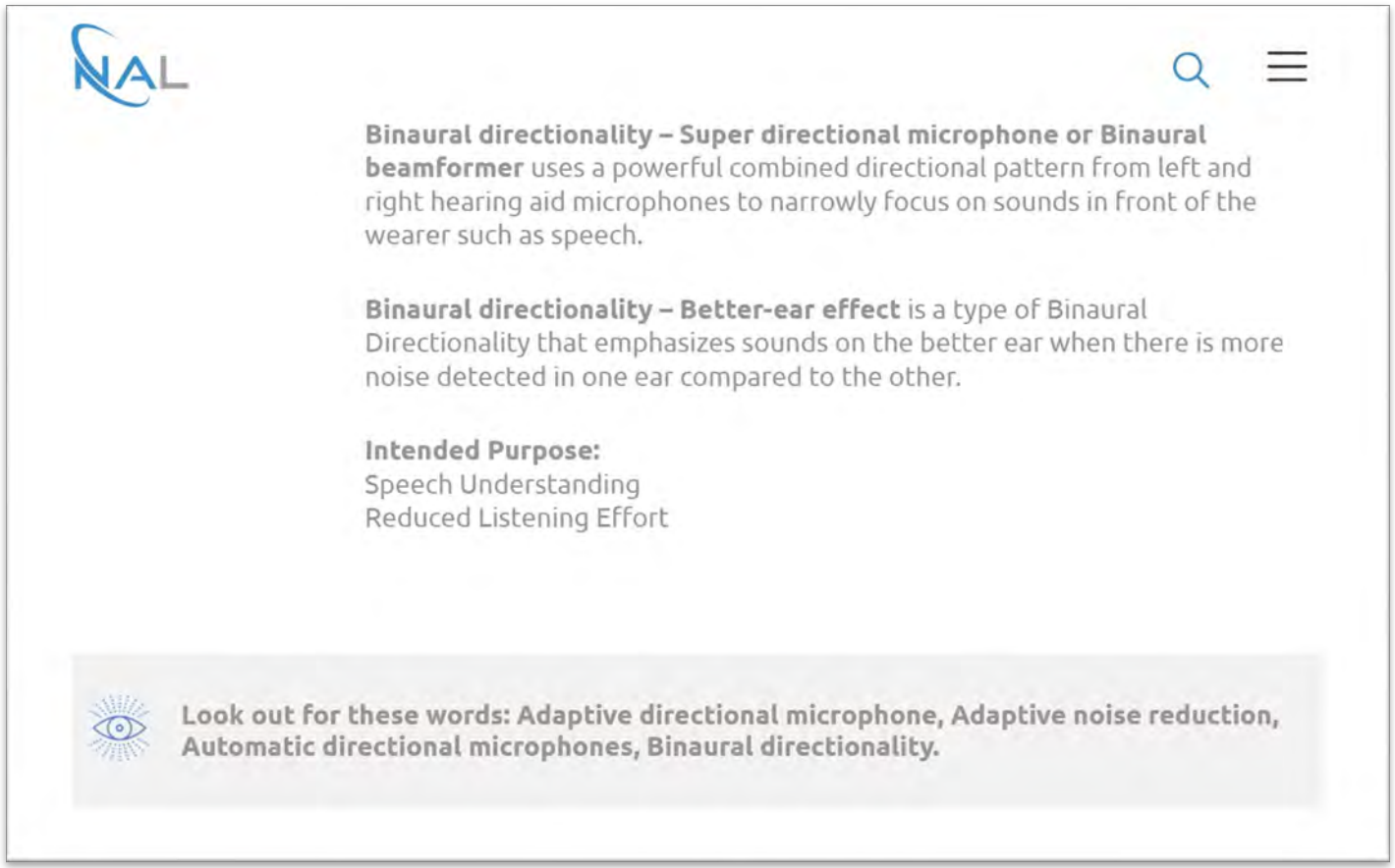
Interactive Online Version



Interactive Online Version



Interactive Online Version



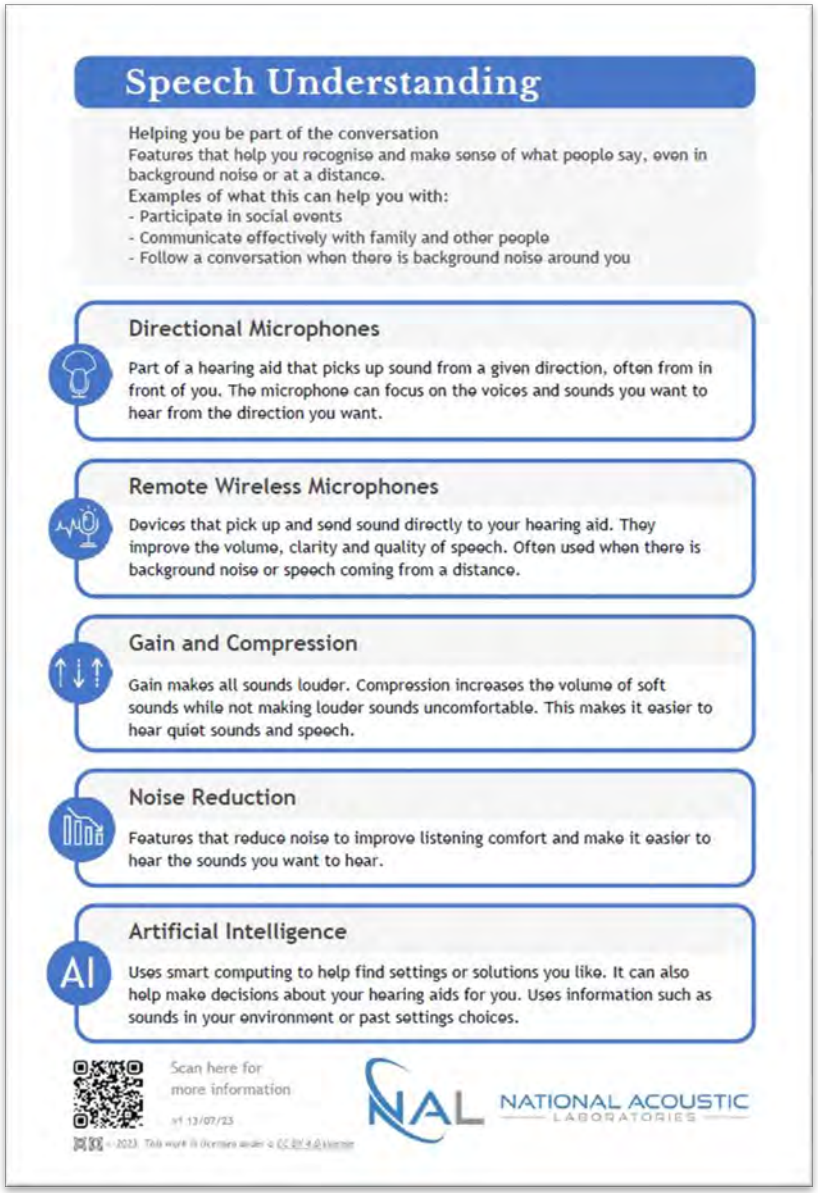
Downloadable and Printable PDF Version

- Contains Higher-Level Essential Detail
  - Category
  - Feature Family with descriptions

NALguide (online and downloadable version) available here:

https://www.nal.gov.au/nal_products/nalguide-hearing-aid-features-explained/

Downloadable and Printable PDF Version



Speech Understanding

Helping you be part of the conversation
Features that help you recognise and make sense of what people say, even in background noise or at a distance.
Examples of what this can help you with:
- Participate in social events
- Communicate effectively with family and other people
- Follow a conversation when there is background noise around you

Directional Microphones

Part of a hearing aid that picks up sound from a given direction, often from in front of you. The microphone can focus on the voices and sounds you want to hear from the direction you want.

Remote Wireless Microphones

Devices that pick up and send sound directly to your hearing aid. They improve the volume, clarity and quality of speech. Often used when there is background noise or speech coming from a distance.

Gain and Compression

Gain makes all sounds louder. Compression increases the volume of soft sounds while not making louder sounds uncomfortable. This makes it easier to hear quiet sounds and speech.

Noise Reduction

Features that reduce noise to improve listening comfort and make it easier to hear the sounds you want to hear.

Artificial Intelligence

AI

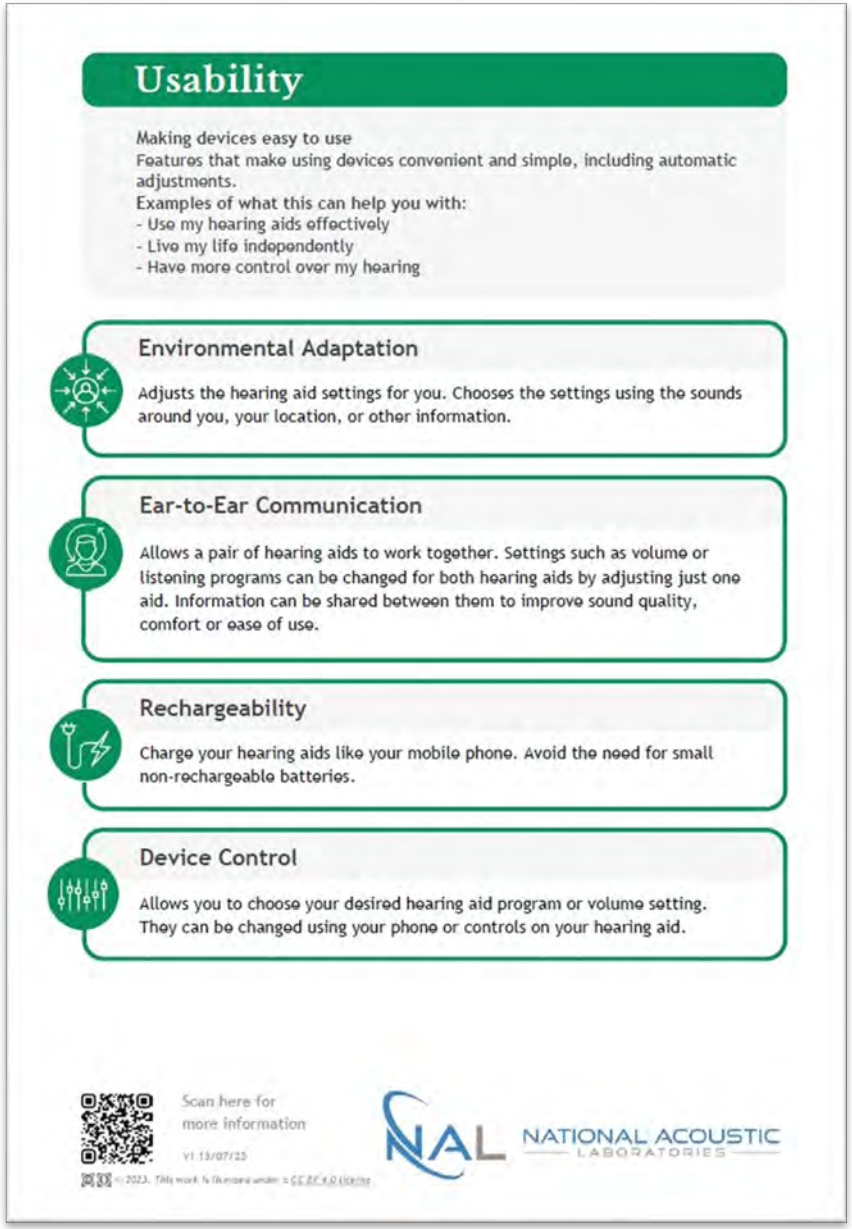
Uses smart computing to help find settings or solutions you like. It can also help make decisions about your hearing aids for you. Uses information such as sounds in your environment or past settings choices.

Scan here for more information

v1 13/07/23

NAL NATIONAL ACOUSTIC LABORATORIES

Downloadable and Printable PDF Version



Usability

Making devices easy to use
Features that make using devices convenient and simple, including automatic adjustments.
Examples of what this can help you with:
- Use my hearing aids effectively
- Live my life independently
- Have more control over my hearing

Environmental Adaptation

Adjusts the hearing aid settings for you. Chooses the settings using the sounds around you, your location, or other information.

Ear-to-Ear Communication

Allows a pair of hearing aids to work together. Settings such as volume or listening programs can be changed for both hearing aids by adjusting just one aid. Information can be shared between them to improve sound quality, comfort or ease of use.

Rechargeability

Charge your hearing aids like your mobile phone. Avoid the need for small non-rechargeable batteries.

Device Control

Allows you to choose your desired hearing aid program or volume setting. They can be changed using your phone or controls on your hearing aid.

Scan here for more information

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Downloadable Booklet (coming soon)

- Contains Higher-Level Essential Detail
  - Introductory and Background Information
  - Category
  - Feature Family with descriptions
- Formatted for easy professional printing and binding.

Downloadable Booklet (coming soon)

Downloadable Booklet (coming soon)

Use Case

Margaret L., Age 71

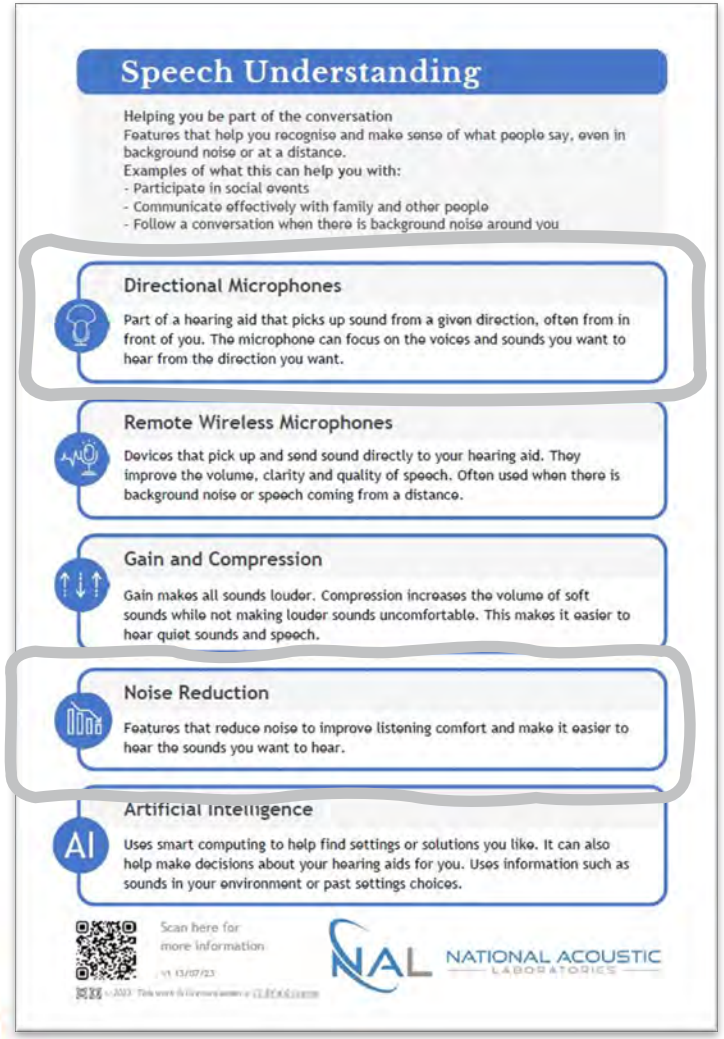
- Margaret has been concerned about her hearing for about the last 5 years and was prompted to investigate her hearing by family members (husband and son who has young children).
- She has spoken to friends who have hearing aids and is not confident in some of the advice, as it is not consistent.
- She attended a hearing screening event and was recommended to see an audiologist as she may have a hearing loss.
- At this event Margaret took a copy of NALguide

Use Case

Margaret L., Age 71

- Although she knows little about the specifics of her hearing difficulty, she knows she has been struggling in key areas:
  - Hearing the TV at a comfortable volume for the rest of the family.
  - Following the conversation with friends at her book club.
  - Understanding her grandchildren speak.

Use Case



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Artificial Intelligence

Uses smart computing to help find settings or solutions you like. It can also help make decisions about your hearing aids for you. Uses information such as sounds in your environment or past settings choices.

Scan here for more information

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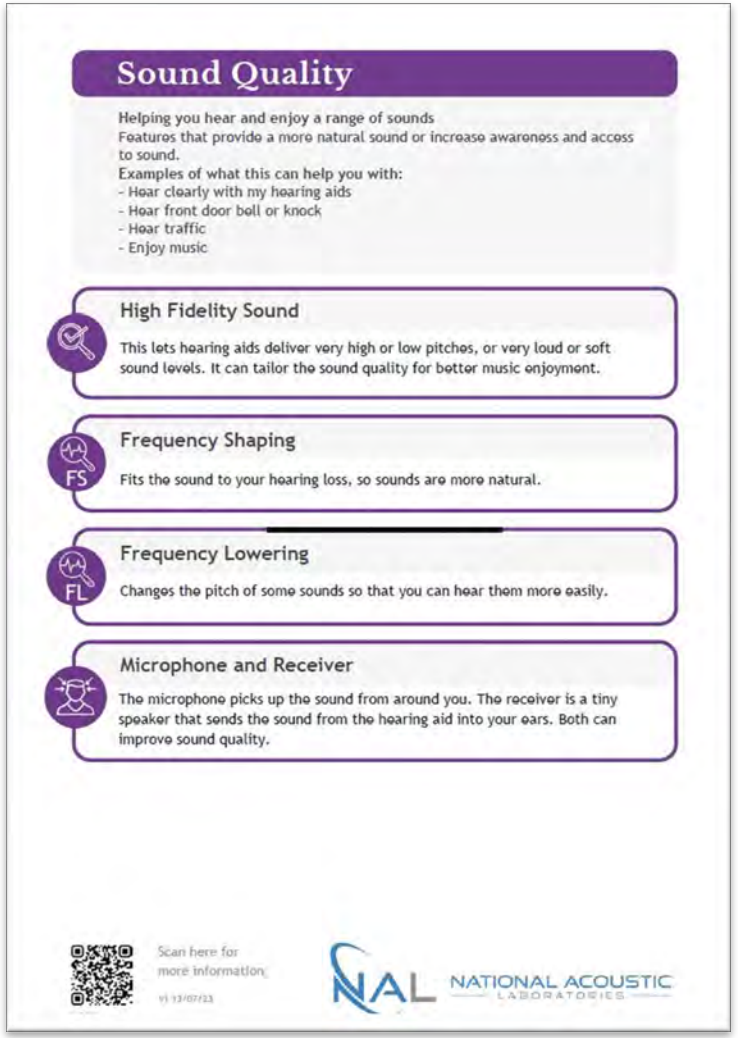

Sound Quality

Helping you hear and enjoy a range of sounds
Features that provide a more natural sound or increase awareness and access to sound.
Examples of what this can help you with:
- Hear clearly with my hearing aids
- Hear front door bell or knock
- Hear traffic
- Enjoy music

High Fidelity Sound

This lets hearing aids deliver very high or low pitches, or very loud or soft sound levels. It can tailor the sound quality for better music enjoyment.

Frequency Shaping

FS

Fits the sound to your hearing loss, so sounds are more natural.

Frequency Lowering

FL

Changes the pitch of some sounds so that you can hear them more easily.

Microphone and Receiver

The microphone picks up the sound from around you. The receiver is a tiny speaker that sends the sound from the hearing aid into your ears. Both can improve sound quality.

Scan here for more information

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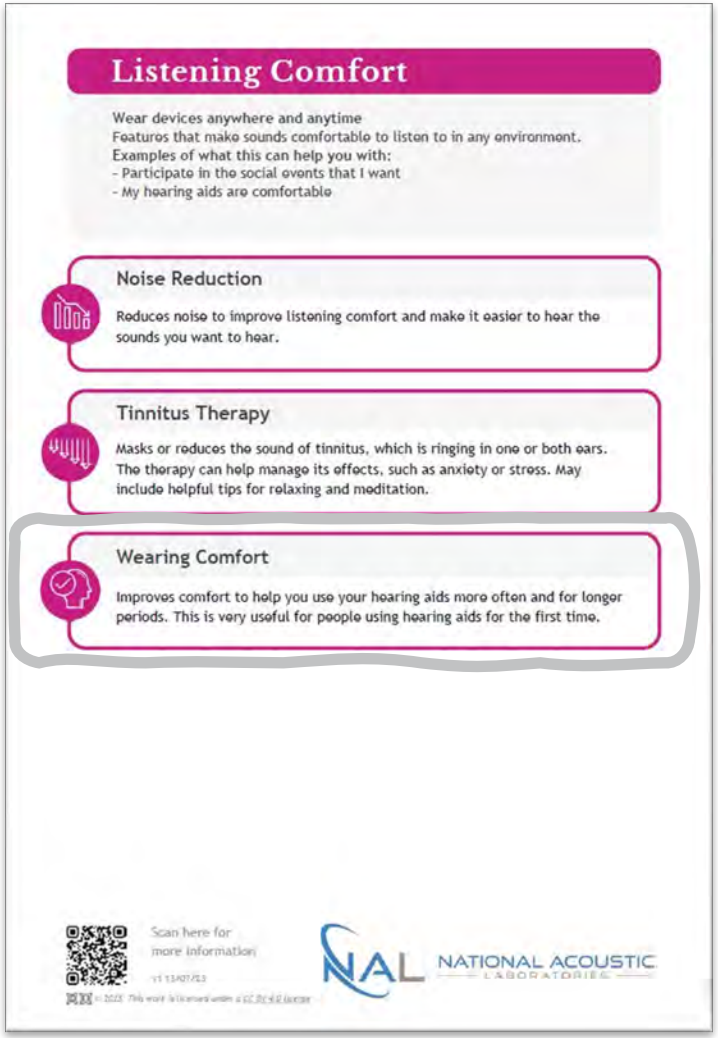

Listening Comfort

Wear devices anywhere and anytime
Features that make sounds comfortable to listen to in any environment.
Examples of what this can help you with:
- Participate in the social events that I want
- My hearing aids are comfortable

Noise Reduction

Reduces noise to improve listening comfort and make it easier to hear the sounds you want to hear.

Tinnitus Therapy

Masks or reduces the sound of tinnitus, which is ringing in one or both ears. The therapy can help manage its effects, such as anxiety or stress. May include helpful tips for relaxing and meditation.

Wearing Comfort

Improves comfort to help you use your hearing aids more often and for longer periods. This is very useful for people using hearing aids for the first time.

Scan here for more information

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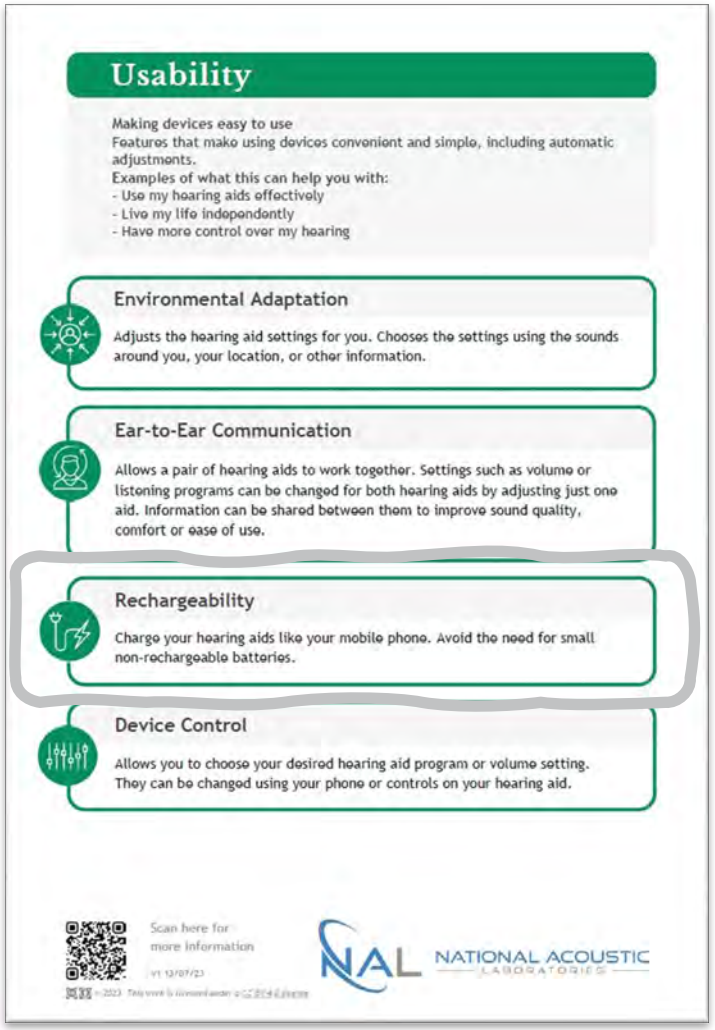
Use Case



Usability

Making devices easy to use
Features that make using devices convenient and simple, including automatic adjustments.
Examples of what this can help you with:
- Use my hearing aids effectively
- Live my life independently
- Have more control over my hearing

Environmental Adaptation

Adjusts the hearing aid settings for you. Chooses the settings using the sounds around you, your location, or other information.

Ear-to-Ear Communication

Allows a pair of hearing aids to work together. Settings such as volume or listening programs can be changed for both hearing aids by adjusting just one aid. Information can be shared between them to improve sound quality, comfort or ease of use.

Rechargeability

Charge your hearing aids like your mobile phone. Avoid the need for small non-rechargeable batteries.

Device Control

Allows you to choose your desired hearing aid program or volume setting. They can be changed using your phone or controls on your hearing aid.

Scan here for more information

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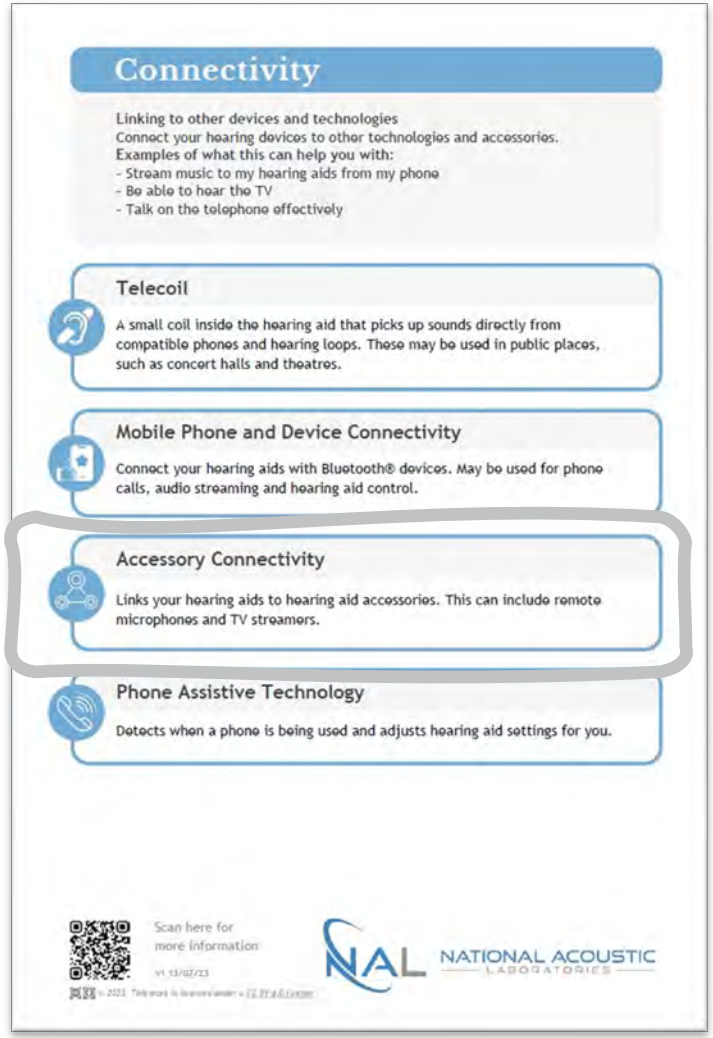

Connectivity

Linking to other devices and technologies
Connect your hearing devices to other technologies and accessories.
Examples of what this can help you with:
- Stream music to my hearing aids from my phone
- Be able to hear the TV
- Talk on the telephone effectively

Telecoil

A small coil inside the hearing aid that picks up sounds directly from compatible phones and hearing loops. These may be used in public places, such as concert halls and theatres.

Mobile Phone and Device Connectivity

Connect your hearing aids with Bluetooth® devices. May be used for phone calls, audio streaming and hearing aid control.

Accessory Connectivity

Links your hearing aids to hearing aid accessories. This can include remote microphones and TV streamers.

Phone Assistive Technology

Detects when a phone is being used and adjusts hearing aid settings for you.

Scan here for more information

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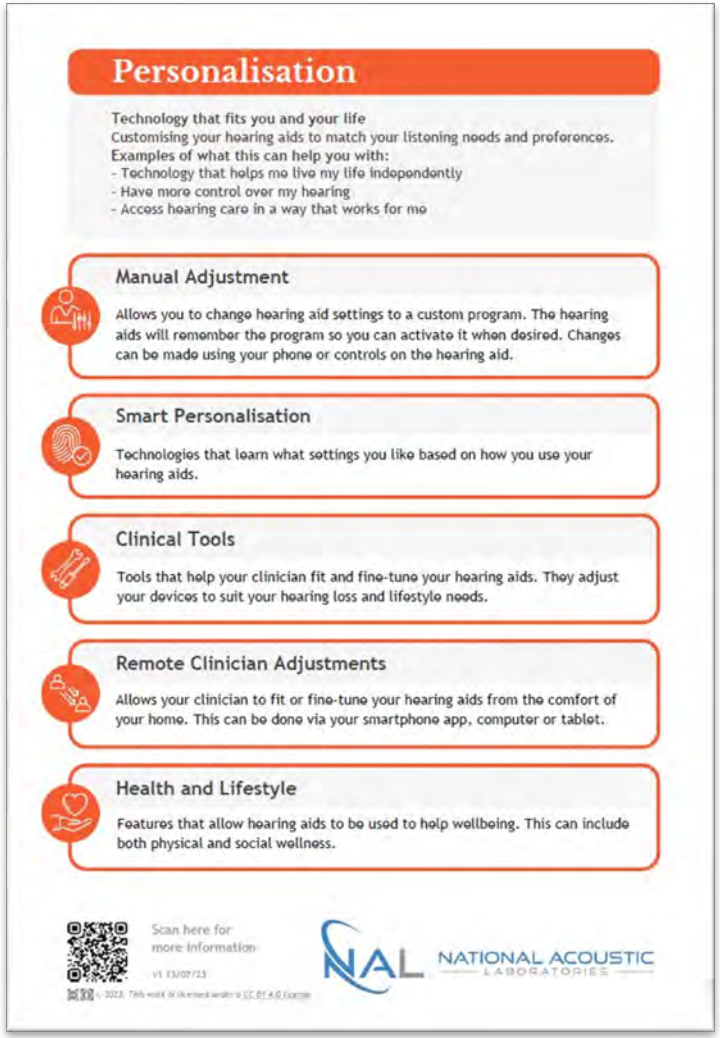

Personalisation

Technology that fits you and your life
Customising your hearing aids to match your listening needs and preferences.
Examples of what this can help you with:
- Technology that helps me live my life independently
- Have more control over my hearing
- Access hearing care in a way that works for me

Manual Adjustment

Allows you to change hearing aid settings to a custom program. The hearing aids will remember the program so you can activate it when desired. Changes can be made using your phone or controls on the hearing aid.

Smart Personalisation

Technologies that learn what settings you like based on how you use your hearing aids.

Clinical Tools

Tools that help your clinician fit and fine-tune your hearing aids. They adjust your devices to suit your hearing loss and lifestyle needs.

Remote Clinician Adjustments

Allows your clinician to fit or fine-tune your hearing aids from the comfort of your home. This can be done via your smartphone app, computer or tablet.

Health and Lifestyle

Features that allow hearing aids to be used to help wellbeing. This can include both physical and social wellness.

Scan here for more information

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Use Case

Directional Microphones

Part of a hearing aid that picks up sound from a given direction, often from in front of you. The microphone can focus on the voices and sounds you want to hear from the direction you want.

Wearing Comfort

Improves comfort to help you use your hearing aids more often and for longer periods. This is very useful for people using hearing aids for the first time.

Noise Reduction

Features that reduce noise to improve listening comfort and make it easier to hear the sounds you want to hear.

Rechargeability

Charge your hearing aids like your mobile phone. Avoid the need for small non-rechargeable batteries.

Accessory Connectivity

Links your hearing aids to hearing aid accessories. This can include remote microphones and TV streamers.

Use Case


Listening Comfort
Noise Reduction
Tinnitus Therapy
Hearing Comfort
Rechargeability
Device Control

Also Note:

- Many Assistive Listening Devices (ALDs) and Personal Sound Amplification Products (PSAPs) were included in the review, and the feature descriptions and definitions are relevant to ALDs and PSAPs.

What's Next?

Feedback on NALguide has been enthusiastic and encouraging so far.

- Some key points that we have noticed:
- A desire to have printed booklets readily available for medical practices, hearing clinics, pharmacies, etc.
- Clinicians have been expressing an interest in a companion feature guide designed for them, with deeper technical detail and kept up to date with new, emerging, a niche trends.

Thanks to…


Paola Incerti


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Taegan Young


Jason Gavrillis


Megan Gilliver


Xiaoyin Shang


Sanna Hou


Katja Turnbull

- Australian Department of Health & Aged Care
- Deafness Forum Australia
- Hearing Aid Manufacturers and Distributors Association of Australia (HAMADAA)

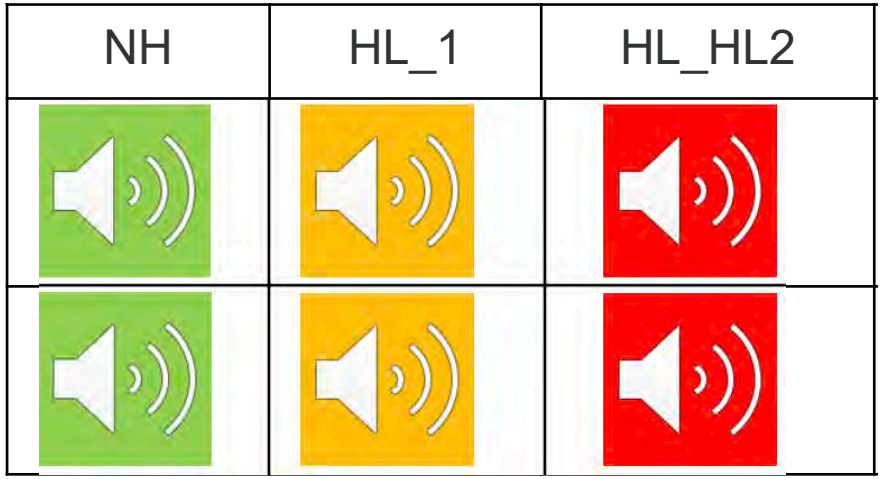
AI-powered Speech Intelligibility Assessment for Children

Vicky Zhang, PhD

Senior Researcher, NAL

Project Overview –
Background: Speech Intelligibility

- Speech Intelligibility (SI) reflects how well a child's speech is understood by other listeners. It is crucial to ensure children's overall speech and language development.
- Children with hearing loss (HL) typically have lower SI scores than children with normal hearing (NH), which may lead to poorer communication outcomes, and potentially have a negative impact on their academic achievements and social integration.



Project Overview – *Background: Speech Intelligibility*

- Early childhood is a critical period for language and speech development. Identifying SI issues at a young age allows for appropriate clinical management and support.
- Advancements in assessment tools and techniques will enable more accurate and efficient evaluations of SI, hence facilitating timely decisions on intervention strategies.

Project Overview –
Background: Methods for Measuring Speech Intelligibility

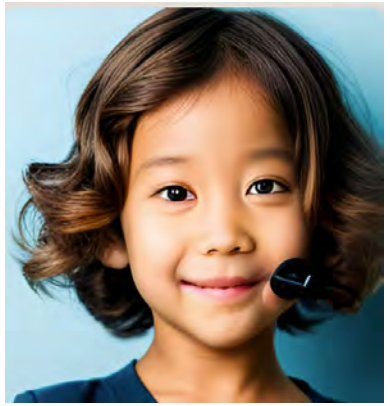
- The optimal methods for assessing SI, including the choice of speech material (nonsense words, words, continuous speech), evaluation techniques (translation or scale-based ratings), and listener expertise, are still under debated.
- There are currently two main methods: transcription and scale-based ratings:

Measurement Method	Material example	Description	Issues/Comments
Transcription	Beginner's Intelligibility Test (BIT)	3 inexperienced listeners who listen, transcribe, and score speech samples	○ The process is time-consuming; ○ It is relatively more accurate than the scale method, but subject to evaluator variability.
Scale	7-point SI Rating (SIR)	Raters (parents, teachers, unfamiliar individuals, and/or professionals) evaluate how well they understand the child's speech in casual conversations.	○ Faster but provide less information than the transcription method; ○ It is also subject to evaluator variability, e.g. parents and professionals often provides higher SI ratings, which may not accurately represent how well the speech can be understood by naive listeners.

PROJECT OVERVIEW

Project Objectives

- To improve the efficiency of SI assessment for young children by developing an AI-based method;



- To validate whether the AI-based method can provide comparable accuracy results as na?ve listeners;

- To investigate whether the AI-based method can distinguish between SI performance in children with HL and those with NH.

Project Overview

- SI MEASURE
  - Beginner's Intelligibility Test (BIT)
  - 4 lists of 10 simple sentences; each sentence includes 2 to 6 words
  - Each child was randomly allocated a list of 10 sentences
- SPEECH SAMPLES FROM CHILDREN AGED 5 YEARS OLD
  - All children have cleaned BIT audio recordings:
  - NH group: N=85 children (850 sentences)
  - HL group: N=214 children (2140 sentences)
  - Total N= 299 children (2990 sentences)
  - No reported additional disabilities
  - All children are native English speakers
  - HL group: all children received their 1st hearing aids (HAs, n=162) or 1st cochlear implants (CIs, n=52) before 3 years of age.

BIT		Correct answer					
Liste number	Sentence number	1	2	3	4	5	6
1	1	The	baby	falls			
1	2	Mommy	walks				
1	3	The	duck	swims			
1	4	The	boy	sits			
1	5	Grandma	sleeps				
1	6	That	is	a	little	bed	
1	7	The	boy	walked	to	the	table
1	8	My	car	is	blue		
1	9	He	is	brushing	his	teeth	
1	10	She	is	talking	a	bath	
2	1	Daddy	runns				
2	2	The	baby	cries			
2	3	The	dog	eats			
2	4	The	girl	drinks			
2	5	The	clown	falls			
2	6	That	is	a	big	bed	
2	7	The	boy	walked	to	the	chair
2	8	My	van	is	green		
2	9	They	are	playing	the	drums	
2	10	She	is	talking	on	the	phone
3	1	Daddy	walks				
3	2	The	bunny	drinks			
3	3	The	dog	sleeps			
3	4	The	girl	jumps			
3	5	Mommy	reads				
3	6	That	is	a	brown	chair	
3	7	The	boy	is	on	the	table
3	8	My	airplane	is	big		
3	9	He	is	trying	his	shoe	
3	10	She	is	brushing	her	hair	
4	1	The	bear	sleeps			
4	2	Mommy	sits				
4	3	The	rabbit	hops			
4	4	The	cowboy	jumps			
4	5	Grandma	falls				
4	6	That	is	a	black	hat	
4	7	The	boy	is	under	the	table
4	8	My	airplane	is	small		
4	9	He	is	painting	the	chair	
4	10	She	is	cooking	dinner		

Project Overview

- LISTENER JUDGES
  - 69 Adult listeners:
  - Aged between 18-40 years old
  - Native Australian English speakers
  - Passed hearing screening
  - No previous exposure to children with HL
- TRANSCRIPTION AND SIR RATING
  - Each BIT sentence was assessed by 3+ adult listeners using the SIR rating scale and transcription method.
  - Each listener transcribed and scored at least 3 children's speech recordings.
  - Some children's speech were evaluated using the SIR scale and by research speech pathologists.

The total number of children whose speech recordings were transcribed by 3+ naïve listeners and whose SIR ratings were assessed by 3+ naïve listeners and research speech pathologists:

- NH group: n=24 children (240 sentences)
- HL group: n=34 children (25 HA; 10 CI) (340 sentences)
- Total: n= 58 (580 sentences)

Rating	Current Functioning
1	I always or almost always understand the child's speech with little or no effort.
2	I always or almost always understand the child's speech; however, I need to listen carefully.
3	I typically understand about half of the child's speech.
4	I typically understand about 25% of the child's speech.
5	The child's speech is very hard to understand. I typically understand only occasional, isolated words and/or phrases.
6	I never or almost never understand the child's speech.
No Rating	Speech intelligibility could not be judged because the child is producing few or no word approximations.

RESULTS

Review of AI Transcription Models

Transcription examples		Transcription example 1 (Q687)	Transcription example 2 (Q671)
Reference list		The boy walked to the table	She is brushing her hair
by AI models	model 1	The boy walked to the table	She is brushing her (hair)
	model 2	The boy walked to the table	She is brushing her hair
	model 3	The boy wooked id the table on	She is brushing her
	model 4	The mo work a the table	She is blushing
	model 5	The bo dti hab	She is blushing
	model 6	The boy wodidde ta bo	He was burshingh
	model 7	The boy wodidde ta b	He was burshingh
by Naʔve listeners	naʔve listener 1	The boy walked to the table	She is brushing her hair
	naʔve listener 2	The boy walked in a table	She is brushing her hair
	naʔve listener 3	The boy walked at a table	She is washing her hair
	naʔve listener 4	The boy walked to the table	She is brushing her hair

Transcription Performance Compared to the Reference Lists

For speech samples of NH children:

- The overall percentage of correct words achieved by the selected optimal AI model: 82.1%
- Averaged overall percentage of correct words by 3 different naïve listeners: 92%

For speech samples of HI children:

- The overall percentage of correct words achieved by the selected optimal AI model: 71%
- Averaged overall percentage of correct words by 3 different naïve listeners: 79%

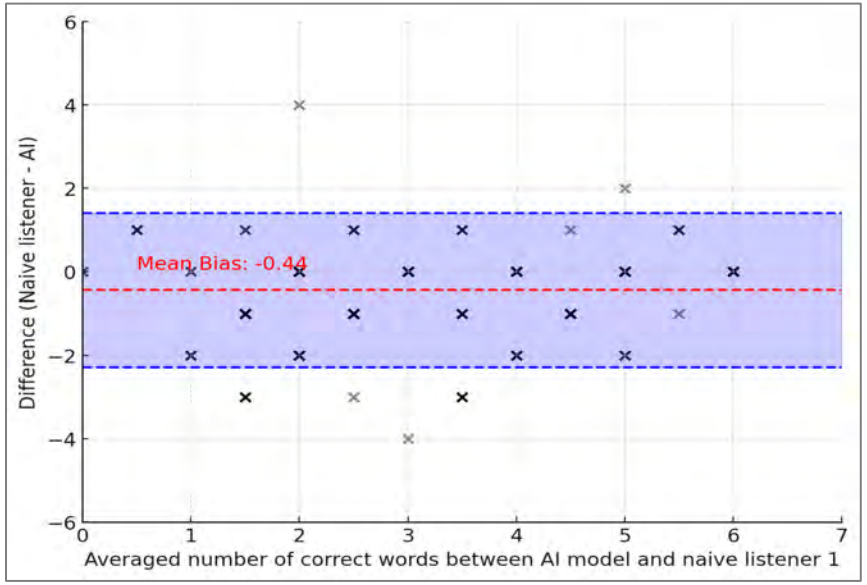
Overall percentage of correct words achieved by AI models (NH group)

AI Models	Overall % correct
model 1	**82.1**
model 2	71
model 3	59
model 4	57
model 5	55
model 6	54
model 7	47
model 8	43
model 9	41

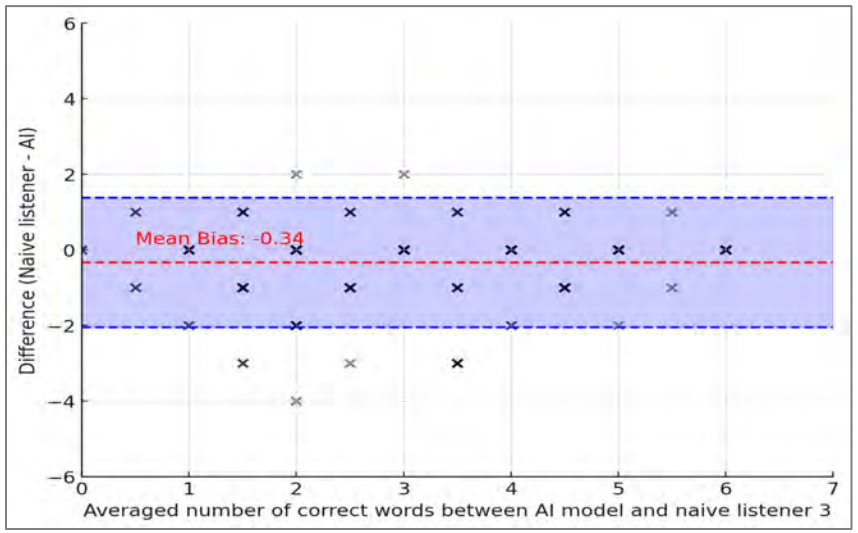
AI Models (cont.)	Overall % correct
model 10	40
model 11	39
model 12	36
model 13	34
model 14	31
model 15	31
model 16	31
model 17	29
model 18	23

WORD-LEVEL TRANSCRIPTION AGREEMENT USING BLAND-ALTMAN PLOTS: AI VS. NAʔVE LISTENERS

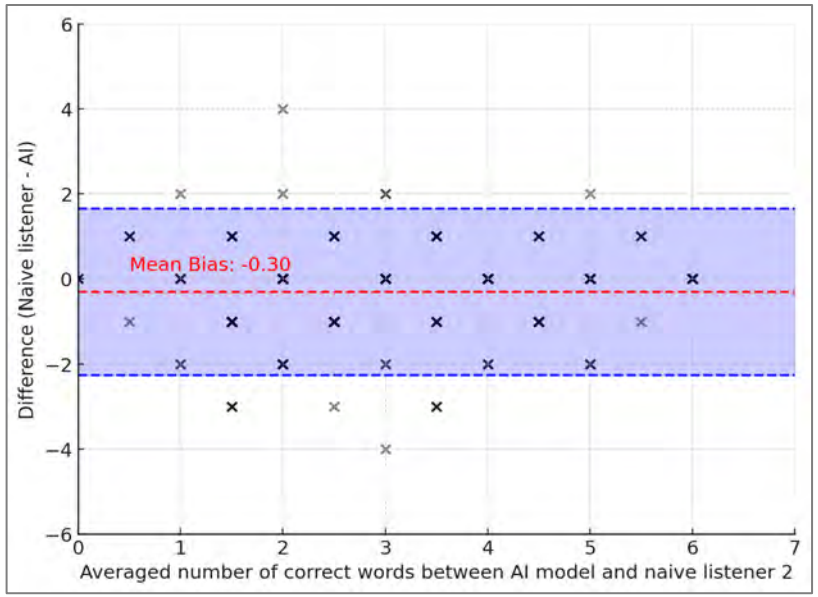
- Speech samples of NH children (N=240 sentences)
- The AI transcription for NH samples at the word level fell within the 95% confidence interval range as recorded by naʔve listeners.
- Significant correlation in the number of correct words between the AI method and the averaged results from 3 naʔve listeners (r=-0.86, p<0.001)



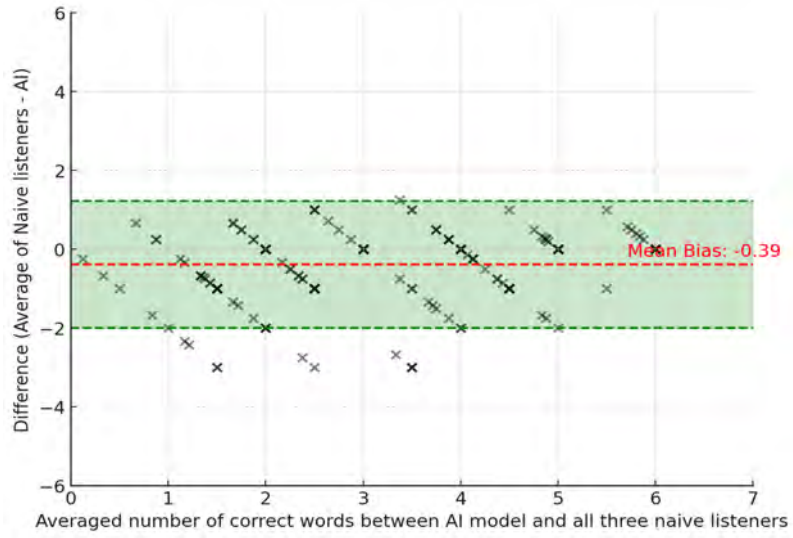
5% (n=12) sentences outside the 95% CI range



4.2% (n=10) sentences outside the 95% CI range



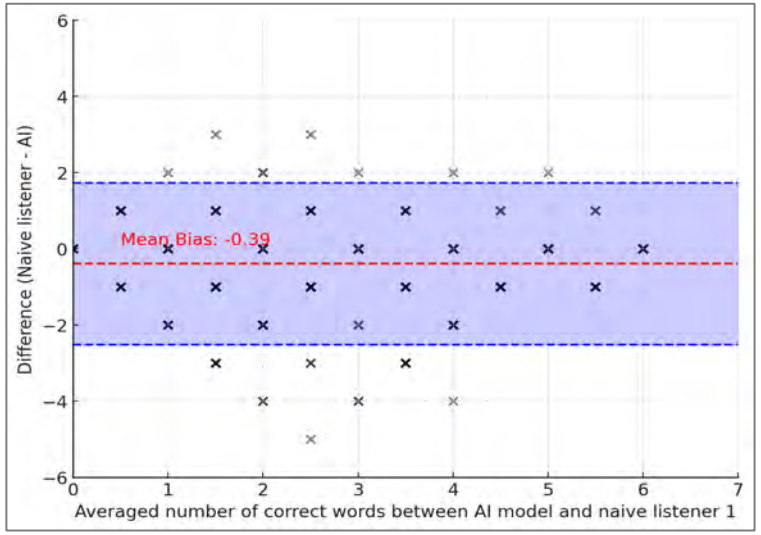
5.8% (n=14) sentences outside the 95% CI range



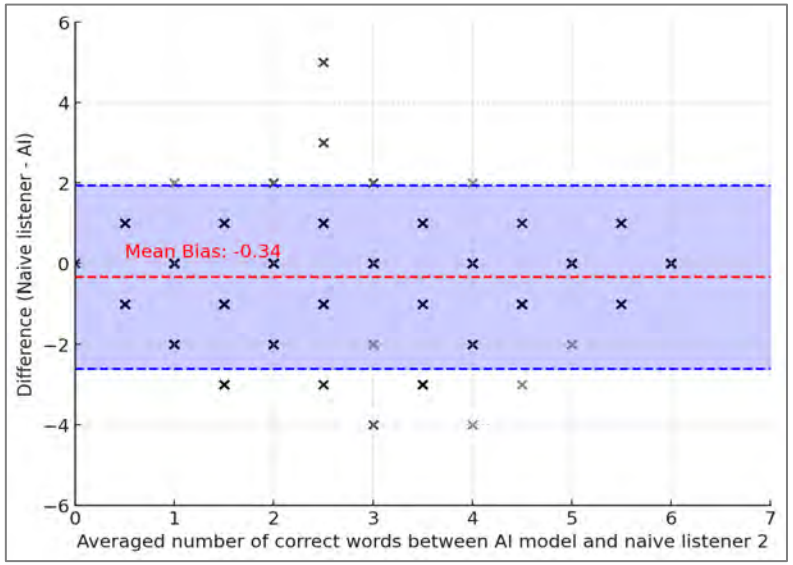
4.6% (n=11) sentences outside the 95% CI range

WORD-LEVEL TRANSCRIPTION AGREEMENT USING BLAND-ALTMAN PLOTS: AI VS. NA?VE LISTENERS

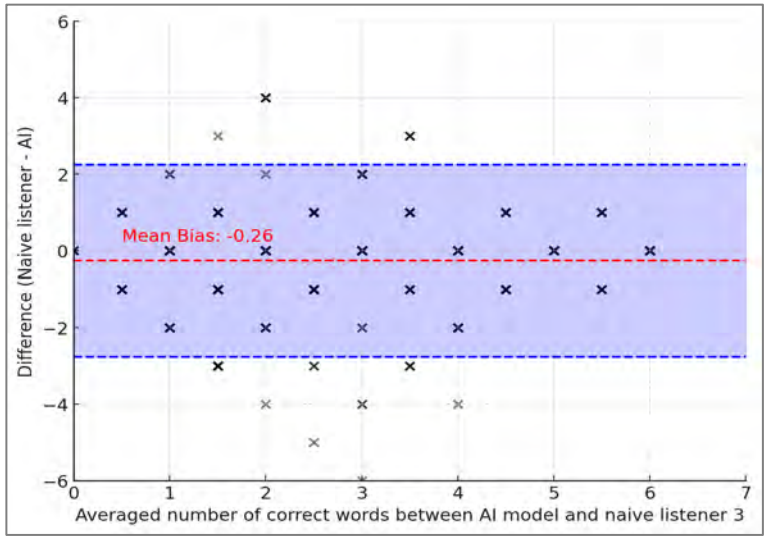
- Speech samples of HI children (N=340 sentences)
- The AI transcription for HI samples at the word level fell within the 95% confidence interval range as recorded by na?ve listeners.
- Significant correlation in the number of correct words between the AI method and the averaged results from 3 na?ve listeners (r=-0.82, p<0.001)



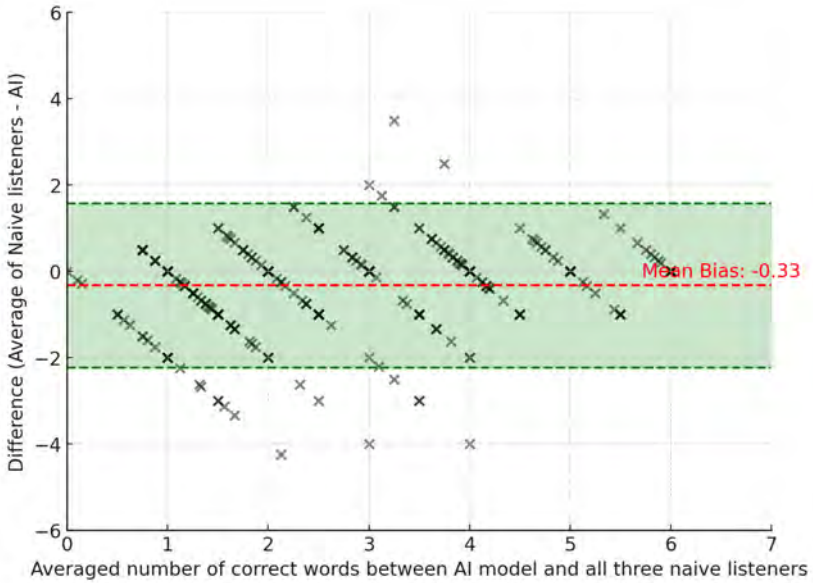
7.6% (n=26) sentences outside the 95% CI range



8.5% (n=29) sentences outside the 95% CI range



7.3% (n=25) sentences outside the 95% CI range



5.6% (n=19) sentences outside the 95% CI range

Consistency Analysis Among AI Model and Naʔve Listeners

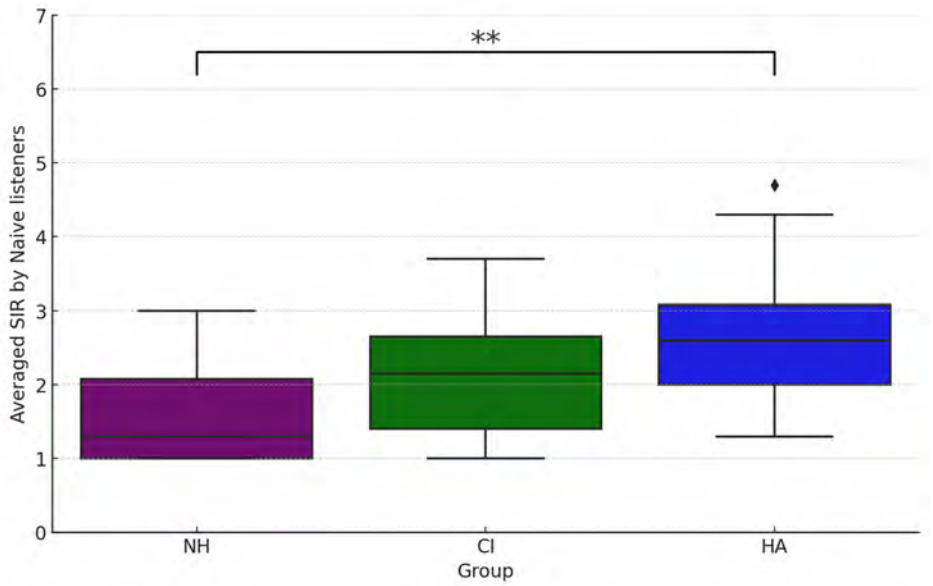
WORD-LEVEL INTRACLASS CORRELATION COEFFICIENT (ICC) RESULTS

	ICC (NH group)	ICC (HI group)	ICC (CI group only)	ICC (HA group only)
Within naʔve listeners only	0.952	0.915	0.957	0.895
Selected AI model vs individual naʔve listener' results	0.955	0.927	0.955	0.914
Selected AI model vs averaged naʔve listeners' results	0.921	0.896	0.904	0.888

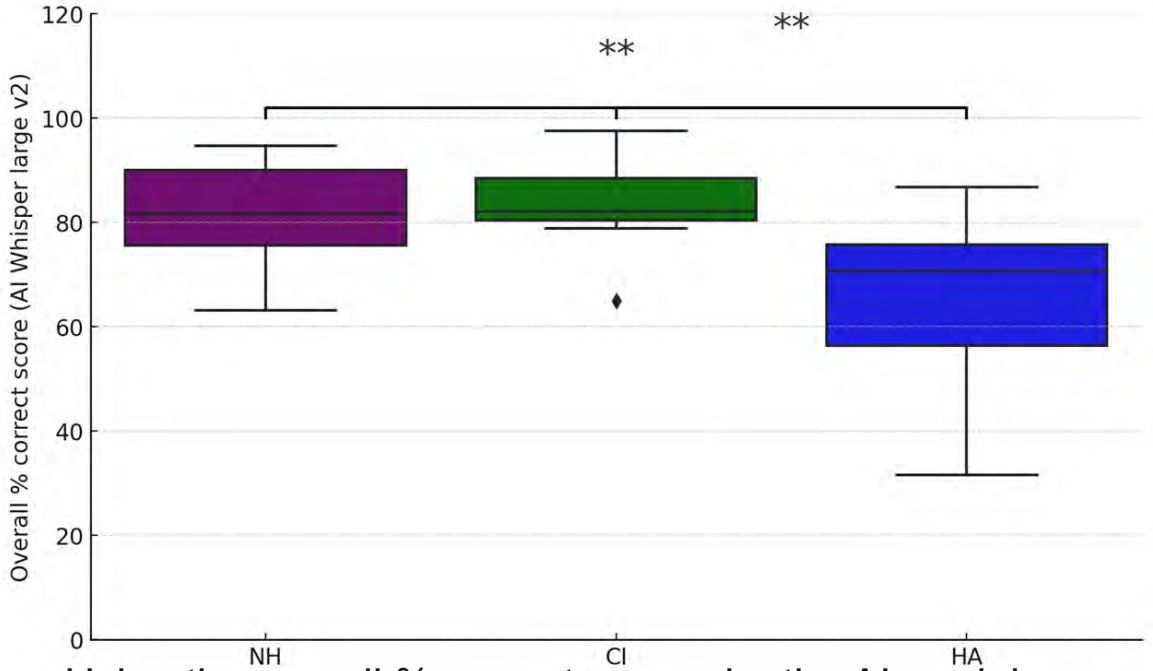
- Treat the AI model as one of the raters.
- High consistency results are observed between the AI model and naʔve listeners within each group of children.
- ICC scores are slightly higher for the NH group than for the other groups, with the HA group exhibiting the lowest ICC scores.

Distinguishing SI Performance In Different Device Groups: AI Transcription vs. Naïve Listener Ratings

- Averaged SIR scores rated by different naïve listeners: Significant differences are observed between children with NH and children fitted with HA.



- SIR rated by research speech pathologists: No significant difference observed among 3 groups of children (p = 0.081)



- Using the overall % correct scores by the AI model:
- Children with HA show significantly poorer SI performance compared to their NH peers, or children with CIs.
- There is no significant difference between NH and CI groups.
- $F(2, 55) = 9.5$, $p<0.001$.

Summary

- This study identified an optimal AI language model for automated transcription of children's speech recordings.
- The AI method demonstrates high accuracy and internal consistency with transcriptions recorded by naïve listeners for both NH and HL groups of children.
- Overall, the validated AI-based method has the potential to revolutionize the assessment of speech intelligibility by using a more efficient and objective approach.

Vicky Zhang

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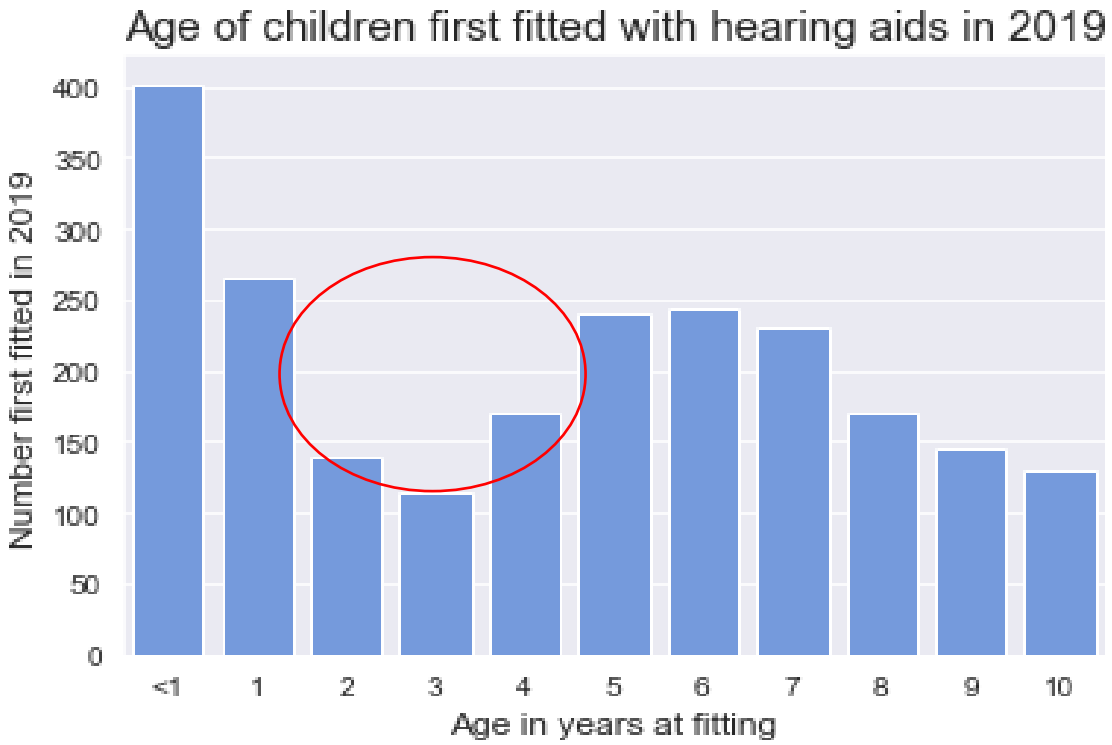
Using AI to detect hearing loss from children's speech

Jessica Monaghan, PhD

Senior Research Scientist

The Problem

- Untreated hearing loss in children can have serious and life-long consequences but is often not picked up until children start school.
- Australian children are screened at birth for hearing loss but prevalence of permanent childhood hearing loss developing subsequently is just as great as that detected at birth
- Currently rely on parents suspecting their child has hearing loss.



The Problem

- Only 30% of children with moderate hearing loss and only 50% of children with severe/profound hearing loss are identified by parents
- Screening pre-school children requires expertise and specialist equipment, not feasible at scale
- A new screening approach is needed to identify hearing loss before children start school

Speech and Hearing Loss

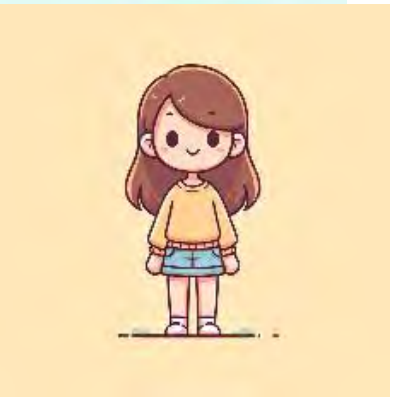
- Speech development is impacted by hearing loss.
- Acquisition of all phonemes is delayed in children with hearing loss.
- Shorter delay for vowels (longer duration and greater energy) than consonants
- Longest delay for fricatives (high frequency consonants)
- Two-year olds with hearing loss three-times as likely to miss final consonants in their speech
- Can AI be trained to detect the ‘signature’ of hearing loss in children’s speech?

Identifying Health Conditions through Speech

- Biomarkers speech have been used to identify health conditions with a high degree of accuracy such as:
  - Chronic pulmonary disease
  - Parkinson's
  - Alzheimer's
  - Depression
  - COVID-19
- There are even some commercially available mobile apps using this kind of technology

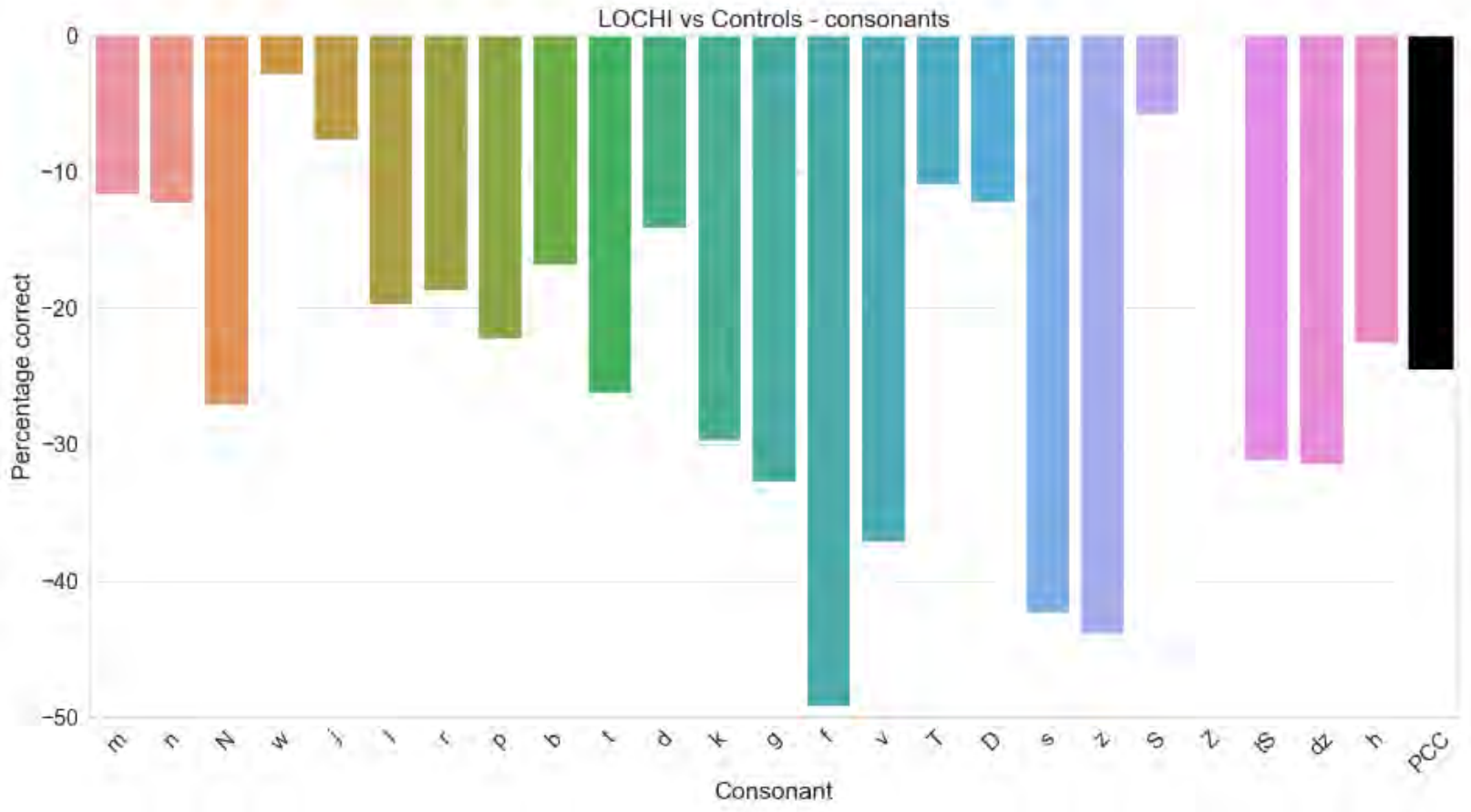
Proof of Concept – Speech Data

- Speech recordings from LOCHI study
- 3 year-old children are prompted with pictures to say 50 words – ‘Elephant’, ‘girl’, ‘lighthouse’
- Sessions were recorded and provide material for audio analysis
- Recordings from 39 children with normal hearing (NH) and 110 children with hearing loss (HL)
- Speech manually isolated



Proof of Concept – Phoneme Production

- Initial analysis looking at transcripts from speech pathologists
- Compared accuracy of phonemes produced for children with HL/NH
- Fricatives f, v, s, z show greatest differences

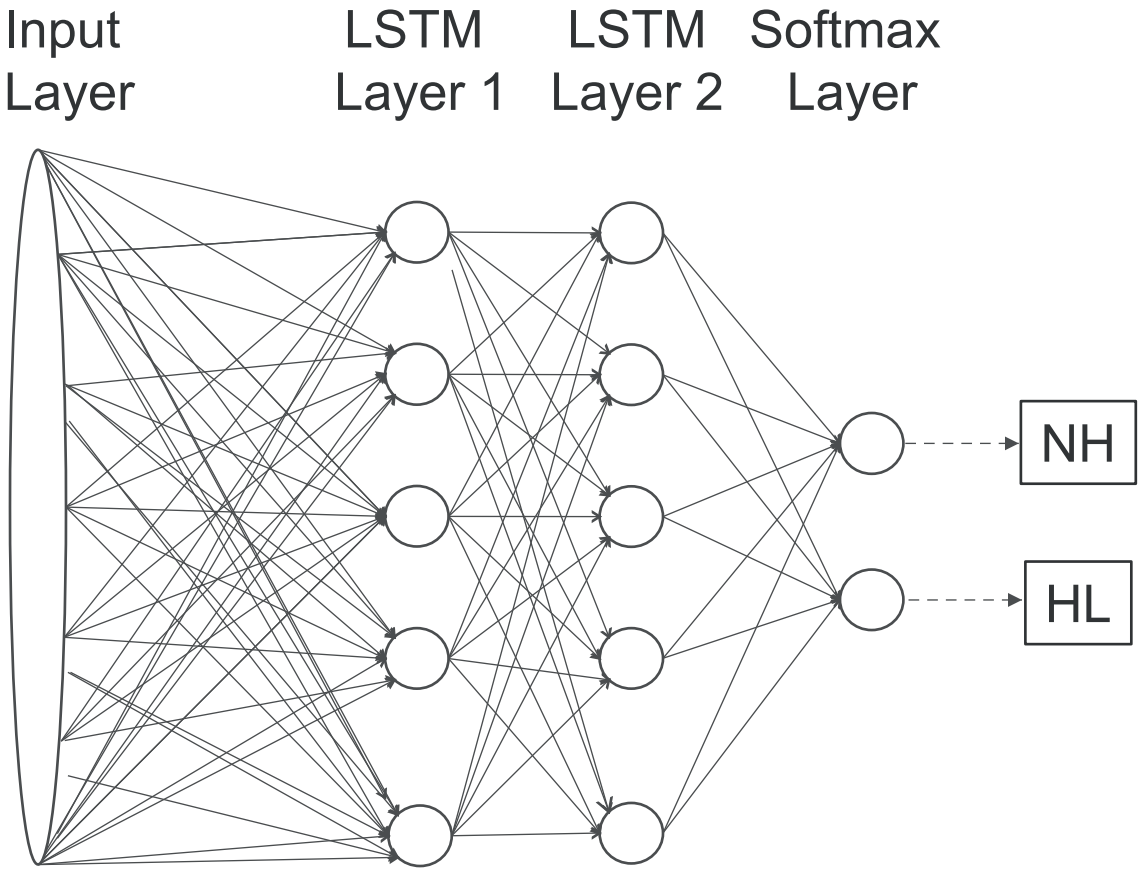


Proof of Concept – Machine Learning

- We wanted to directly analyse the acoustics of the speech
- Convert speech recordings into ‘feature vectors’ which capture different information about the speech, e.g., pitch, formants, shape of the spectrum

Proof of Concept – Machine Learning

- A machine learning model is trained with many examples of the feature vectors corresponding to speech from children with NH and HL
- 96% accuracy for HL, 97% accuracy for NH
- 97% accuracy overall



Proof of Concept Summary

- Proof of concept results very promising with relatively small dataset
- Accuracy higher than most traditional screening approaches
- Indicates that it may be possible to use speech to screen hearing in pre-school children & potentially older age groups
- Opportunity for unobtrusive and convenient screening approach – phone app, smart speaker, website

Discovery: Do parents want this solution?

- We informally interviewed parents of children in the target age range about:
- whether they ever had concerns about speech and hearing
- their experience with the current hearing screening pathway (if any)
- whether they would use the proposed solution

Discovery: Do parents want this solution?

- Problems with hearing and speech very common – most parents had concerns
- Parents often perceived hearing problems as speech problems and did not seek referral for hearing test
- GPs not identifying hearing and speech problems and not referring for hearing test if referring to speech pathologist
- For children who were tested, there was often many months delay before hearing test takes place
- Parents want hearing check before starting school – several compared to vision check of 4 year-olds
- Like the idea of not having to go to GP to check
- Would want app to test speech as well as hearing
- Would want GPs/day-care/early childhood nurses/ Raising Children webpage to recommend an app
- Reputable source important

Discovery: Do parents want this solution?

Quotes about the solutions and whether parents would want the app:

- “Amazing! I can’t imagine anyone saying they didn’t want that.”
- “Amazing. That would be excellent. I think it would be really popular with parents.”
- “OMG 100%”
- “It would save me a GP visit. Parents are busy, working and looking after kids so it’s a time thing.”
- “I think it’s essential there is a hearing screening like the eye test before they start school. Make sure no one slips through the gaps.”

Next Stage – Collecting a Larger Speech Database

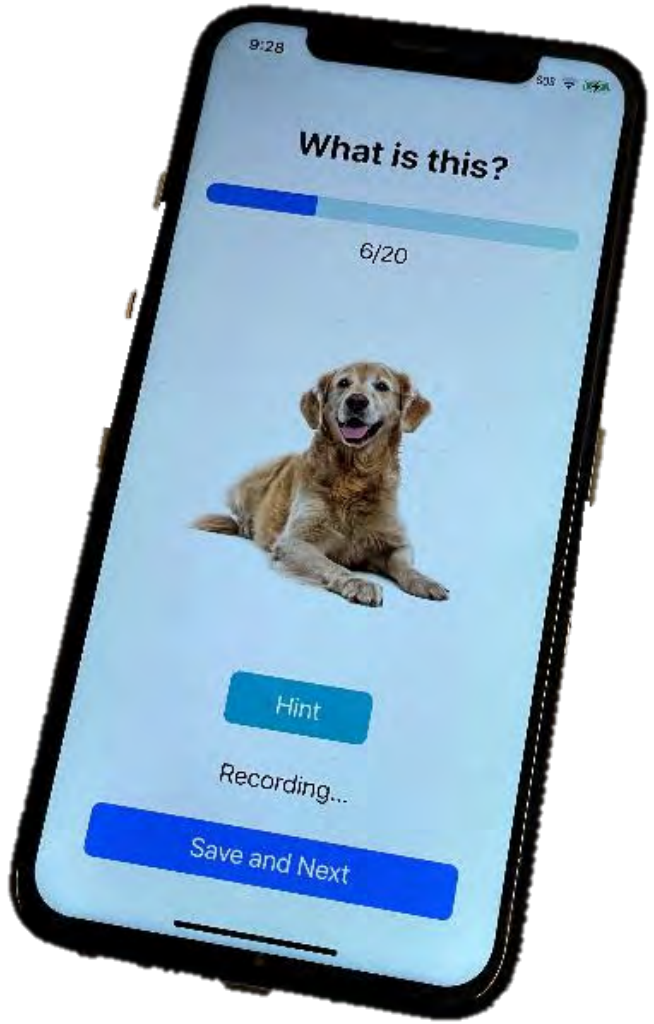
- Received grant funding from the Australia National Health and Medical Research council to develop solution
- Larger and more diverse speech database needed to ensure accuracy is high for all demographics and backgrounds
- We are developing app to collect speech samples from 2½ - 3½ year old children in their homes
- Goal: collect speech samples from up to 1000 children with and without hearing loss across Australia
- This will enable us to train an AI-powered app to deliver immediate, accurate hearing-screening results, and recommendations

OME

- As well as permanent hearing loss children can also experience hearing loss as a result of otitis media with effusion (OME), or ‘glue ear’,
- OME is very common in young children, affecting 80% of Australian children by the age of three Particularly prevalent and often chronic in Aboriginal and Torres Strait Islander children
- We will collect also speech data from children with OME to determine whether it can be detected from speech
- Potential to be a valuable tool for ongoing screening and monitoring

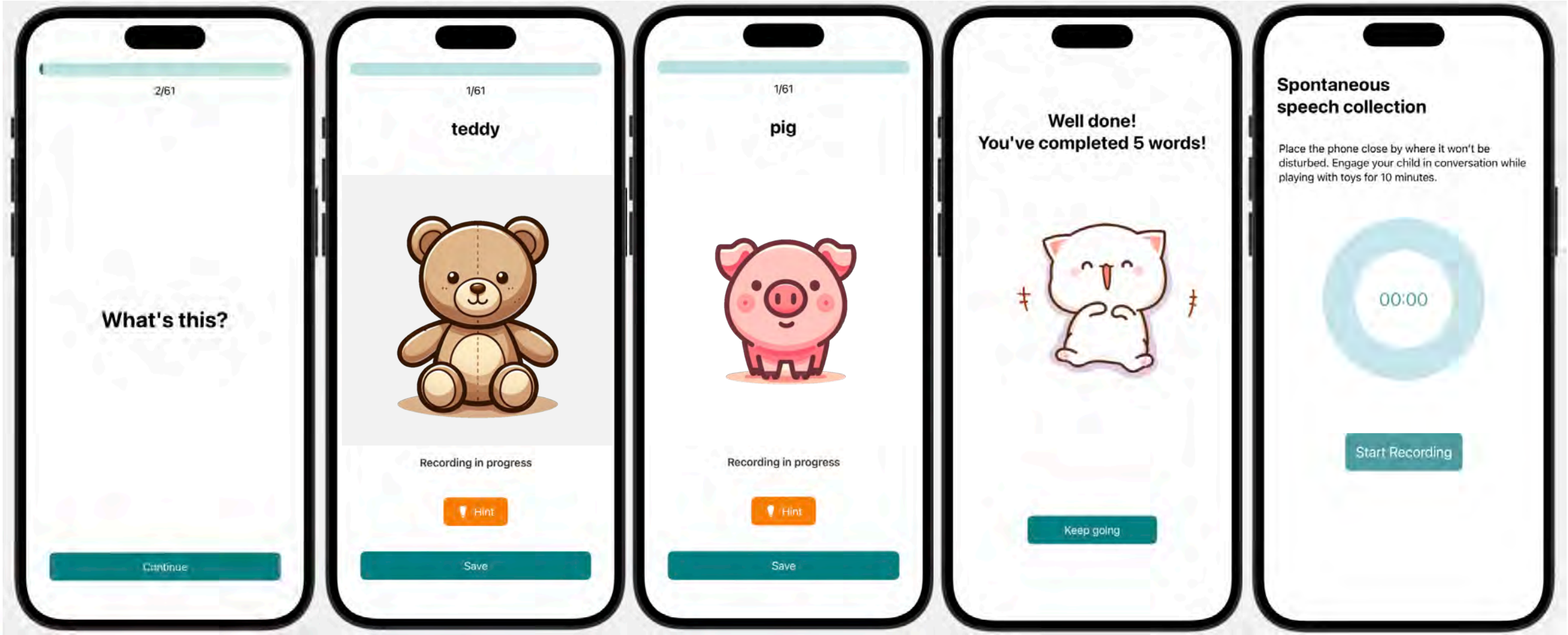
App Piloting

- Parents and children run through the app in front of researchers
- Questions for refinements:
  - Are the app instructions clear enough to guide the parent through the app without guidance from researcher?
  - Are the words familiar to the child?
  - Do the pictures clearly convey the target word to the child?
  - Are the pictures and rewards sufficiently stimulating to sustain the child's attention?
  - Are the parent and child happy with the test duration?
  - The app is refined in between piloting sessions based on user feedback and researcher observations



App Piloting

App Piloting



Piloting Summary

- App was piloted with children with NH and HL and a range of SES
- Overall, the words chosen were familiar and the target word was elicited after prompting
- Some pictures were replaced to improve target
- Video instructions were preferred and easier for parents to follow
- Some parents felt that 60 words was too long so will be reduced to 45-50 with opportunity to pause the test and return later
- Children generally found the app fun and enjoyed the reward images

Summary and Next Steps

- Proof of concept work demonstrates it is possible to identify hearing loss in young children from a sample of their speech using AI
- Potential to be used as a convenient and inexpensive screening tool
- Collecting a large and diverse speech dataset will increase robustness of tool and reduce bias
- Potential to detect OME as well as permanent hearing loss will be tested
- Speech collection app to be released early next year

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Thank you!
Questions?

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