# Novel Diagnostic and Evaluation Tools, presented in partnership with NAL

Joaquin Tomas Valderrama-Valenzuela, PhD and
Vicky Zhang, PhD

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# Novel Diagnostic and Evaluation Tools, presented in partnership with NAL

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# Towards the efficient diagnosis and management of patients with speech-in-noise hearing difficulties and normal audiograms

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*Senior Research Scientist*

12 October 2021

# Disclosures

**Presenter Disclosure:** Financial: Joaquin Tomas Valderrama-Valenzuela is employed by NAL. Non-financial: Joaquin Tomas Valderrama-Valenzuela 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 in partnership with NAL and Continued.

# Structure

- Part 1. Problem statement
- Part 2. Neurophysiological factors underlying speech-in-noise hearing difficulties
- Part 3. Management strategies

# Learning outcomes

After this course, participants will be able to:

1. Identify four important unmet needs of people with normal audiograms and speech in noise hearing difficulties
2. Describe three plausible neurophysiological pathologies underlying these hearing difficulties

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# Part 1 – Problem statement

**We used innovative *design thinking* strategies to identify the unmet needs of people with speech-in-noise hearing difficulties and the clinicians who treat them.**

AJA

Research Article

## Discovering the Unmet Needs of People With Difficulties Understanding Speech in Noise and a Normal or Near-Normal Audiogram

Kiri Mealings,[a] Ingrid Yeend,[a] Joaquin T. Valderrama,[a,b] Megan Gilliver,[a] Jermy Pang,[a] Jason Heeris,[a] and Pamela Jackson[a]

**Purpose:** A proportion of people with a normal audiogram or mild hearing loss (NA-MHL) experience greater-than-expected difficulty hearing speech in noise. This preliminary exploratory study employed a design thinking approach to better understand the clinical pathway and treatment options experienced by this population.
**Method:** Exploratory survey data were analyzed from 233 people with NA-MHL who had consulted a clinician and 47 clinicians. Qualitative analysis was performed on interview data from 21 people with NA-MHL and seven clinicians.
**Results:** Results revealed that noisy environments, such as restaurants, were where many people experienced listening difficulties. Most people with NA-MHL were not offered a treatment option at their audiology appointment, and their satisfaction with the appointment was diverse. Many clients reported frustration at being told that their hearing was "normal." Data from clinicians showed that there is no standard test protocol for this population, and most felt that they did not have adequate training or resources to help NA-MHL clients.
**Conclusion:** This study discusses the research needs regarding the experience of those with NA-MHL, their help-seeking behaviors, and treatment options. Understanding these needs is the first step to designing projects to improve the quality of life of this population.

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# Methods

Q1

We conducted personal interviews and sent online questionnaires to adults with speech-in-noise hearing difficulties and normal hearing or mild hearing loss (NH-MHL population) and their clinicians in order to identify their **unmet needs**.

*Methods*.

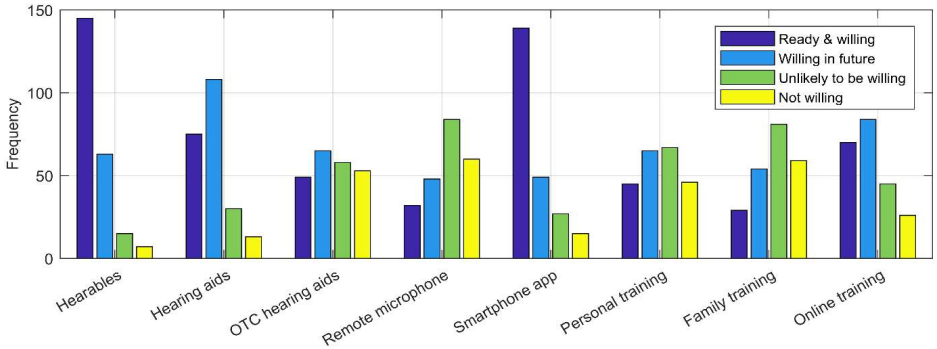
- ✓ Questionnaires from 233 NH-MHL and 49 clinicians
- ✓ Personal interviews from 21 NH-MHL and 8 clinicians

NH-MHL participants reported to struggle communicating in a diverse range of environments


# Relevant findings

Q1

**Hearing performance** was not checked uniformly across participants. While most of them reported to have done an audiogram (94%), only 33% of them did a speech-in-quiet test, and 22% did a speech-in-noise tests.




Most participants were **willing to try** hearing aids and hearables

76% did not receive any type of **treatment** option from their audiologists

79% were not offered a **follow-up** appointment

The *satisfaction with the hearing appointment* of most participants (72%) was in the range of 'partially satisfied' or 'not satisfied'. They complained that (1) they received very **limited help**, advice or treatment options; (2) they found the **cost** of hearing aids prohibitive; (3) the **testing was not sufficient** to describe their difficulty or seemed biased to the interpretation of the audiologist; (4) the options provided **did not solve the problem** or would not help them long-term; (5) they felt that the audiologist was pushing to **sell hearing aids**; (6) they were told they had good hearing but, still, they had issues with their hearing.

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# In their own words…

Q1

*About their hearing difficulties*

*<<I think that other people must be able to filter that background noise and put it down to a lower level so that they can focus on conversation, so I must have a problem because I can't do that.>>*

*Change of behaviour*

*<<It just makes me feel disinclined to go out, and when I do go I tend to avoid restaurants and cafes and anything which is likely to be a crowd of people, unfortunately.>>*

*Impact on their quality of life*

*<<I have to try harder to hear. I can't always hear what they're speaking to me about, or questions. It takes a lot of concentration>>*

*<<People talk about the vibe or atmosphere of a place and I couldn't care less. I just go somewhere where I don't have to yell or be yelled at.>>*

*Increase public awareness*

*<<I don't think many people that I know would voluntarily say "oh well we don't have to go to that place that is too noisy for you, let's go somewhere else". Most people would just say "oh well it's my issue therefore I can come or not come".>>*

*Frustration and anxiety for potential misinterpretation*

*<<I think that people feel I am rude because sometimes you nod and smile at the wrong point because you're not following what's happening.>>*

*What they would love to have*

*<<Something easy and attractive which enhances my hearing. As well it feels unobtrusive.>>*

NAL CONTINUED

# We identified four important unmet needs

Q1

**Need 1.** A way to **improve the communication experience** of adults with speech-in-noise difficulties in groups of people where background noise in combination with high conversational content, and distance between speaker and listener is an issue.

**Need 2.** A way for clinicians to identify- and diagnose NH-MHL adults with self-reported hearing difficulties in order to improve and standardize **assessment protocols**, and also characterize these clients' functional everyday listening difficulties (including listening effort, as well as social and emotional impacts), in addition to their clinical test performance, in order to inform rehabilitation procedures and options.

**Need 3.** A way to **evaluate different treatment options** (including different brands of hearables and online communication training) for solving speech-in-noise difficulties and reducing listening effort in real-world environments in order to provide clinicians with evidence-based information about their effectiveness, and therefore, increase their confidence in addressing client concerns.

**Need 4.** A way to evaluate/understand the population's insights about the **acceptability of technological solutions** for NH-MHL difficulties (e.g. hearables, discreet hearing aids) in order to provide industry with guidelines for creating less stigmatized and more comfortable solutions.

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# Part 2 – Underlying mechanisms

Animal research suggest that **three plausible neurophysiological pathologies** are behind the speech-in-noise hearing difficulties of people with normal or near-normal audiograms

- ✓ Cochlear synaptopathy
- ✓ Auditory nerve demyelination
- ✓ Midbrain maladaptation

# Pathology 1 – Cochlear synaptopathy

Q2

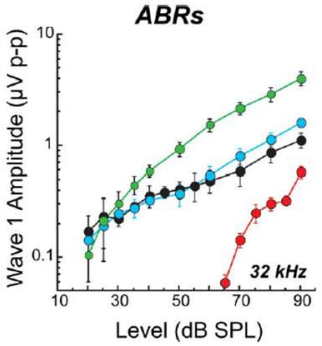
Behavioral/Systems/Cognitive

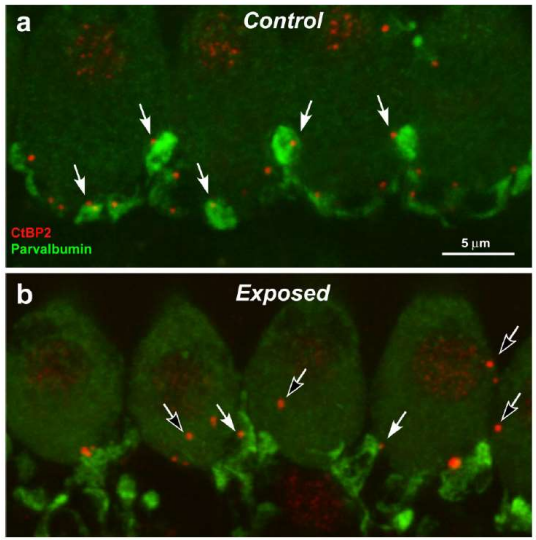
The Journal of Neuroscience, November 11, 2009 • 29(45):14077–14085 • 14077

## Adding Insult to Injury: Cochlear Nerve Degeneration after "Temporary" Noise-Induced Hearing Loss

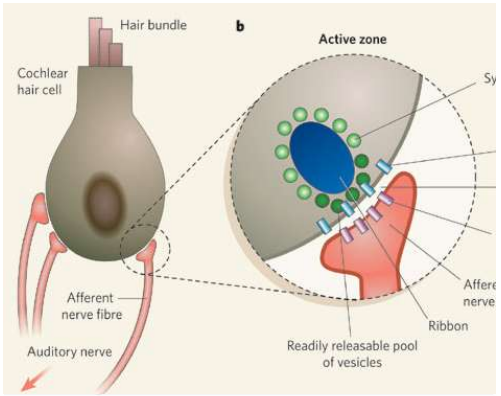
Sharon G. Kujawa[1,2,3,4] and M. Charles Liberman[1,2,4]

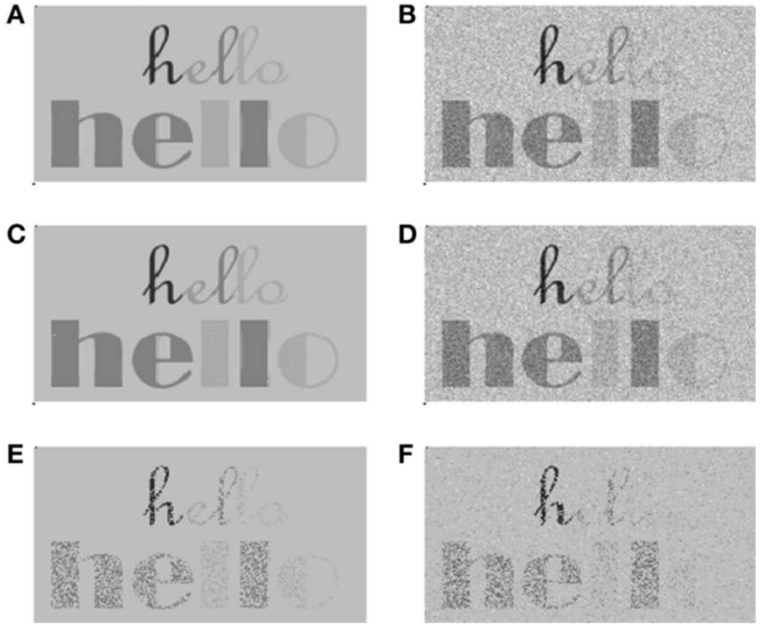
- Anaesthetized mice
- 8-16 kHz noise
- 2 h, 100 dB SPL




Noise exposure disconnected auditory nerve fibres from their inner hair cells, which led to worse neural encoding of sounds




*Lopez-Poveda (2014). Frontiers in Neuroscience, 348.*

# Pathology 2 – Auditory nerve demyelination

Q2

nature COMMUNICATIONS

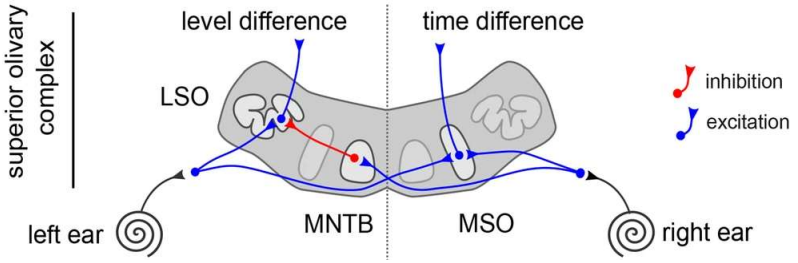
ARTICLE

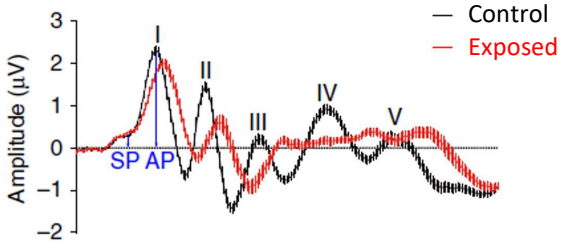
Received 23 Nov 2016 | Accepted 4 Jan 2017 | Published 17 Feb 2017

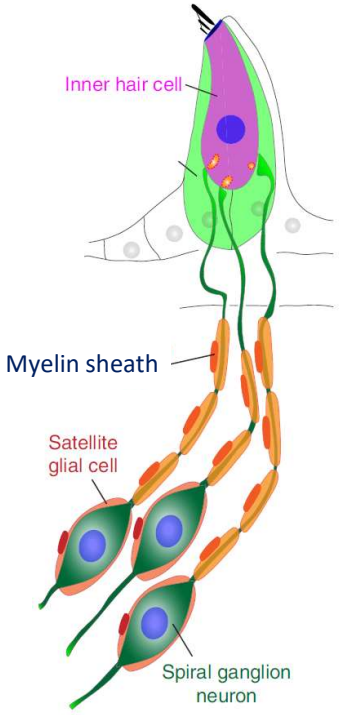
DOI: 10.1038/ncomms14487 OPEN

## Transient auditory nerve demyelination as a new mechanism for hidden hearing loss

Guoqiang Wan[1,2] & Gabriel Corfas[1]

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The transient loss of myelin in the auditory nerve **impairs the precise timing required in binaural hearing**, which is critical because binaural hearing deficits result in poor localization of sounds, poor segregation of speech streams, and **impaired speech-in-noise performance**.

# Pathology 3 – Midbrain maladaptation

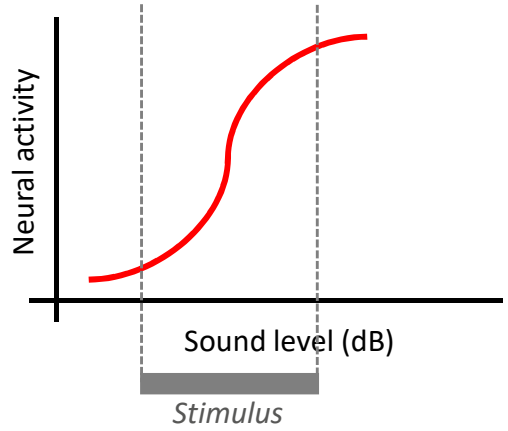
Q2

6430 • The Journal of Neuroscience, June 18, 2008 • 28(25):6430 – 6438

Behavioral/Systems/Cognitive

## Rapid Neural Adaptation to Sound Level Statistics

Isabel Dean,[1] Ben L. Robinson,[1] Nicol S. Harper,[1,2] and David McAlpine[1]
[1]University College London Ear Institute and [2]CoMPLEX, University College London, London WC1X 8EE, United Kingdom




The neural activity **adapts** to the statistics of the stimulus to optimise the neural encoding of acoustic information

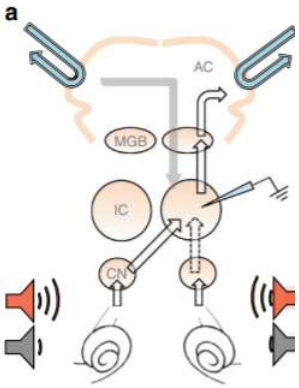
nature COMMUNICATIONS

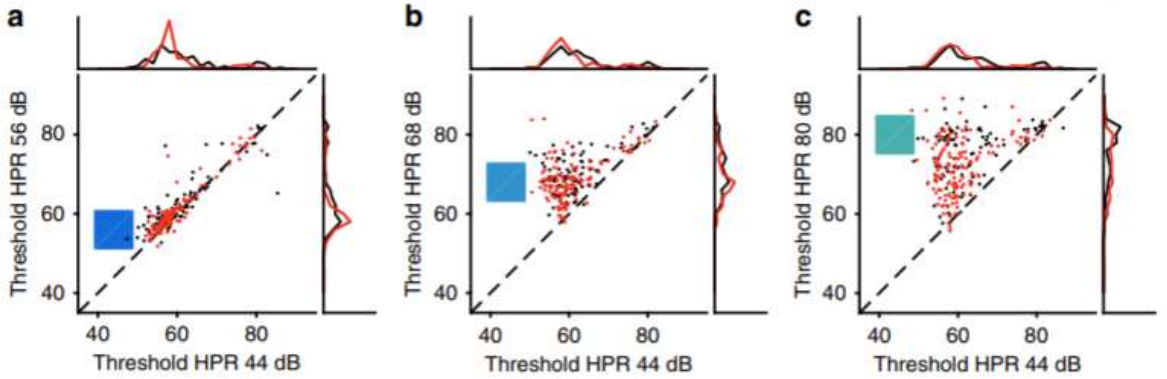
ARTICLE

DOI: 10.1038/s41467-018-06777-y OPEN

## Hidden hearing loss selectively impairs neural adaptation to loud sound environments

Warren Michael Henry Bakay[1,2], Lucy Anne Anderson[1], Jose Alberto Garcia-Lazaro[1], David McAlpine[1,3] & Roland Schaette[1]

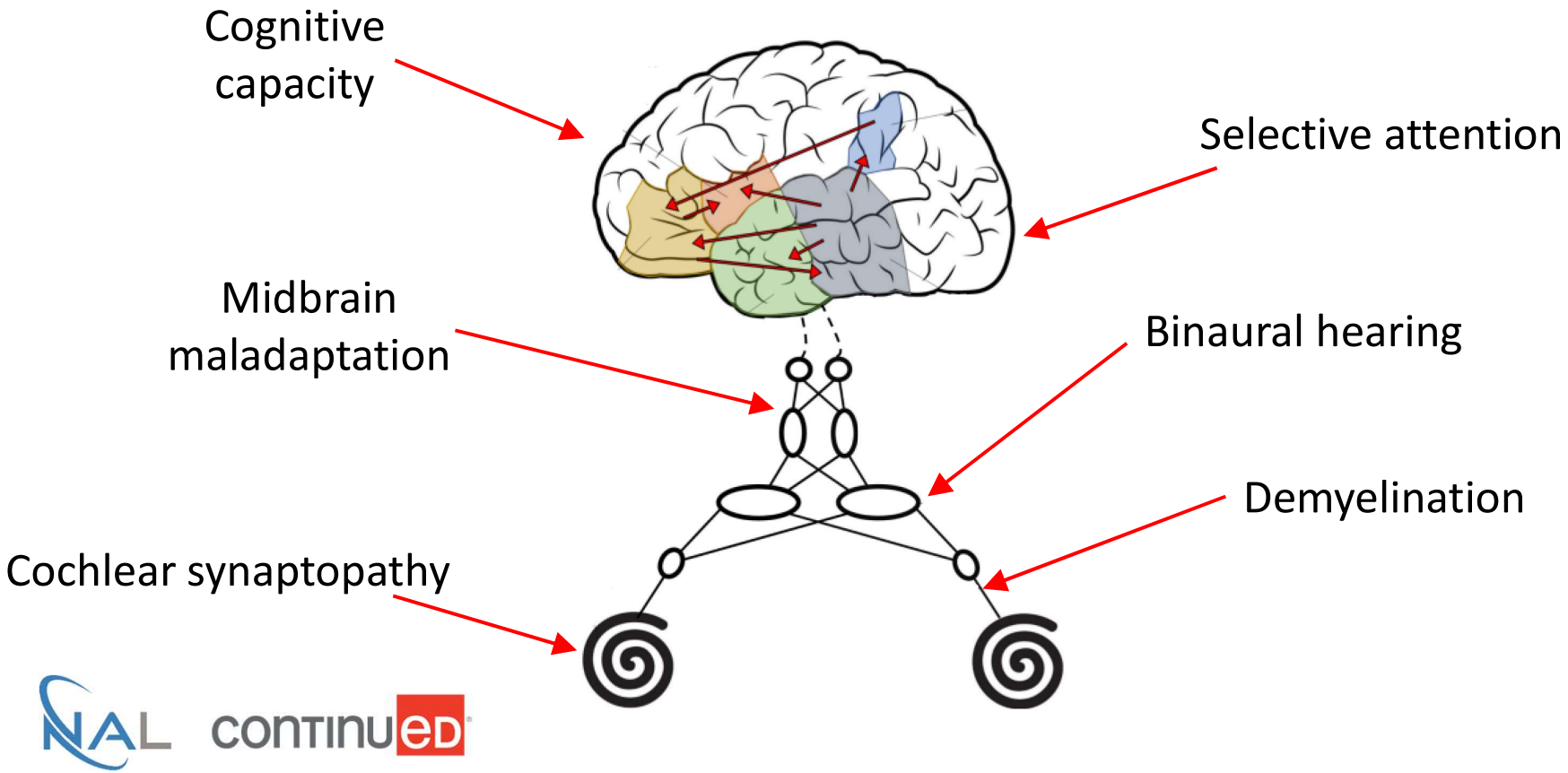



Noise exposure **impairs the neural adaptation** to loud sound environments

# A new diagnostic approach is required

Q2

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# Part 3 – Management strategies

- ✓ Cochlear synapses regeneration
- ✓ The use of low-gain hearing aids

# Cochlear synapses regeneration

SCIENTIFIC REPORTS

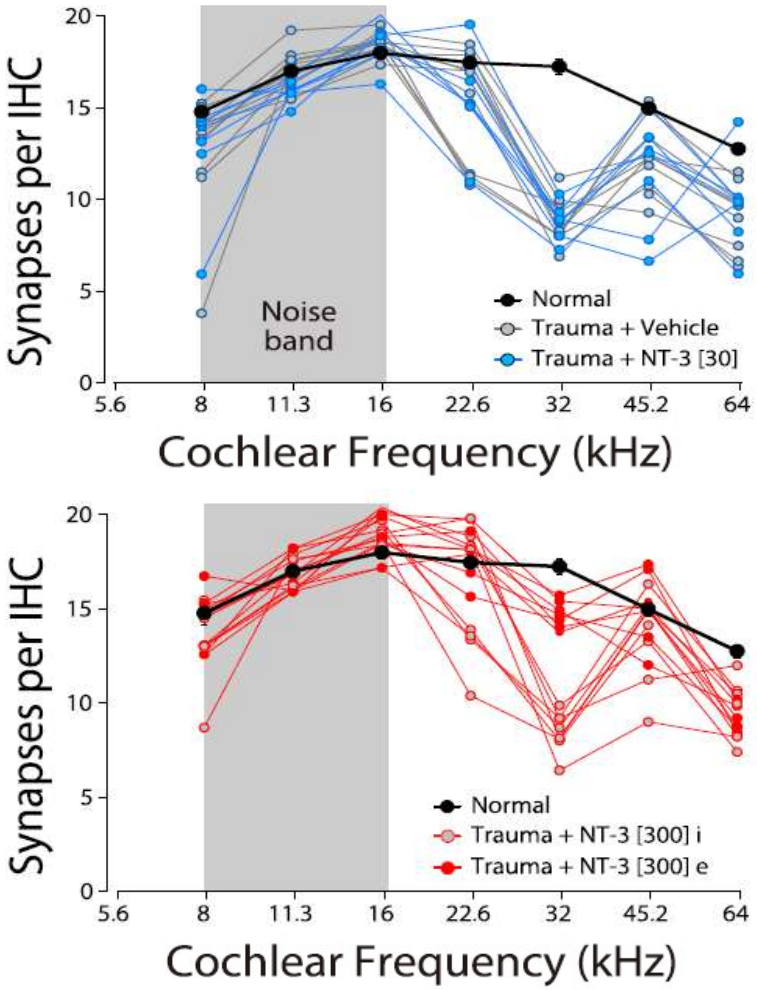
OPEN

## Round-window delivery of neurotrophin 3 regenerates cochlear synapses after acoustic overexposure

Received: 11 January 2016
Accepted: 04 April 2016
Published: 25 April 2016

Jun Suzuki[1,2,3], Gabriel Corfas[4] & M. Charles Liberman[1,2]

Animal studies show promising results of the viability of the use of neurotrophin-3 to **restore the disconnected synapses** between inner hair cells and auditory nerve fibres – however, this technology will require several years (perhaps decades) before it is ready to be used in the clinic.

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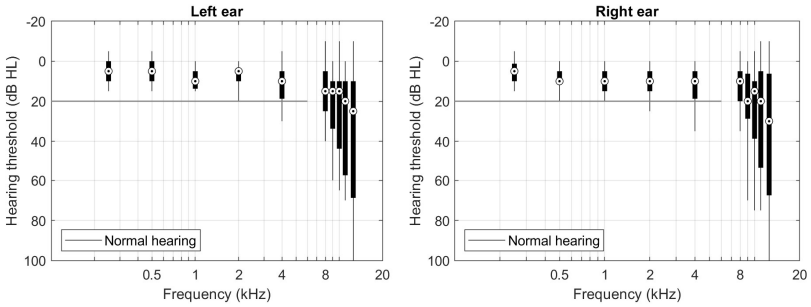
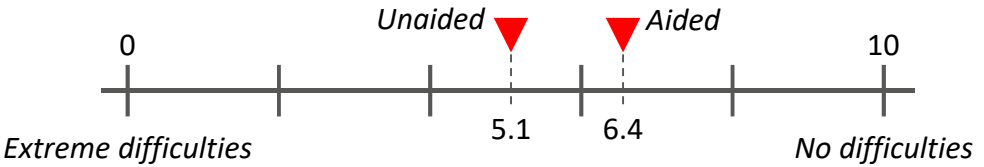
# The use of low-gain hearing aids

13 normal hearing participants (8 female, 31-68 yr) with speech-in-noise hearing difficulties

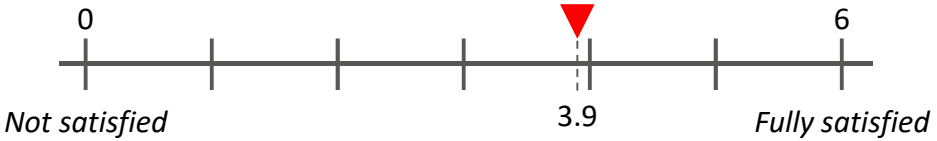


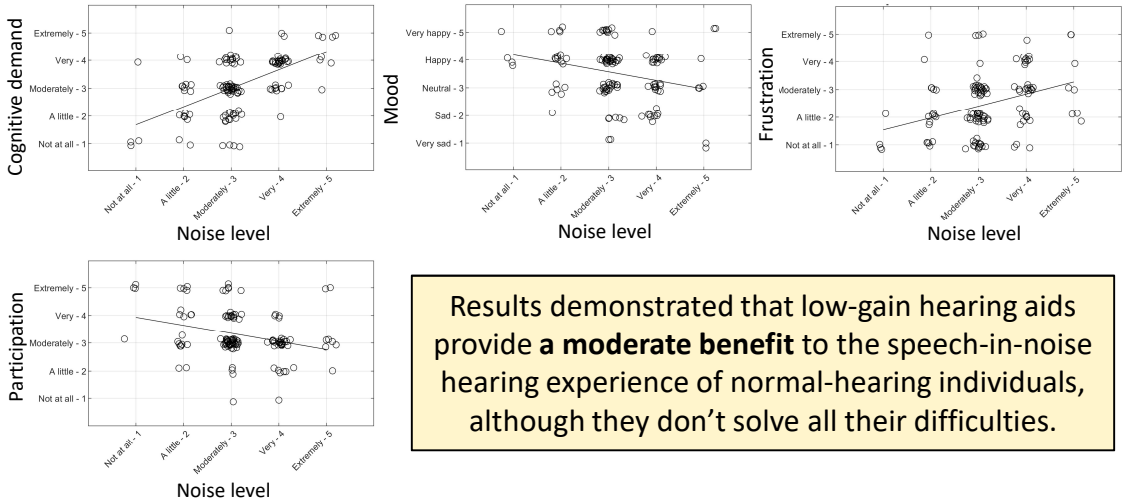

Low-gain (8 dB) gain – we **hypothesized** that the directionality provided by the hearing aids would provide an acoustic advantage that would lead reduce their speech-in-noise hearing difficulties.

**Speech-in-noise hearing**




**Hearing aids satisfaction**




Results demonstrated that low-gain hearing aids provide **a moderate benefit** to the speech-in-noise hearing experience of normal-hearing individuals, although they don't solve all their difficulties.

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# Take-home message

- ✓ There are people with important hearing difficulties insensitive to the audiogram
- ✓ Several neurophysiological mechanisms could be behind these difficulties
- ✓ Low-gain hearing aids may provide a benefit to their hearing experience

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# Thanks to…

Dr Brent Edwards
*NAL Director*

Ms Vivian Sun
*Clinical Audiologist*

Dr Kiri Mealings

Dr Ingrid Yeend

Dr Elizabeth Beach

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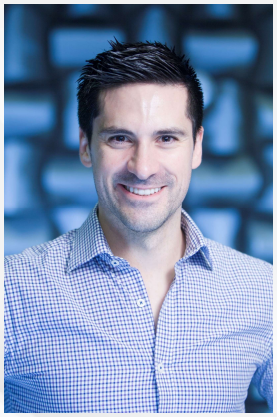

# Q&A


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