Cognition, Audition and Amplification

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Adjunct Professor SUNYAB

Senior Editor Hearing Review

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life-changing technology

Speaker Disclosure

Relevant financial relationships:

Douglas L. Beck Au.D. is an employee of Oticon and receives a salary.

Relevant nonfinancial relationships:

Dr. Beck is a Senior Editor at Hearing Review
Dr. Beck is an Adjunct Clinical Professor at SUNYAB
Dr. Beck is a peer reviewer for multiple publications

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Journal of Otolaryngology-ENT Research

Review Article

Open Access

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Hearing loss and cognition: a discussion for audiologists and hearing healthcare professionals

Abstract and goals

Among researchers, clinicians and patients, there is widespread and growing interest in the relationship between hearing and cognition. The Cognition in Hearing Special Interest Group (SIG) is part of the British Society of Audiology (BSA) and is uniquely positioned to explore the relationship between hearing loss, amplification and cognitive ability and cognitive decline. The multiplicity of emerging reports concerning hearing loss and cognition is increasing rapidly. In light of this vast growth, there is a risk that clinicians may be left uncertain regarding the nature and extent of the emerging evidence linking hearing and cognition. The trickle-down corollary of such uncertainty can negatively impact patient care. Answering challenging questions and disseminating complex information about the

Volume 12 Issue 3 - 2020

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Cognitive Decline, Dementia and MCI

Cognitive Decline…The normal aging process associated with declines abilities such as processing speed, memory, language, visuospatial, and executive function abilities. www.ncbi.nlm.nih.gov

Dementia describes various symptoms such as forgetfulness. Dementia is not a single disease in itself, but a general term to describe symptoms of impairment regarding memory, communication and thinking. www.medicalnewstoday.com most common is Alzheimer's Disease.

Mild Cognitive Impairment (MCI) is the stage between the expected cognitive decline of normal aging and the more serious decline of dementia (Mayo Clinic). 25% of USA over age 65 years have MCI (WashingtonPost.com Jun 2018).

MEASURING COGNITION (big problem!)

We are not able to thoroughly or accurately measure human cognition (Rowe and Healy, 2014).

Cognitive abilities cannot be directly observed, they must be inferred (Boogert & Madden, 2018).

The ability to predict overall cognitive ability based on a specific sub-skill is not a proven attribute of any cognitive measure.

Lin, Yaffe, Xia
Hearing Loss and Cognitive Decline in Older Adults
JAMA 2013

1,984 older adults no cognitive impairment per the Modified MMSE.

1162 hearing loss (>25 dB) and 822 WNL

6 years later, people with hearing loss declined on the MMMSE (41%)

The rates of COGNITIVE DECLINE and the RISK of COGNITIVE IMPAIRMENT were linearly

associated with severity of hearing loss.

SUMMARY:

Hearing Loss is independently associated with accelerated cognitive decline and cognitive impairment in community dwelling older adults.

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What effect does hearing loss have on cognitive performance?

Even WNL, a reduction in SNR can reduce a person's memory for spoken words, and even more so for people with hearing loss.

As hearing ability decreases WITHIN NORMAL from "excellent" to "normal"

specific measurable aspects of cognition decrease (per the MMSE).

Gaeta, Azzarello, Baldwin (2019)

Can we intervene on the relationship between hearing loss and cognition?

Amieva et al. (2015) reported (n=3670) prospective population-based studies assessing the association between self-reported hearing loss and cognitive trajectories over a 25-year period for three groups:

1- Those w/reported hearing loss but no hearing aid use (“unaddressed hearing loss”),

2- Those w/reported hearing loss and hearing aid use, and

3- Those that reported no hearing loss.

CONCLUSION: Addressing one’s hearing loss by use of hearing aids may slow cognitive decline by alleviating communication difficulties and improving mood and social interactions.

Deal et al. (2017) 40 adult participants in an RCT (aged 70-84 years) with untreated, adult-onset, bilateral, mild-to-moderate hearing loss who did not have dementia. Participants were randomized into either rehabilitation with hearing aids or rehabilitation without hearing aids. In the WITH HA group, there was an improvement in the cognitive domain score for memory. In the WITHOUT HA group, no change or worse function.

Due in 2022/3 ACHIEVE study.

Can we intervene on the relationship between hearing loss and cognition?

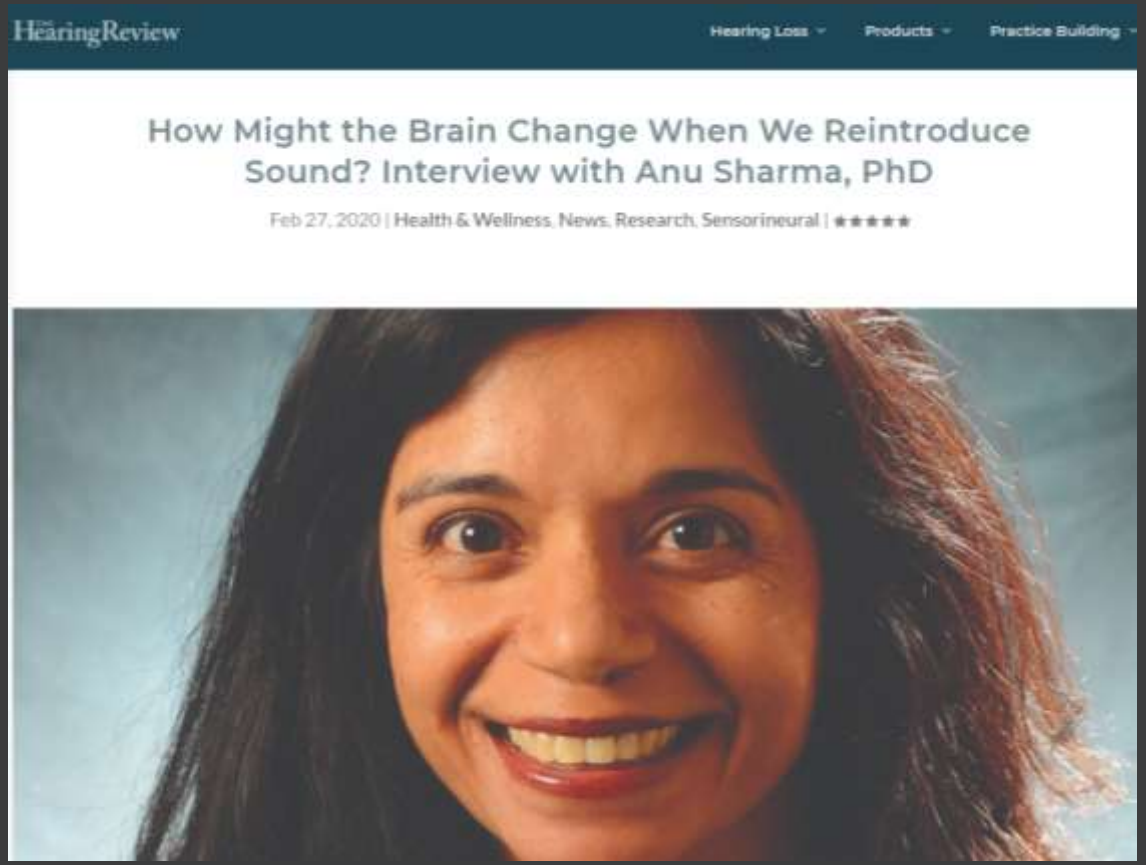
Amieva & Ouvard (2020):

"…the available data globally support the hypothesis that hearing aids have a positive impact on long-term cognition in older adults suffering from hearing loss…"

The protective effects of hearing aid use may be hardly observable in clinical trials involving small samples of participants.

The available data globally support the hypothesis that hearing aid use positively impacts long-term cognition in older adults suffering from hearing loss, but definitely calls for more research to ascertain such a statement and provide more information on the delay at which the benefits can be observable, the daily frequency of hearing aids use required, and many other questions that remain fully open.

February 27, 2020



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Glick & Sharma (2020):
ARHL is associated with cognitive decline and functional and structural brain changes. They determined that multiple deficits were improved after 6 months of daily hearing aid use, providing striking evidence of compensatory cortical neuroplasticity. They noted a reversal in cross-modal re-organization, and speech perception improvements and gains in cognitive performance.

After 6 months with well-fit hearing aids, reversal of the cross-modal recruitment of auditory cortex for visual processing in the ARHL group occurred and coincided with gains in

auditory speech perception abilities

improvements in global cognitive function,

executive function,

processing speed,

and visual working memory performance.

USA mortality timeline

In 1700	average age at death	35 years
In 1800	average age at death	42 years
In 1900	average age at death	49 years
In 2020	average age at death	79 years

Fun Fact: Medicare/Social Security

National council on aging (April 23, 2021) www.ncoa.org

- 80% of adults > 65 years have at least one chronic condition
- 68% of adults > 65 years have two or more

Validation of a Cognitive Screening Tool for Hearing-Impaired Older Adults. University College of London (UCL) Doctoral Thesis by Nattawan Uloomprurkporn. 2021

Dementia usually starts in people age 65 years and older.

One-third of people over the age 65 have hearing loss.

Older adults with hearing loss are twice as likely to develop dementia, compared to those WNL.

Early and accurate screening...is even more important.

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Ten most chronic conditions for adults 65 years+
(April 2021)

www.ncoa.com

Hypertension	58%
High Cholesterol	47%
Arthritis	31%
Ischemic/Coronary heart disease	29%
Diabetes	27%
Kidney Disease	18%
Heart Failure	14%
Depression	14%
Alzheimer's and Dementia	11%
Obstructive Pulmonary Disease	11%

HEARING LOSS
44%

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AUDITORY PROBLEMS

52%

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37
million
people
26
million
people

Beck, DL, Danhauer JL, Abrams HB, et al. Audiologic considerations for people with normal hearing sensitivity yet hearing difficulty and/or speech-in-noise problems. Hearing Review. 2018;25(10) [Oct]:28-38.

Audiologic Considerations for People with Normal Hearing Sensitivity Yet Hearing Difficulty and/or Speech-in-Noise Problems

Why do so many people with "normal hearing" report that they have hearing problems?

By DOUGLAS L. BECK, AuD; JEFFREY L. DANHAUER, PhD; HARVEY B. ABRAMS, PhD; SAMUEL R. ATCHERSON, PhD; DAVID K. BROWN, PhD; MARSHALL CHASIN, AuD; JOHN GREER CLARK, PhD; CHRISTINE DE PLACIDO, PhD; BRENT EDWARDS, PhD; DAVID A. FABRY, PhD; CAROL FLEXER, PhD; BRIAN FLIGOR, ScD; GREGORY FRAZER, PhD, AuD; JASON A. GALSTER, PhD; LAURA GIFFORD, AuD; CAROLE E. JOHNSON, PhD, AUD; JANE MADELL, PhD; DAVID R. MOORE, PhD; ROSS J. ROESER PhD; GABRIELLE H. SAUNDERS, PhD; GRANT D. SEARCHFIELD, PhD; CHRISTOPHER SPANKOVICH, PhD, AuD, MPH; MICHAEL VALENTE, PhD, and JACE WOLFE, PhD

FEB 2019 JOENTR Beck & Danhauer

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Amplification for adults with hearing difficulty, speech in noise problems - and normal thresholds

Keywords: amplification, adults, hearing difficulty, speech, normal thresholds, signal-to-noise ratios

Volume 11 Issue 1 - 2019

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Introduction

Most physicians and audiologists know that hearing difficulty (HD) and/or the inability to understand speech-in-noise (SIN) are chief complaints for some 38 million people with sensorineural hearing loss (SNHL) in the United States. These are neither trivial nor rare complaints. Rather, they represent a nearly universal descriptor of the most typical auditory complaints of most people with SNHL

Beck, Weinstein, Harvey. Jan 2016, Hearing Review

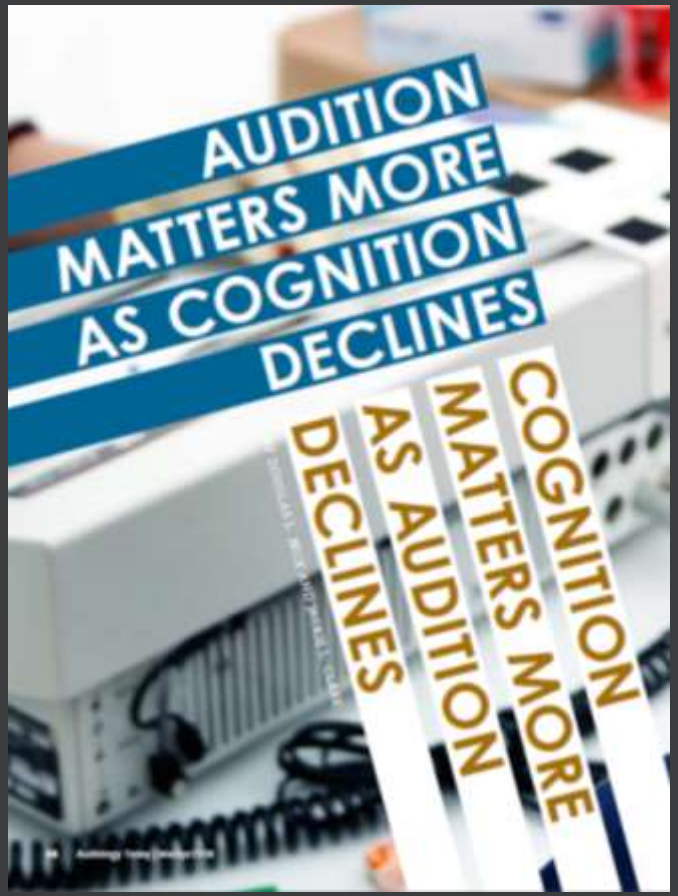
The idea that audiology, cognition, and psychology overlap is not new.

Myklebust 1949

Clinical psychology has an important contribution to make in audiology. In reality, one cannot readily separate cognition, language, and audition. These processes are intimately interwoven and interdependent.

The most difficult and challenging dilemma is to determine how much of a communicative disorder originates with hearing loss, versus how much is based in other causes.

Beck & Clark
March/April 2009
American Academy of Audiology



2014

On the Importance of Working Memory with Regard to Hearing, Listening, Amplification, Prodigies, and More

Tweet Like 3

April 20, 2014 Editorials

Opinion Editorial by Douglas L. Beck, AuD

Beck and Flexer (2011) coined "Listening Is Where Hearing Meets Brain" to emphasize the fact that attributing meaning to sound (i.e., listening) is the more important and significant goal from the patient's perspective, than simply hearing or perceiving sounds. Indeed, patients want to be able to make sense of sound, not just hear it. Of course, it *almost* goes without saying that rule number one is they must hear it with an excellent signal-to-noise ratio in order to listen to, and process it. Indeed, we have to make all speech sounds audible for maximal listening…but let's assume we've done an excellent job of amplifying all the sounds and we've validated and verified our fitting…now let's talk about what happens *after* the full complement of sound reaches the brain.

Livingston, Huntley, Sommerland et al....Lancet Vol 396, Issue 10248, Pgs 413-446, Aug 8, 2020

Dementia: 60% non-modifiable (DNA) and 40% potentially modifiable

12 modifiable risk factors for dementia.

Less education, hypertension, hearing impairment, smoking, obesity, depression, physical inactivity, diabetes, low social contact, excessive alcohol consumption, TBI, air pollution

HEARING LOSS is 1/5th of all modifiable factors with a PAF of 8.2%

Depression	3.9%
Social Isolation	3.5%
TBI	3.4%

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Age Related Hearing Loss and the Development of Cognitive Impairment and Late-Life Depression: A Scoping Review Sharma, Chern, Golub Seminars in Hearing 42(1) 2021

GROUP DATA vs PERSONAL DATA/RISK???

Men are generally taller than women.

The risk of dementia over a 12-year period was 1.9 times higher for those with **MILD** hearing loss as compared to those WNL (Lin, Metter, O'Brien et al 2011 ArchNeurol).

Hearing loss is associated with depression and cognitive impairment.

ARHL is a potential risk factor for cognitive impairment, dementia and late-life depression.

ARHL is prevalent and is highly treatable.

ENT & Audiology News
March 2021
Cognitive Psychologist Boaz M. Ben-David

- Cognitive performance is intertwined with speech perception and hearing.
- Cognitive ability has a large effect in speech perception.
- Hearing status affects cognitive reserve.
- When assessing speech processing, we need to consider cognitive ability.
- When assessing cognitive ability, we need to consider auditory & visual sensory input.

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The REAL challenge…

Beyond hearing.

Improve the opportunity

For listening success!

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Addressing the Hearing Needs of People with Dementia

Piers Dawes PhD (in ENT & Audiology News March 2021)

Untreated hearing loss exacerbates the impact of dementia.

Hearing Care should be person-centered, tailored to the needs of the individual and should involve multidisciplinary professionals.

Hearing professionals should receive training in dementia awareness.

“IT IS TIME FOR HEARING PROFESSIONALS TO ADDRESS THE GLOBAL DEMENTIA CHALLENGE.”

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Irace, Chern & Golub. ENT & Audiology News March 2021

Hearing loss and cognition: Something to think about

> If ARHL goes untreated, it may result in social isolation, loneliness, loss of productivity and autonomy, depression as well as cognitive decline. A growing body of evidence linking hearing loss to the development of dementia has substantially increased interest in promoting adoption of hearing aids.

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Hearing Science

Listening Is Where Hearing Meets Brain...in Children and Adults

Research continues to find close links for cognition and hearing

BY DOUGLAS L. BECK, AuD, AND CAROL FLEXER, PhD

Hearing is a sense; listening is a skill. Listening can be thought of as applying meaning to sound:

Dogs have extraordinary hearing. The literature varies on the actual spectral response of canine hearing across breeds, but in general, it appears to be from about 50 Hz to 40,000 Hz. In practical terms, dogs hear roughly one octave more than humans—thus allowing dogs to hear annoying dog thoughts, and more. Indeed, *listening* can be thought of as applying meaning to sound, allowing the brain to organize, establish vocabulary, develop receptive and expressive language, learn, internalize, and indeed ... *listening is where hearing meets brain*. Extraordinary listening (much like language) is uniquely human.

It’s all about the brain…

we can make anyone hear,
we can’t make anyone listen.

To be

at the top of the

food chain depends more on

LISTENING than HEARING

JAAA, 2011 R. Wilson: Clinical experience with the Words-In-Noise Test on 3,430 veterans: Comparisons with PT Thresholds and WRS in Quiet.

1- Speech in quiet does not predict speech in noise.

2- SIQ and SIN different domains of auditory function.

3- STRESS TEST (i.e., SIN)

Goyette, Crukley & Galster. AJA March 2018
The Effects of Varying Directional Bandwidth in
HA Users' Performance and Speech in Noise Performance

An established goal of modern hearing aids is to improve speech understanding for the wearer. This goal is best achieved by improving SNR.

In occupations with hearing critical tasks…SIN may be more important than thresholds. This study involved 5,487 people…

RESULTS

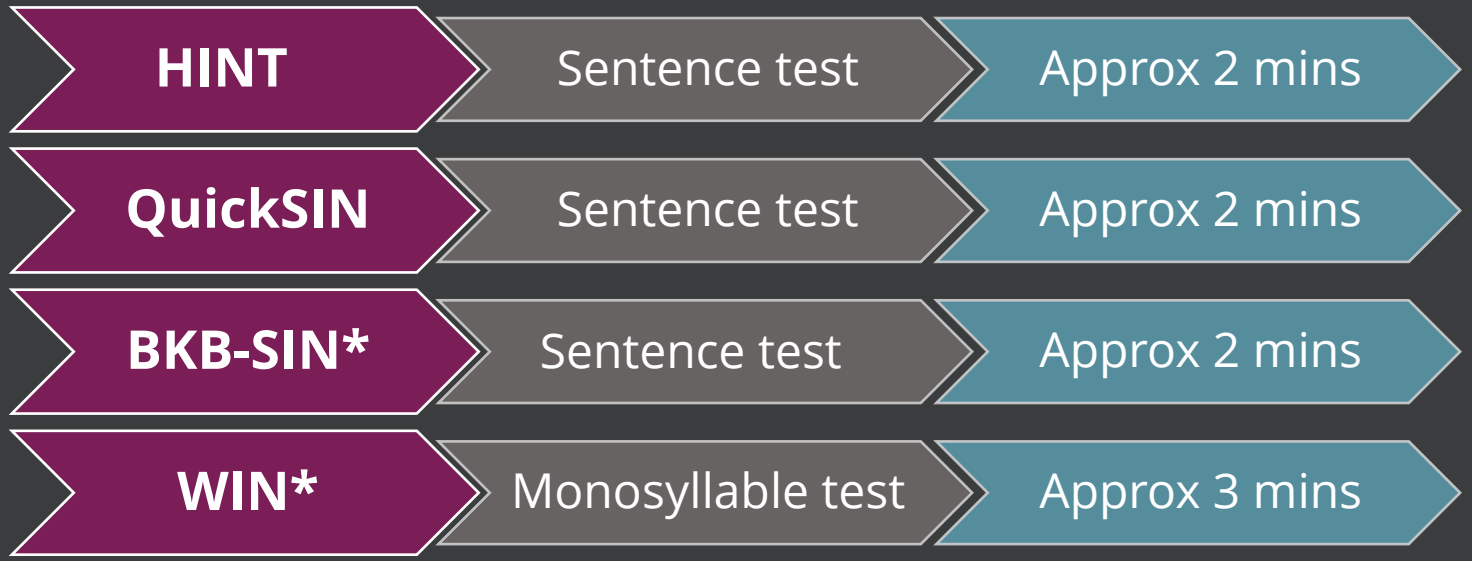
Suggest that details of the audiogram are a “relatively insensitive predictor of performance in SIN tasks…”

50 years of SIN testing

Carhart & Tillman (1970) advocated speech-in-noise testing to be part of standard test battery.

*(pediatric application per Andrea Hillock-Dunn AO Sept 7, 2015)
Other Pediatric Speech in Noise tests: SPIN HINT-C
McArdle JAAA 2006

Speech-in-Noise Test Times



(rounded up by DLB)

May/Jun 2019 www.audiology.org

FREE

A Two-Minute Speech-in-Noise Test: Protocol and Pilot Data

By Douglas L. Beck | Lauren Benitez

Appears in Audiology Today May/June 2019

In this article, we demonstrate a simple protocol that can rapidly determine speech-in-noise thresholds and can be used to validate and verify important differences between unaided and aided responses.

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SPEECH IN NOISE
Overview and Protocol

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What is the single largest complaint we (HCPs) hear from people with SNHL and from people with hearing aids?

Unfortunately,

SPEECH and NOISE

are the same thing.

It’s just a matter of who you want to pay attention to.

Beck, DL. & Le Goff, N. (2017): Oticon Opn: Speech-In-Noise Test Results. Hearing Review September/October

Hearing is?
“perceiving sound.”

Listening is?
“comprehending sound.”

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It ain’t all about hearing!

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“The first 75 years of audiology were about hearing, the next 75 years will be about listening”

Beck 2017

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It’s all about the brain…

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People live in a world where cognition, attention, intention, vocabulary, processing speed and processing ability, memory and hearing interact and each plays a critical role in listening.

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Research continues to find close links for cognition and hearing

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Predicting SIN Deficits from the Audiogram
E&H May 2019 Shub, Makashay & Brungart

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RESULTS
Suggest that details of the audiogram are a “relatively insensitive predictor of performance in SIN tasks…”

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Harvey Dillon, in HEARING AIDS 2012
page 7, Boomerang Press

As hearing loss increases,
the required SNR increases.

SNR-50 = SRT-50

The SNR-50 reflects the SIN level at which the listener correctly identifies 50% of the words.

For example, an SNR-50 of 5 dB means the listener correctly repeats 50% of the words when the SNR is 5 dB.

Likewise, an SNR-50 of 12 dB, means the listener requires an SNR of 12 dB, to achieve 50% correct.

B. Taylor and G. Mueller:
FITTING AND DISPENSING HEARING AIDS 2nd ed. 2017
Page 297

For every 1 dB improvement in SNR, the patient benefits 7-10% WRS.

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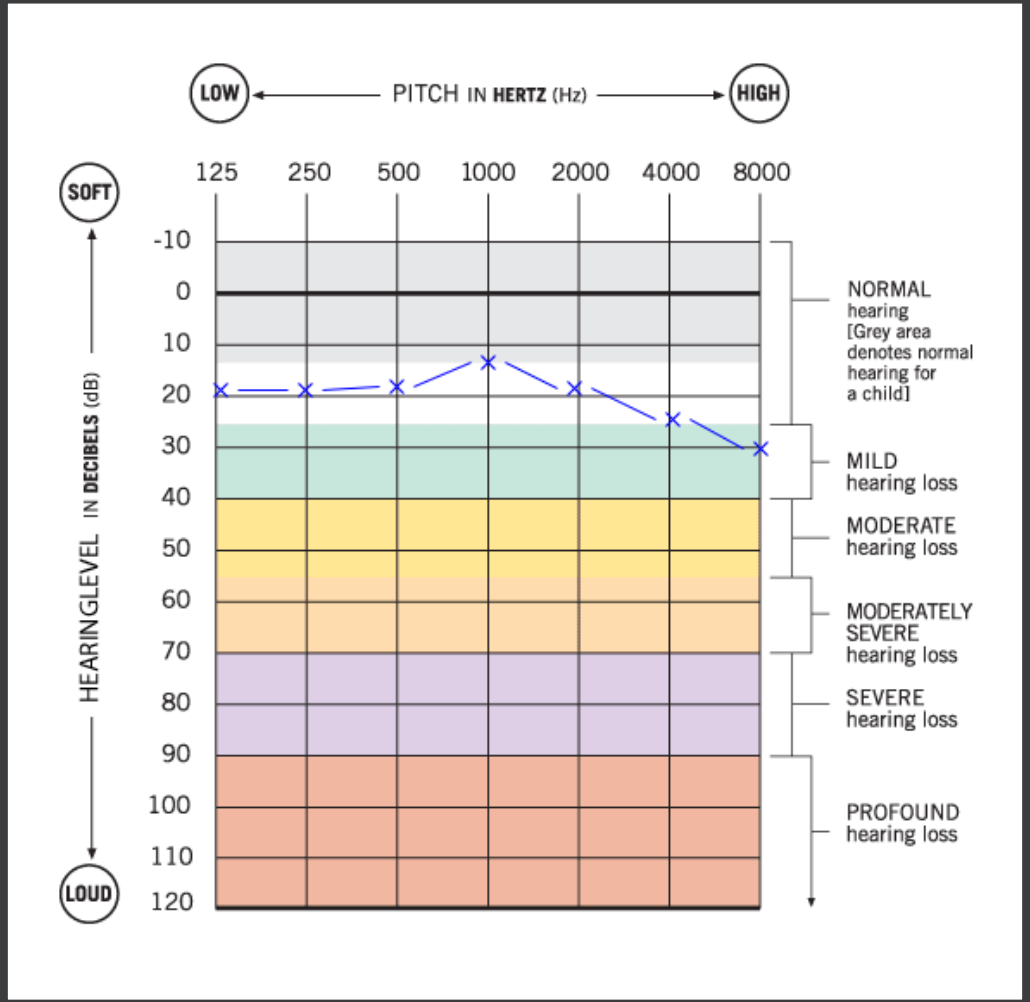
Harvey Dillon
2nd Edition of HEARING AIDS
2011/2012

For every 10 dB of hearing loss 3 dB increase in SNR is required to MAINTAIN intelligibility.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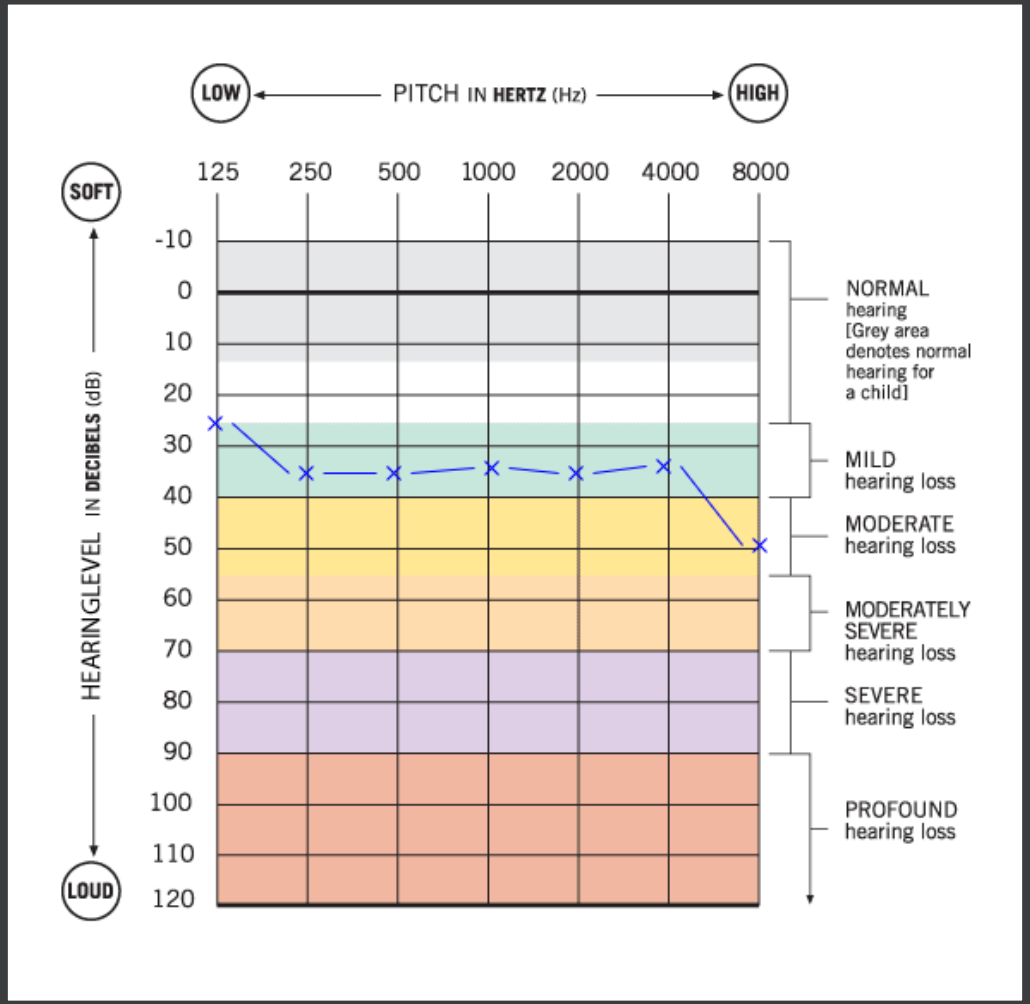
NORMAL hearing [Grey area denotes normal hearing for a child]
MILD hearing loss
MODERATE hearing loss
MODERATELY SEVERE hearing loss
SEVERE hearing loss
PROFOUND hearing loss

oticon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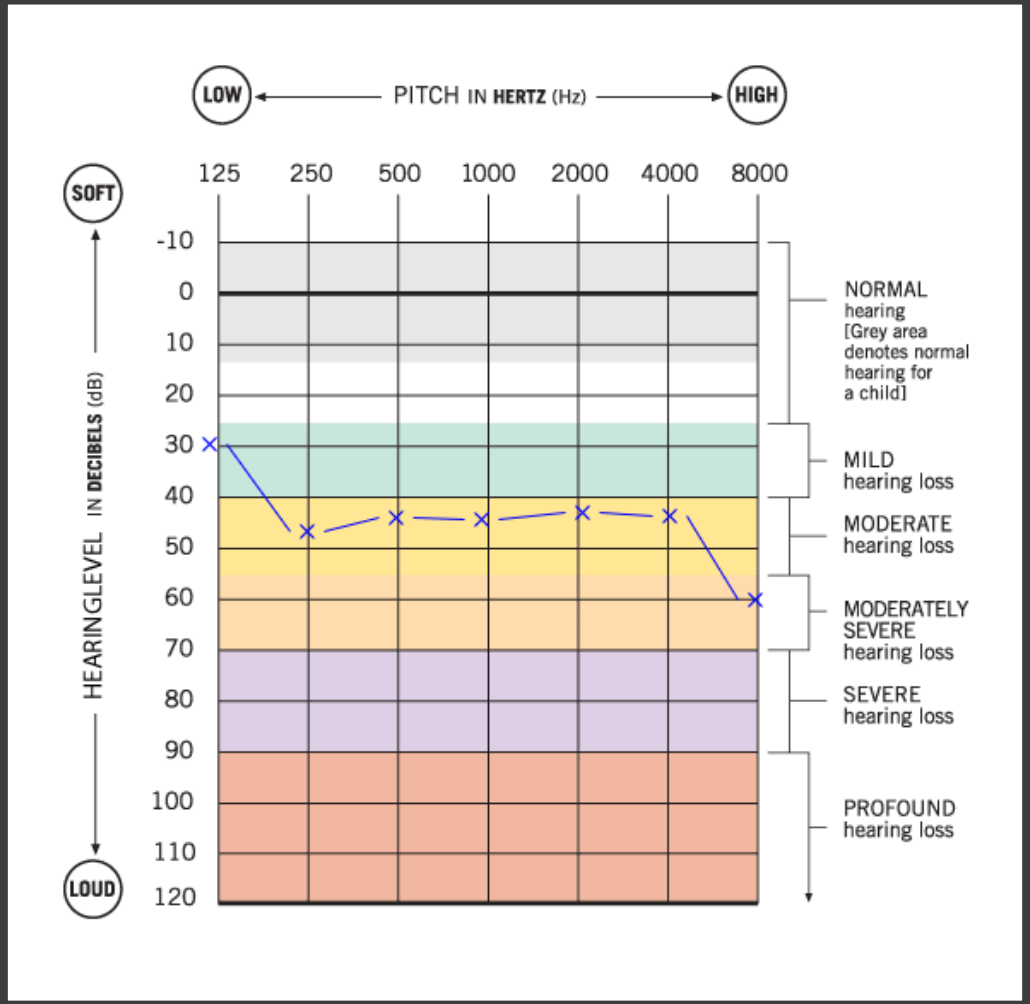
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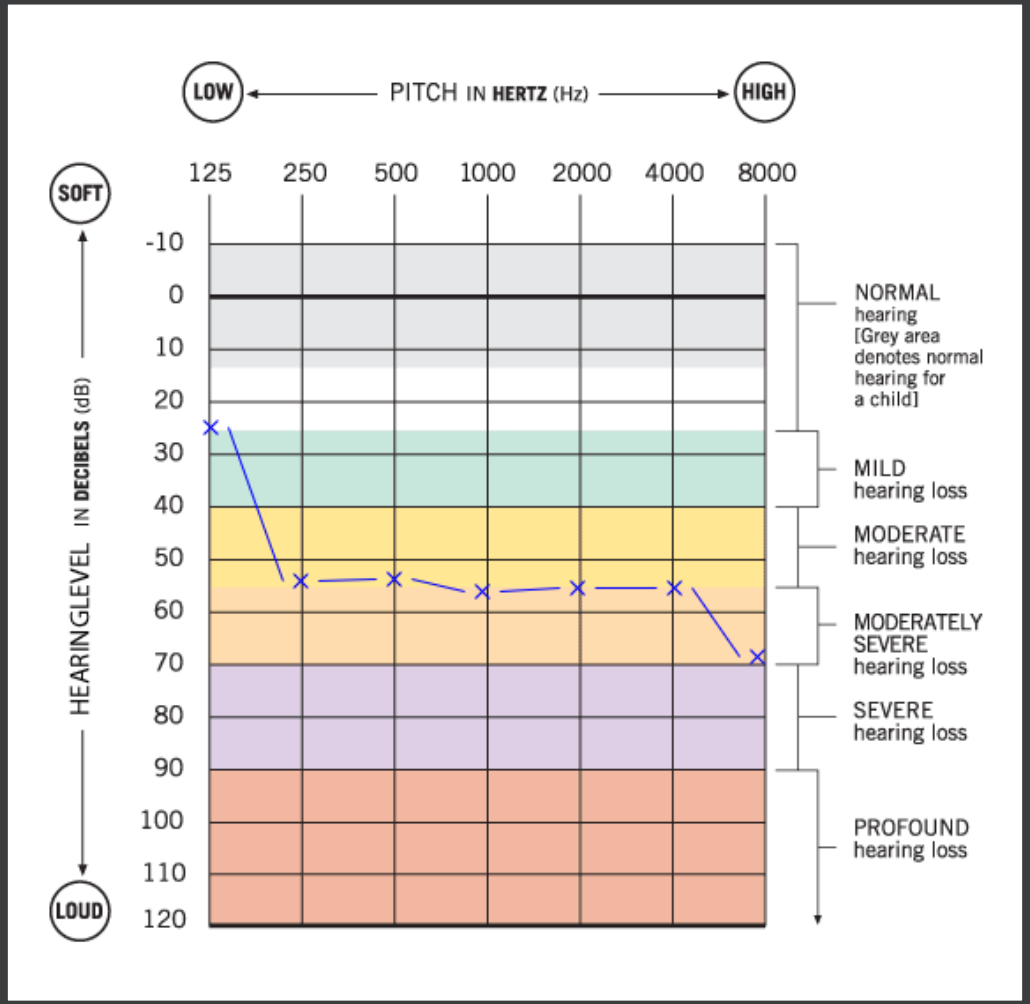
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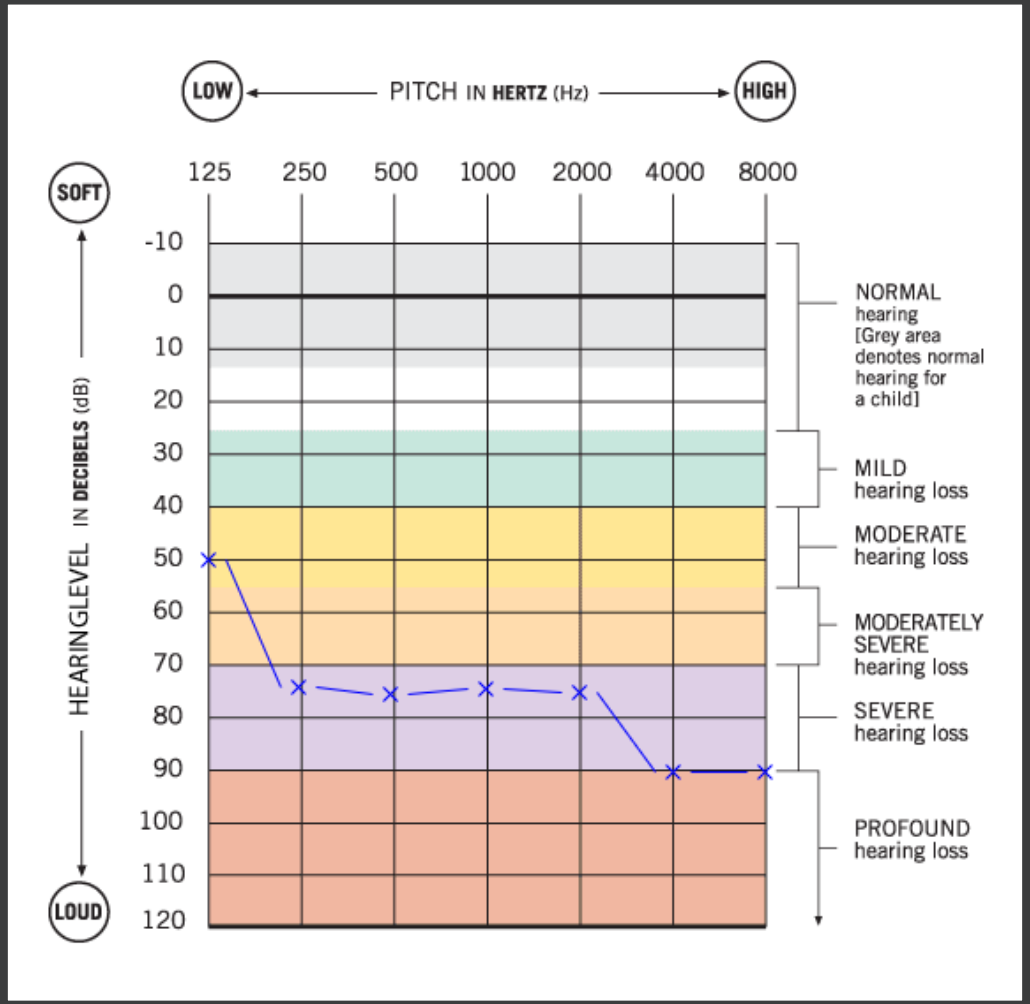
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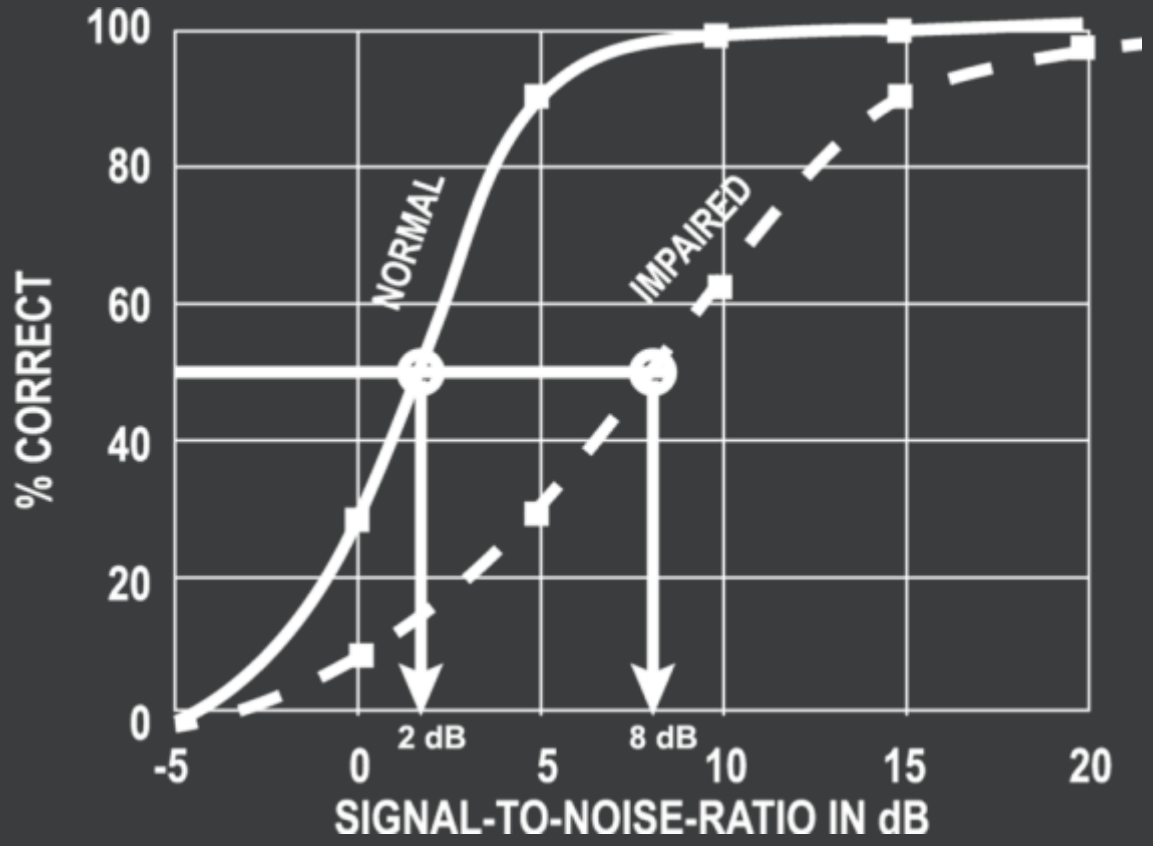
Illustration of SNR 50 i.e., the difference between normal and hearing impaired SNR required for 50% correct identification of words in sentences.



Killion, Seminars in Hearing, 2002.

QSIN SNR Loss Categories

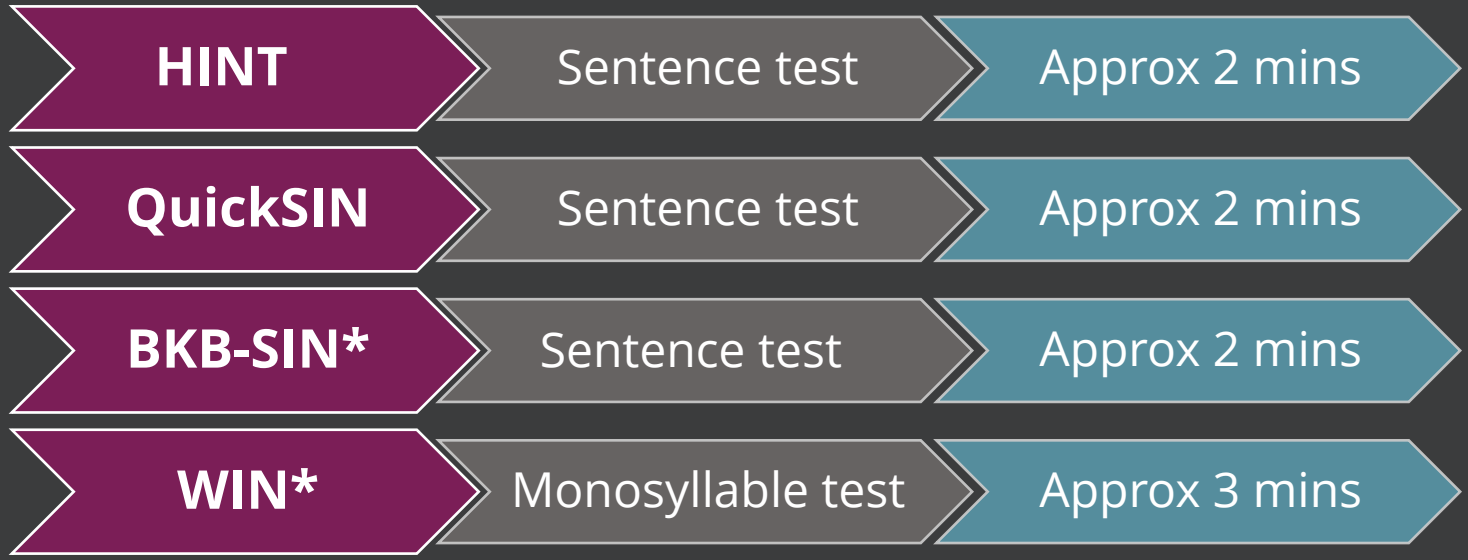
Normal 0-2 dB SNR loss

Mild 3-6 dB SNR Loss

Moderate 7-12 dB SNR Loss

Severe >12 dB SNR loss

Speech-in-Noise Test Times



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Appears in Audiology Today May/June 2019

In this article, we demonstrate a simple protocol that can rapidly determine speech-in-noise thresholds and can be used to validate and verify important differences between unaided and aided responses.

Hearing-care professionals (HCPs) and hearing aid wearers report the chief complaint secondary to hearing loss and to wearing traditional hearing aids, is the inability to understand speech-in-noise (SIN; see Beck et al, 2019). Beck et al (2018) reported that, in addition to the 37 million Americans with audiometric hearing loss, 26 million have hearing difficulty and/or difficulty understanding SIN, despite clinically normal thresholds. As such, helping people hear (i.e., to perceive sound) and helping people listen (i.e., to comprehend, or apply meaning to sound) remains paramount.

APPENDIX

EQUIPMENT

MedRx Stealth or MedRx ARC with Free Field Speakers

STIMULUS

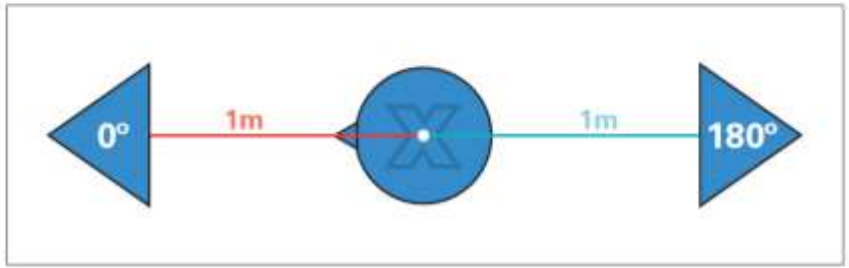
NU-6 Word Lists

BABBLE

Auditec Speech Babble (included with all MedRx Audiometers)

CALIBRATION

Calibrations should be performed by a trained technician with speakers at ear level. Speakers should be placed (ideally) at 0- and 180-degree azimuth



All measurements should be made with the microphone in this static position. Set the sound level meter (SLM) to SPL mode (see FIGURE 2).

1. Subject and speaker diagram where X marks the calibration microphone (FIGURE 1).

2. Speakers at 0 degrees (right channel)

FIGURE 1. Subject and speaker diagram where X marks the placement of the calibration microphone.

Step by Step (front speaker never changes)

FRONT (primary talker) REAR (four talker babble)

70dB SPL (or MCL, or MCL +5 dB) 55 dB SPL

Should be EASY for most…this ABOVE is a 15 dB SNR…if they get three words correct,

INCREASE REAR FOUR TALKER BABBLE by 5 dB, to 60 dB, creating a 10 dB SNR

70 dB 60 dB

Should be EASY for most…this is a 10 dB SNR…if they get three words correct,

INCREASE REAR FOUR TALKER BABBLE by 5 dB, to 65 dB…now at 5 dB SNR

70 dB 65 dB

Note…to this point you've only given 9 recorded words!

Hughson-Westlake protocol…but bracket in 5 dB, then 3 dB, then 2 dB, then 1 dB steps

Repeat the last SNR to make sure it is correct!

Finished.

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QSIN SNR Loss Categories

Normal 0-2 dB SNR loss

Mild 3-6 dB SNR Loss

Moderate 7-12 dB SNR Loss

Severe >12 dB SNR loss

The Necessity of a Speech-In-Noise Measure as a Component of the Audiological Evaluation (2008): McArdle & Wilson. May/June 2008. Audiology Today.

The time is past due for SIN testing to be embraced as a necessary measure in an audiologic evaluation in order to provide the most ecologically valid care to our patients

Doug's Conclusions:

The patient's primary goal is improving speech in noise.

Best Practices means achieving the goal(s) of the patient.

Knowing her SNR-50 reveals information the audiogram doesn’t address…

Difficulty hearing her husband and children at home

Difficulty hearing employees at weekly staff meetings

Difficulty hearing in noisy restaurants

Normal Otoscopy, Normal ENT Eval,

Normal Audiogram

SNR-50 = 12

POSSIBLE ETIOLOGIES?

Auditory Neuropathy Spectrum Disorder

Cochlear Synaptopathy

Hidden Hearing Loss

Auditory Processing Disorder

Neurocognitive Disorder

Alzheimer’s Disease

Attention Deficit Hyperactivity Disorder

Meniere’s Disease

Additional Possible Etiologies

Dyslexia

Attention Deficit Disorder

Traumatic Brain Injury

Specific Language Disorder

Blast Exposure

Dementia

Extended High Frequency SNHL

Asymmetric Hi Freq SNHL

Beck, DL, Danhauer JL, Abrams HB, et al. Audiologic considerations for people with normal hearing sensitivity yet hearing difficulty and/or speech-in-noise problems. Hearing Review. 2018;25(10) [Oct]:28-38.

Audiologic Considerations for People with Normal Hearing Sensitivity Yet Hearing Difficulty and/or Speech-in-Noise Problems

Why do so many people with "normal hearing" report that they have hearing problems?

By DOUGLAS L. BECK, AuD; JEFFREY L. DANHAUER, PhD; HARVEY B. ABRAMS, PhD; SAMUEL R. ATCHERSON, PhD; DAVID K. BROWN, PhD; MARSHALL CHASIN, AuD; JOHN GREER CLARK, PhD; CHRISTINE DE PLACIDO, PhD; BRENT EDWARDS, PhD; DAVID A. FABRY, PhD; CAROL FLEXER, PhD; BRIAN FLIGOR, ScD; GREGORY FRAZER, PhD, AuD; JASON A. GALSTER, PhD; LAURA GIFFORD, AuD; CAROLE E. JOHNSON, PhD, AUD; JANE MADELL, PhD; DAVID R. MOORE, PhD; ROSS J. ROESER PhD; GABRIELLE H. SAUNDERS, PhD; GRANT D. SEARCHFIELD, PhD; CHRISTOPHER SPANKOVICH, PhD, AuD, MPH; MICHAEL VALENTE, PhD, and JACE WOLFE, PhD

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Journal of Otolaryngology-ENT Research

Mini Review

Open Access

CrossMark

Amplification for adults with hearing difficulty, speech in noise problems - and normal thresholds

Keywords: amplification, adults, hearing difficulty, speech, normal thresholds, signal-to-noise ratios

Volume 11 Issue 1 - 2019

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Correspondence: Douglas L Beck, Au.D, Executive Director of Academic Sciences, Oticon Inc., 580 Howard Ave, Somerset, NJ 08873, USA, Tel 732-673-4048, Email dbec@oticon.com

Introduction

Most physicians and audiologists know that hearing difficulty (HD) and/or the inability to understand speech-in-noise (SIN) are chief complaints for some 38 million people with sensorineural hearing loss (SNHL) in the United States. These are neither trivial nor rare complaints. Rather, they represent a nearly universal descriptor

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Our Challenge

Beyond hearing.

Improve the opportunity

For Listening Success!

Hearing Research 365 (2018) 90–99

Contents lists available at ScienceDirect

Hearing Research

journal homepage: www.elsevier.com/locate/heares

Research Paper

Impact of SNR, masker type and noise reduction processing on sentence recognition performance and listening effort as indicated by the pupil dilation response

Barbara Ohlenforst [a, d, *], Dorothea Wendt [d, e], Sophia E. Kramer [a], Graham Naylor [f], Adriana A. Zekveld [a, b, c], Thomas Lunner [b, c, d, e]

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[b] Department of Behavioral Sciences and Learning, Linköping University, Sweden
[c] Linnaeus Centre HEAD, The Swedish Institute for Disability Research, Linköping and Örebro Universities, Sweden
[d] Eriksholm Research Center, Oticon A/S, Denmark
[e] Department of Electrical Engineering, Technical University of Denmark, Denmark
[f] MRC/CSO Institute of Hearing Research, Scottish Section, Glasgow, United Kingdom, Part of the University of Nottingham

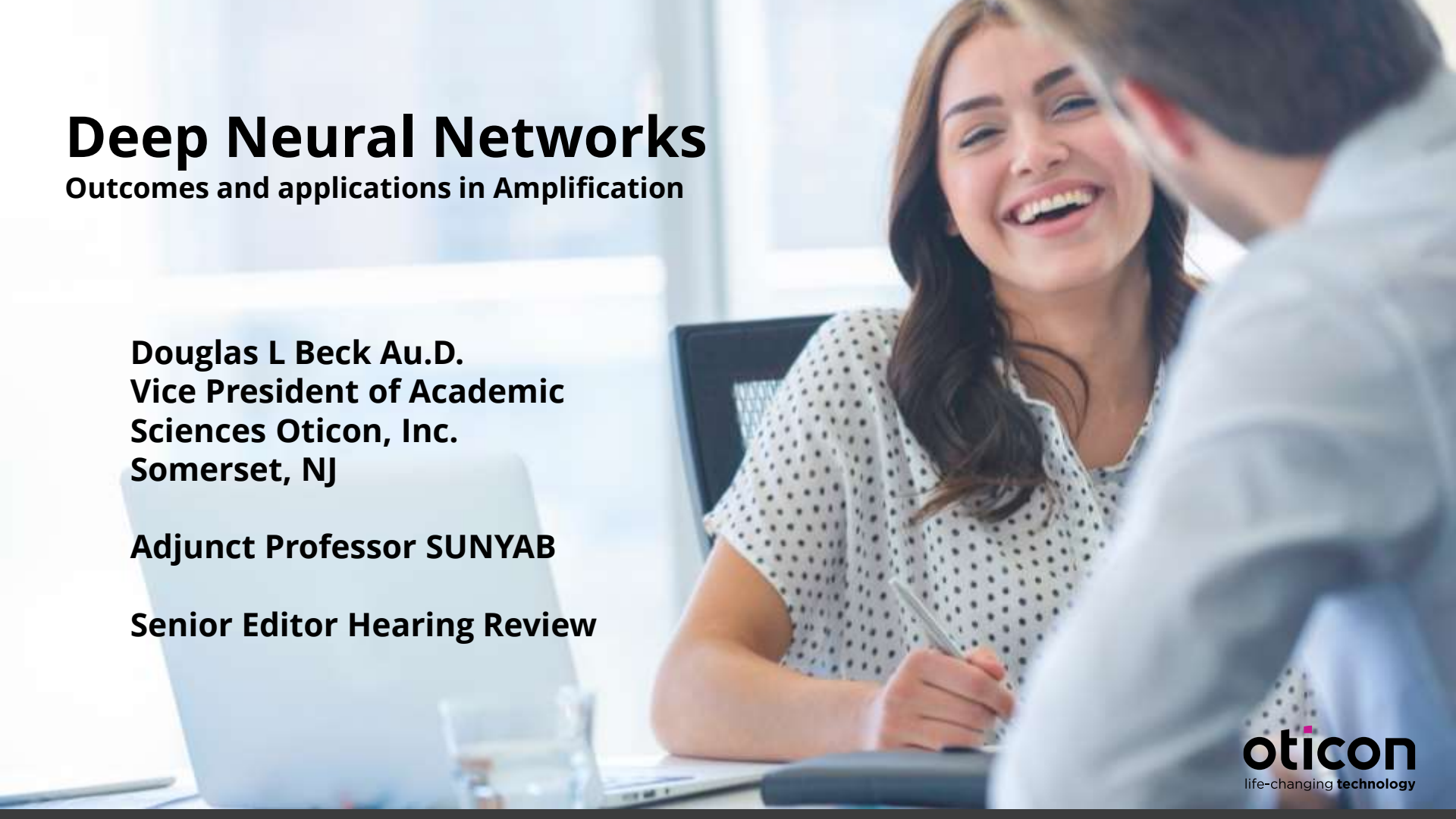
Deep Neural Networks

Outcomes and applications in Amplification

Douglas L Beck Au.D.
Vice President of Academic Sciences Oticon, Inc.
Somerset, NJ

Adjunct Professor SUNYAB

Senior Editor Hearing Review



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life-changing technology

Speaker Disclosure

Relevant financial relationships:

Douglas L. Beck Au.D. is an employee of Oticon and receives a salary.

Relevant nonfinancial relationships:

Dr. Beck is a Senior Editor at Hearing Review
Dr. Beck is an Adjunct Clinical Professor at SUNYAB
Dr. Beck is a peer reviewer for multiple publications

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www.douglaslbeck.com

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Deep Neural Networks

Artificial Intelligence, Machine Learning….DNNs

Biologic DNNs

- Vast quantities of input data
- Looks for patterns
- Organizes information
- Best-Fit outcomes
- Self-checks to make sure output maximally represents input

Digital Tech-based DNNs

- Facial Recognition
- Speech recognition
- Self-Driving Cars
- Amazon/Netflix/Google/Facebook…

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Compression and Amplification Algorithms in Hearing Aids Impair the Selectivity of Neural Responses to Speech. Nature Biomedical Engineering, March 16, 2021
Armstrong' Lam, Sabesan and Lesica

'In quiet environments, hearing aids improve the perception of low-intensity sounds, However, for high intensity sounds in background noise, the aids often fail to provide a benefit to the wearer…"

"Low selectivity is a consequence of hearing aid compression (which decreases the spectral and temporal contrasts of incoming sounds) and amplification (which distorts neural responses)…"

"Processing strategies that avoid the trade-off between neural sensitivity and selectivity should improve the performance of hearing aids."

Q- Can a DNN solve these dilemmas (directionality, compression, beam-forming)?

Deep artificial neural networks reveal a distributed cortical network encoding propositional sentence-level meaning
Anderson, Kiela, Binder, et al. Journal of Neuroscience 22 March 2021, JN-RM-1152-20; DOI: https://doi.org/10.1523/JNEUROSCI.1152-20.2021

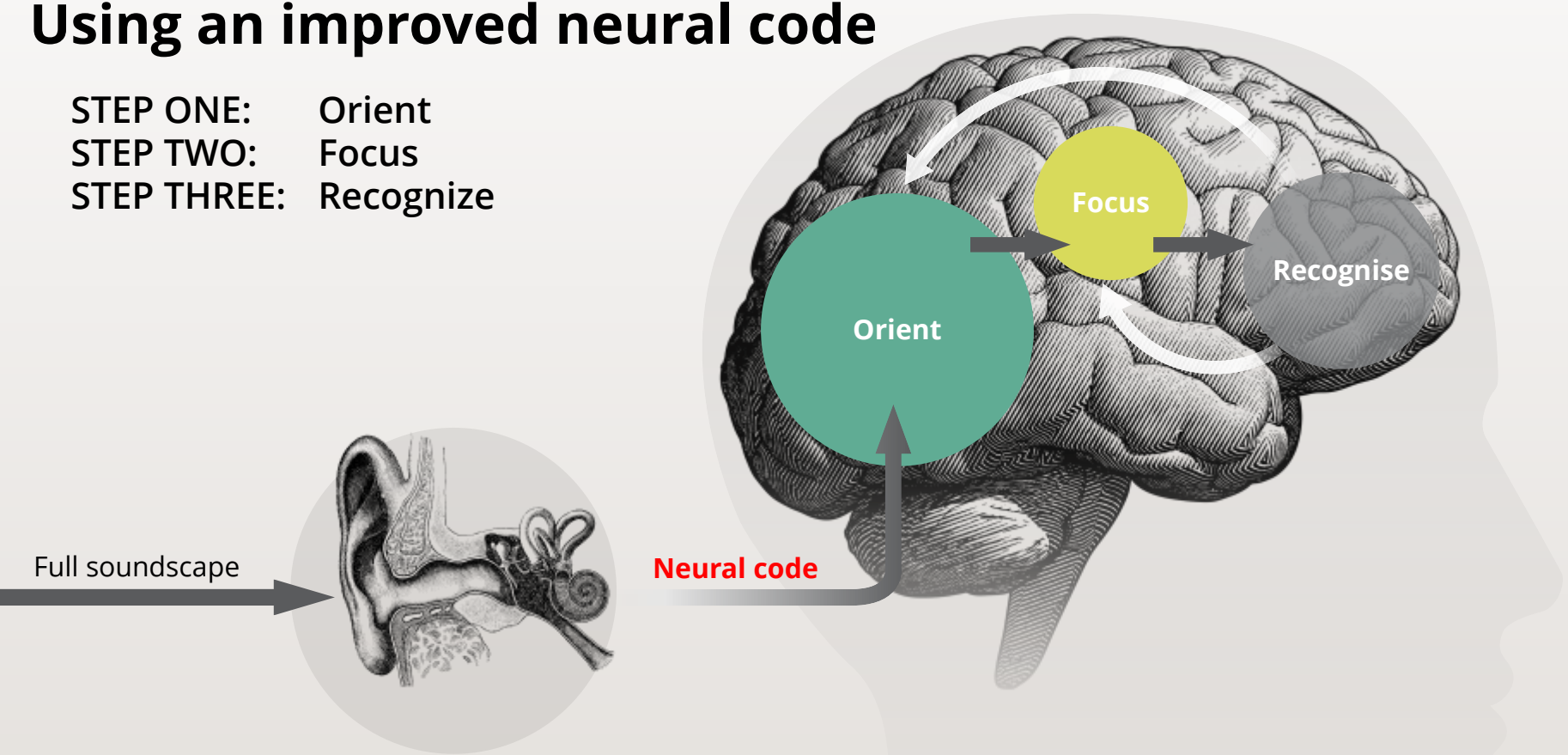
Understanding how and where in the brain sentence-level meaning is constructed from words presents a major scientific challenge…

…Studies have helped map out semantic representation across a distributed brain network spanning temporal, parietal and frontal cortex…

…Sentence-level meaning is represented within and across multiple cortical regions rather than at any single site.

Using an improved neural code

STEP ONE: Orient
STEP TWO: Focus
STEP THREE: Recognize



O'Sullivan et al., 2019; Puvvada & Simon, 2017; Shinn-Cunningham & Best, 2008

STEP ONE ORIENT

Brain responses (EEG)

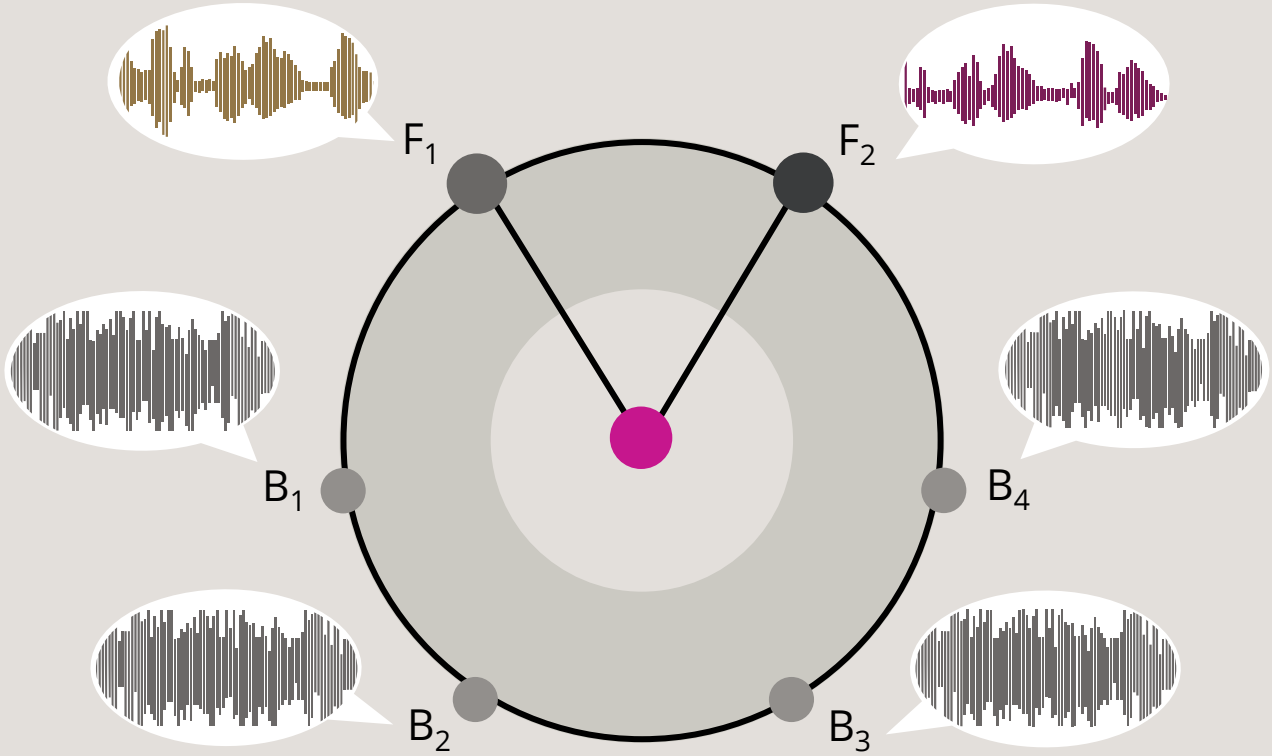
Sound representation and clarity in the brain

Santurette, Ng, Juul Jensen & Man, 2020

Test setup

Realistic complex sound scene

Task:
Focus on one foreground talker



F: Foreground talker
B: Background babble

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Methods

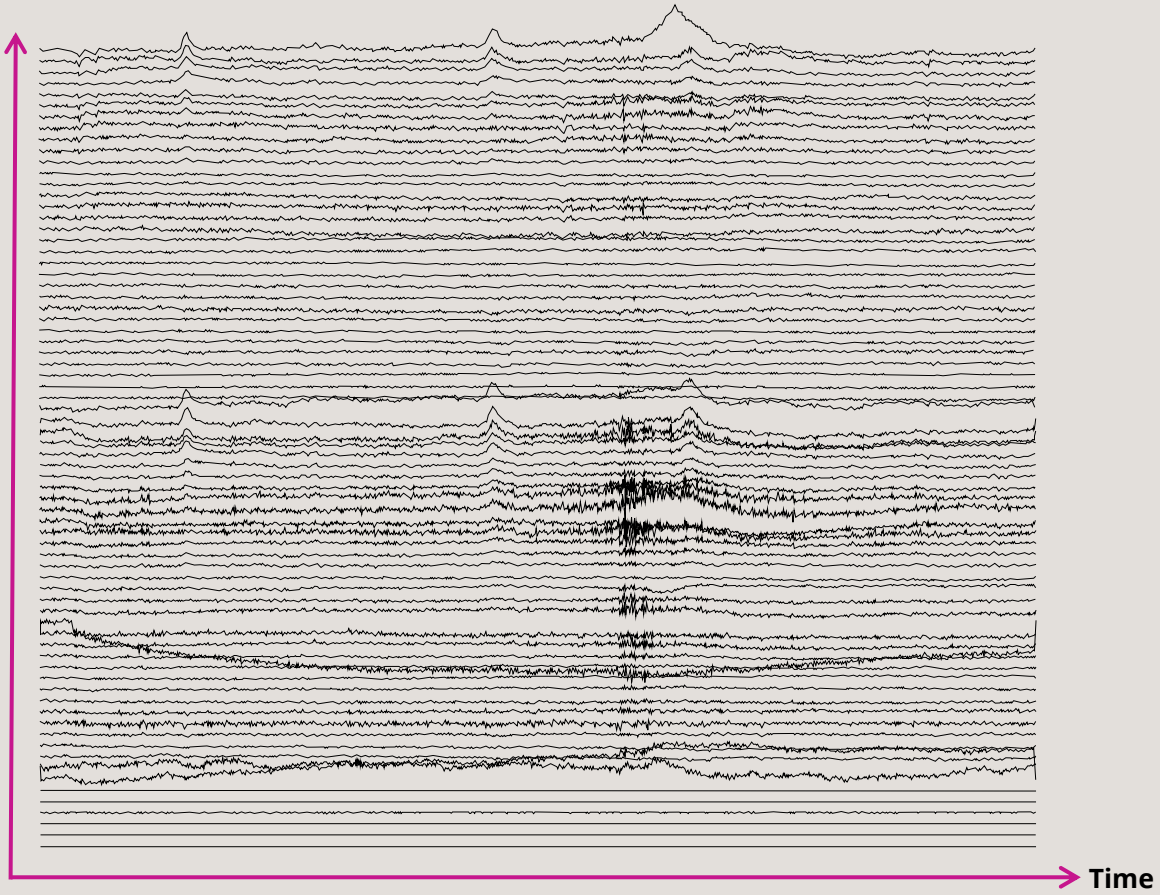
Electroencephalography (EEG)

Method for measuring electrical activity in the brain

Recorded through 64 electrodes

The EEG raw data

An example



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Stimulus reconstruction

An example

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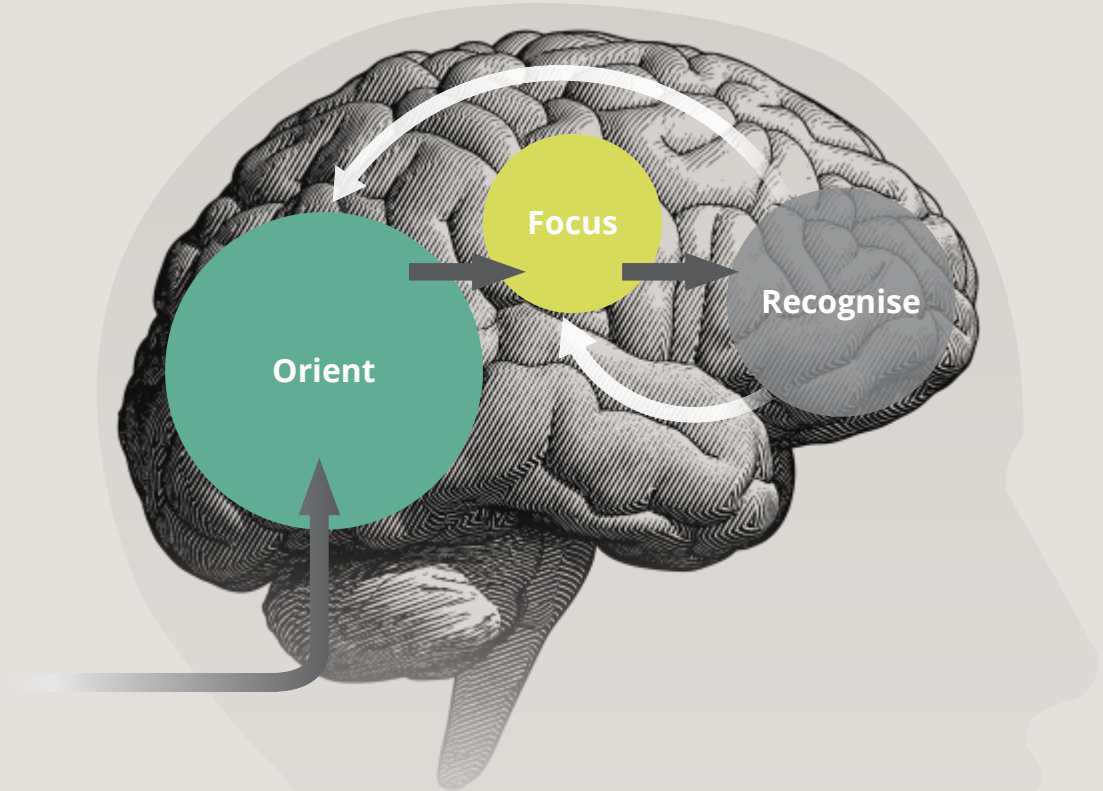


O'Sullivan et al., 2019; Puvvada & Simon, 2017; Shinn-Cunningham & Best, 2008

Selective attention in hearing

As hearing becomes poorer – so does the ability to use selective attention

> **Selective attention** is the brain's natural ability to organize and prioritize sounds. This ability is vital for social interaction. As we focus on the person we are speaking with, selective attention enables us to monitor our surroundings, pick out other sounds, and switch our attention when needed.

Inspired by Shinn-Cunningham & Best, 2008

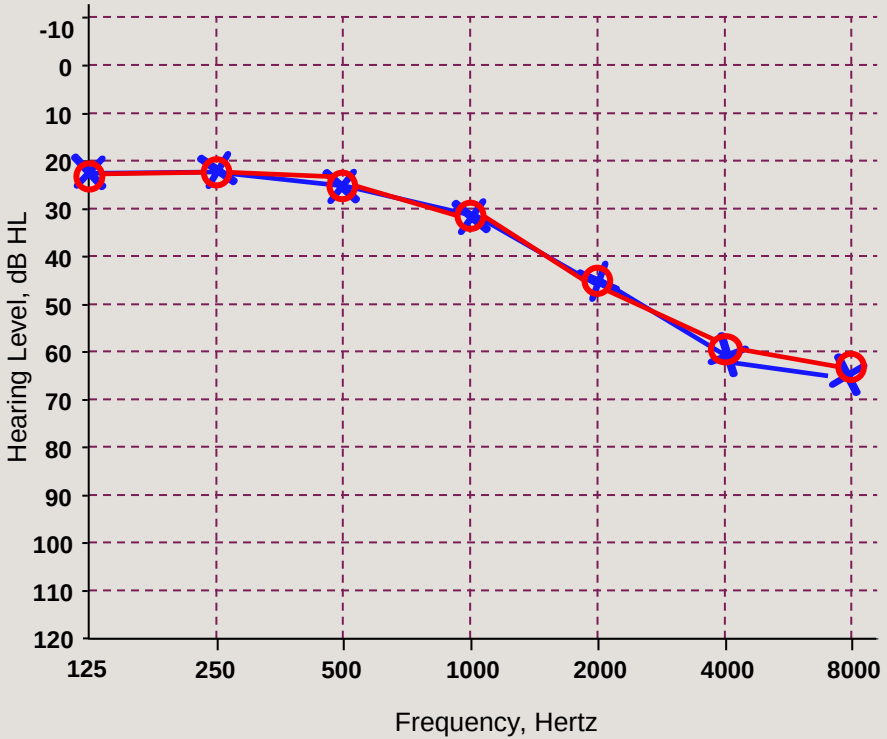
Background

Study: Ability to understand speech in focus

Participants:

- 34 experienced hearing aid users
- Mean age: 63 years
- Mild to moderate sensorineural hearing loss

SELECTIVE ATTENTION



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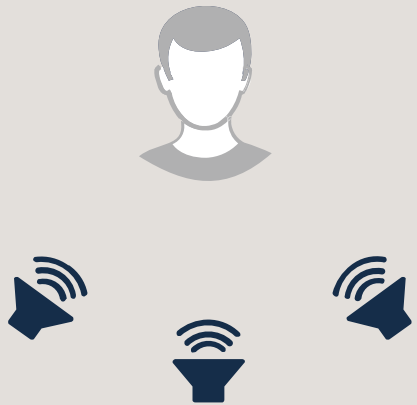
Test setup

TFocus on one talker and ignore the other two in SIMPLE and COMPLEX

Simple environment



Complex environment

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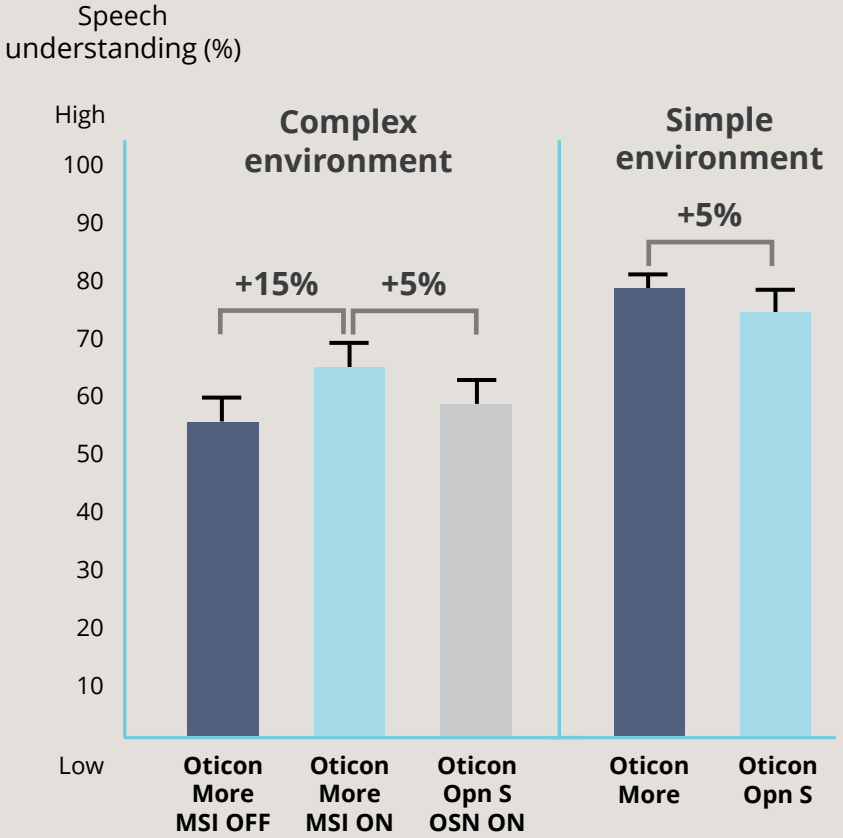
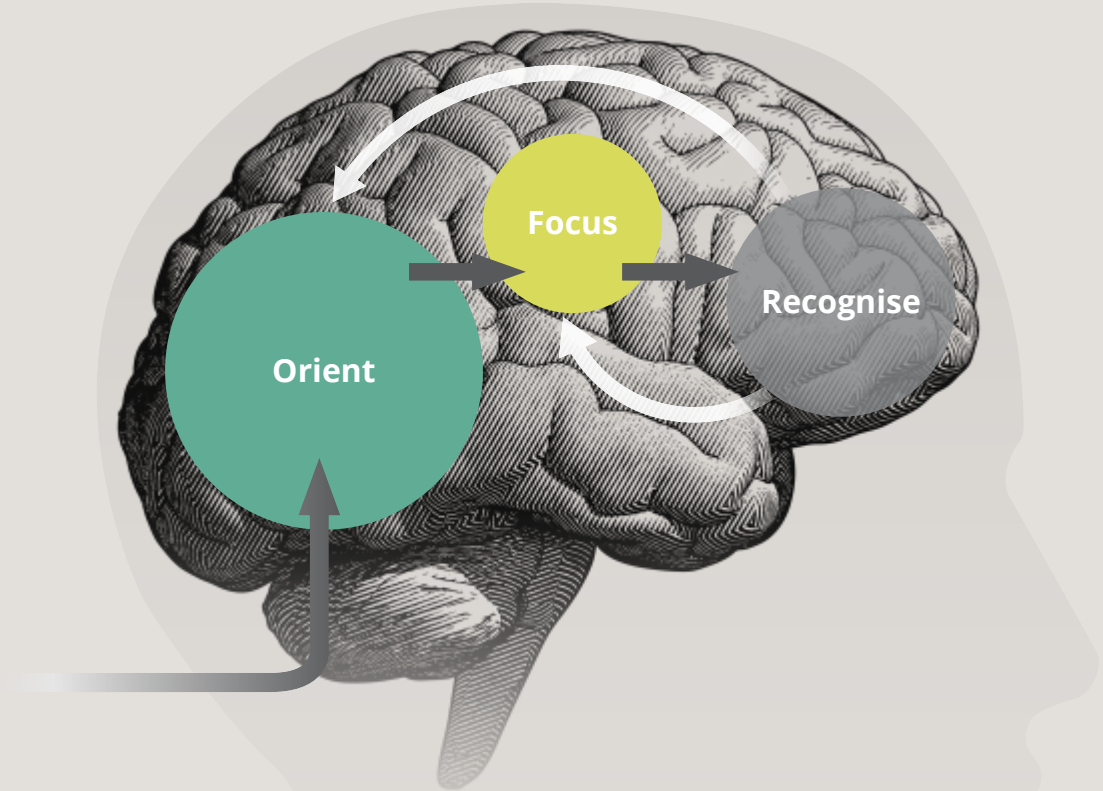
Selective Attention

Results

15% higher performance with MSI enabled in complex environements

Oticon More outperforms Oticon Opn S by 5% on average in both simple and complex environments





O'Sullivan et al., 2019; Puvvada & Simon, 2017; Shinn-Cunningham & Best, 2008

STEP THREE:
Speech understanding (SIN) and memory recall

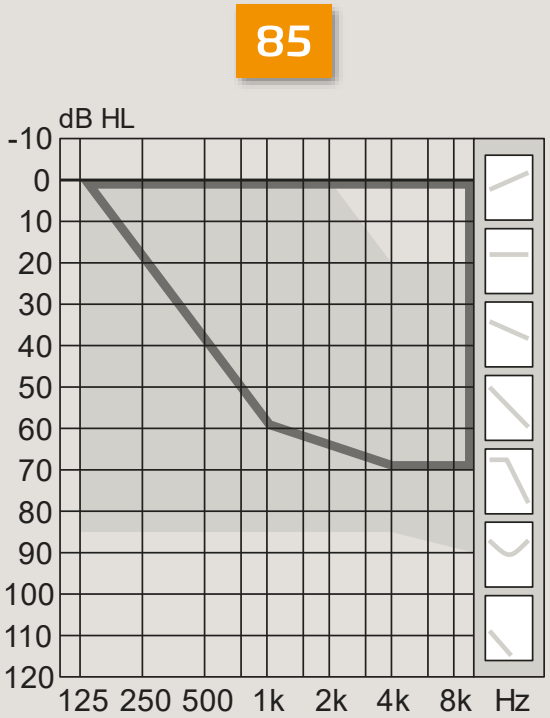
Santurette, Ng, Juul Jensen & Man, 2020

Background

Study: Speech understanding in noise

Participants:

- 18 experienced hearing aid users
- Mean age: 68.5 years
- Hearing loss within 85 dB receiver level range



Test conditions

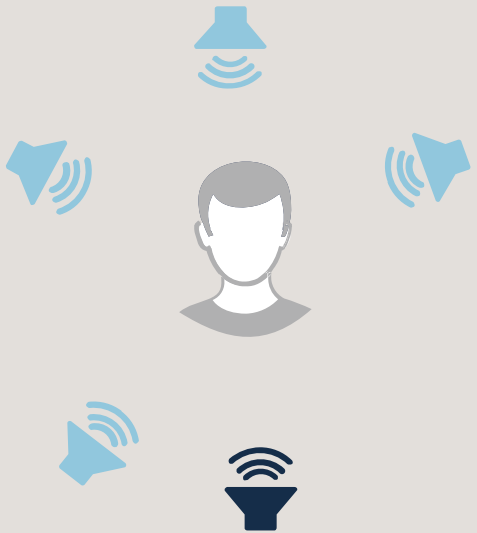
Measuring speech recognition in Oticon Opn S and Oticon More

Hearing aid settings:

- Oticon More vs. Oticon Opn S
  - Default setting
  - Personalized 1

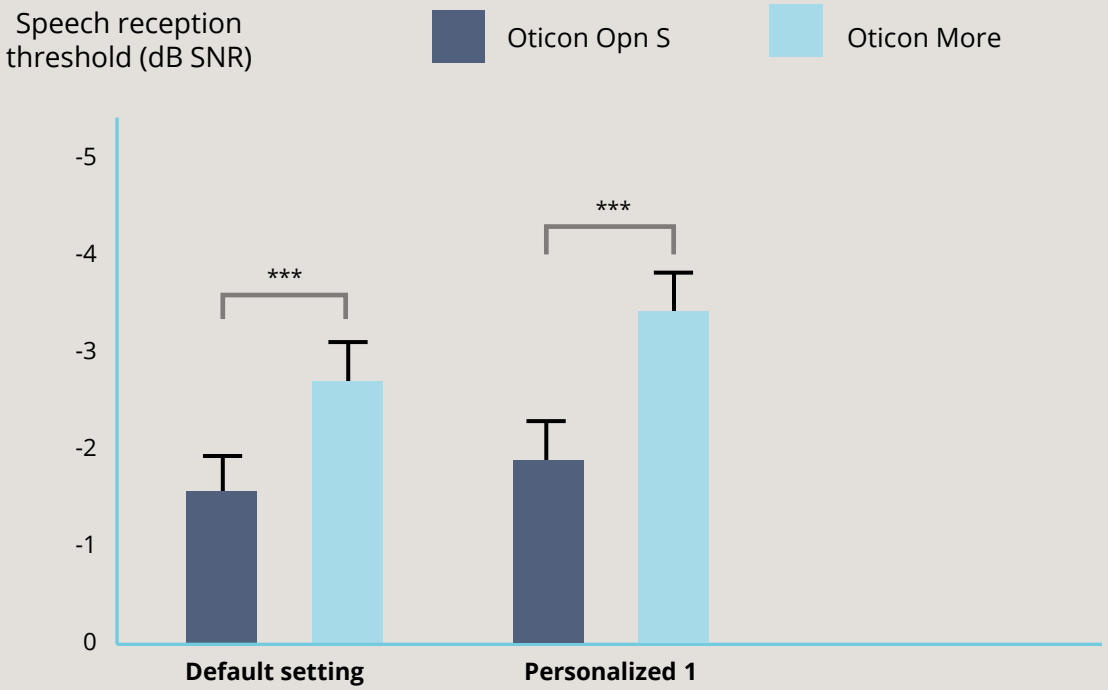
Test environment:

- Matrix sentence test (Dantale II)
- Test performed at 70% speech intelligibility



Speech understanding in noise

Oticon More outperforms Oticon Opn S across settings

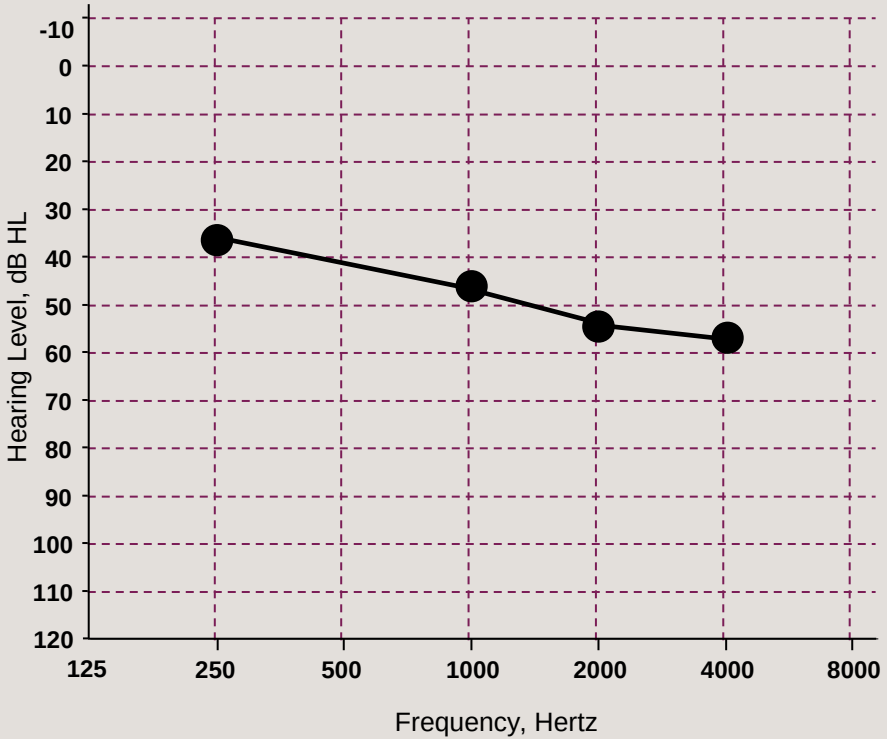


Background

Study: Memory recall

Participants:

- 25 experienced hearing aid users
- Mean age: 58.8 years
- Average PTA: 48.5 dB HL
- Mild to moderate sensorineural hearing loss



Memory recall

SWIR (Sentence-final Word Identification and Recall)

1st task : **repeat** last word

1. The team lost the **match**
2. The lady hurt her **arm**

Long-term memory

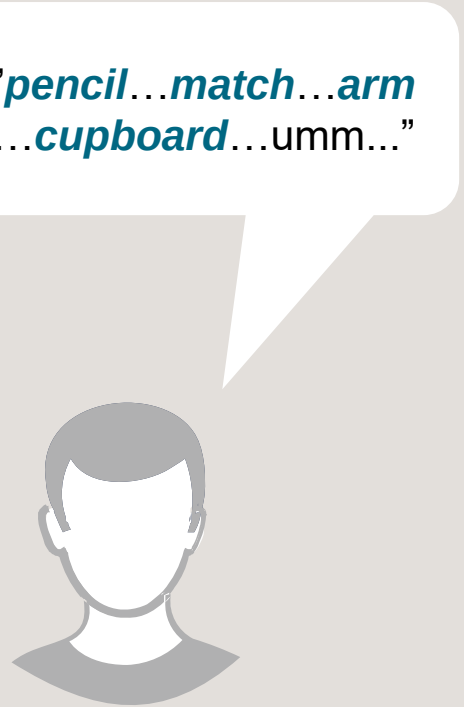
3. The coat hangs in a **cupboard**
4. The new towel was **clean**
5. She closed her **eyes**

In transfer

6. The lemons were quite **bitter**
7. The man drew with a **pencil**

Short-term memory

2nd task: **recall** the last words

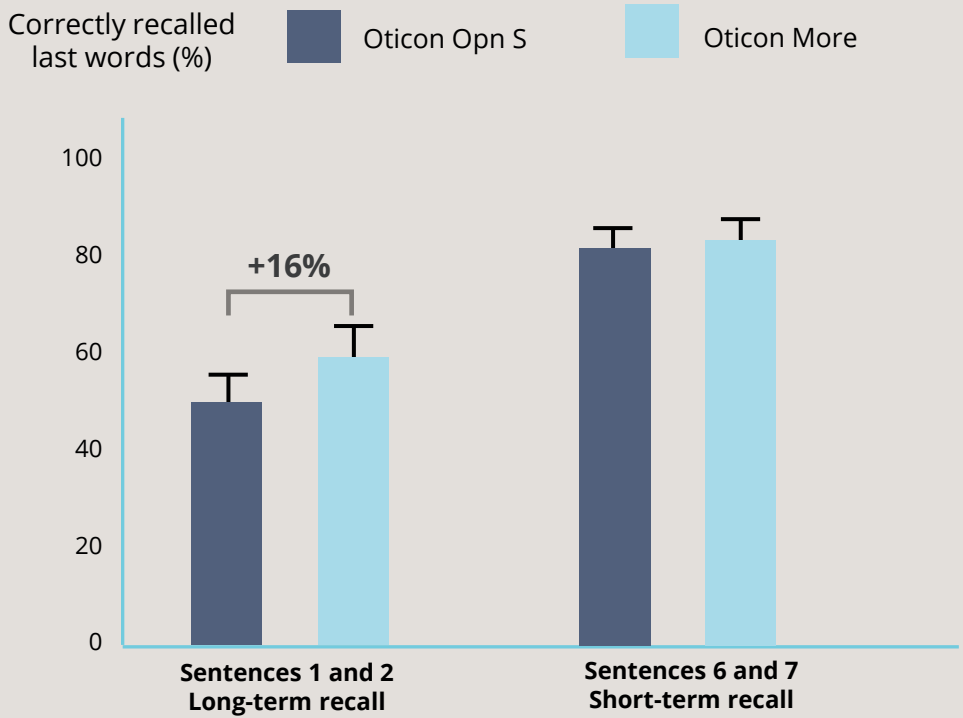


Memory recall

Results: Long-term and short-term memory

Oticon More offers a **16% improvement in long-term memory recall** compared to Oticon Opn S

Better long-term memory recall means more cognitive resources available and less listening effort

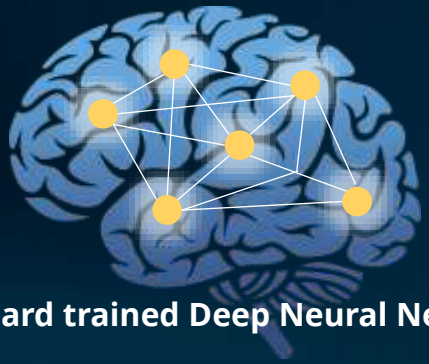


100%
More processing power

Secure platform

12 million
Sound scenes

x8
More memory



On-board trained Deep Neural Network

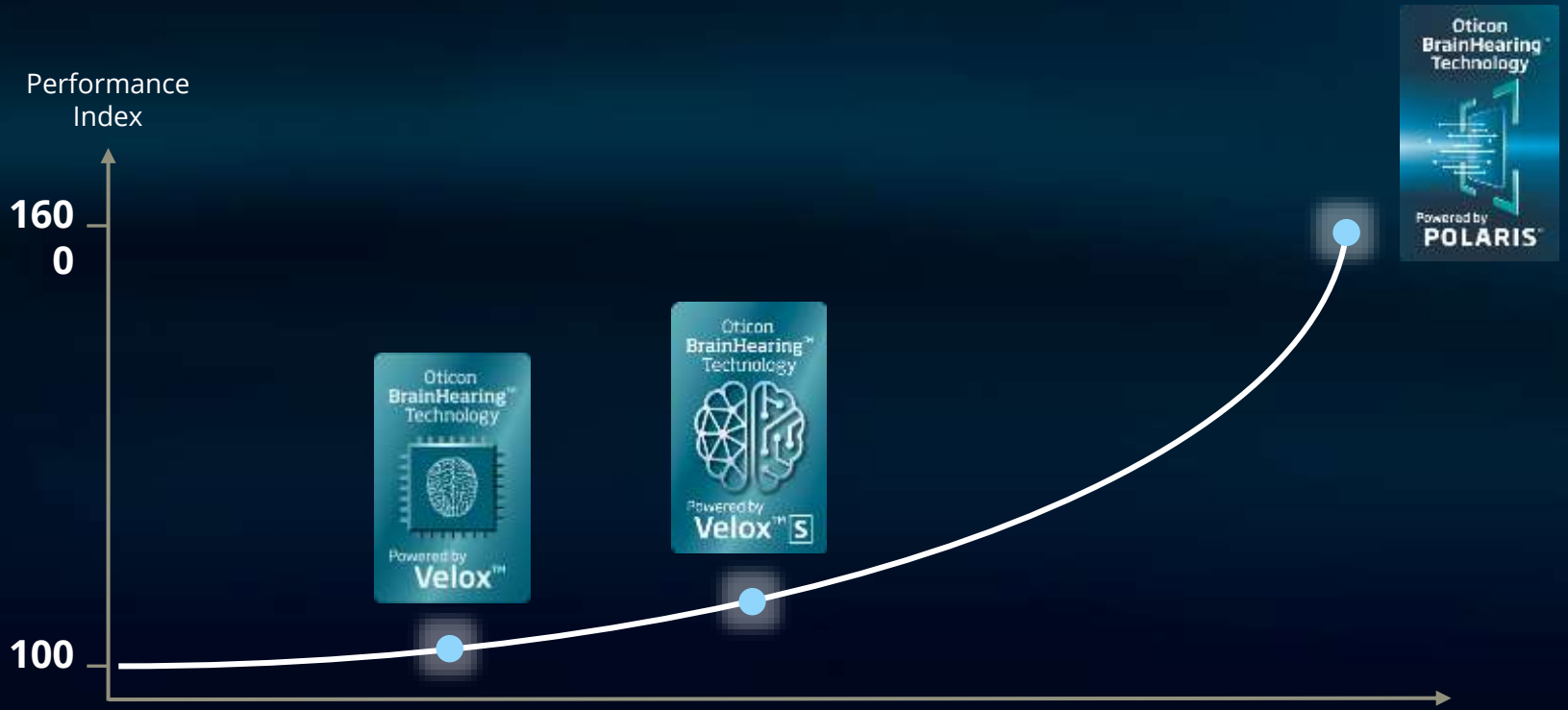
500
Scans per second

28nm
Chip technology

154 million
Transistors

64
Signal-processing channels

Significant step-up in performance



Polaris supports direct streaming from Android™ phones using ASHA

(Audio Streaming for Hearing Aids)

iOS

Android

TwinLink
NFMI + 2.4 GHz

Made for
iPhone | iPad | iPod

Works with
android

MoreSound Amplifier

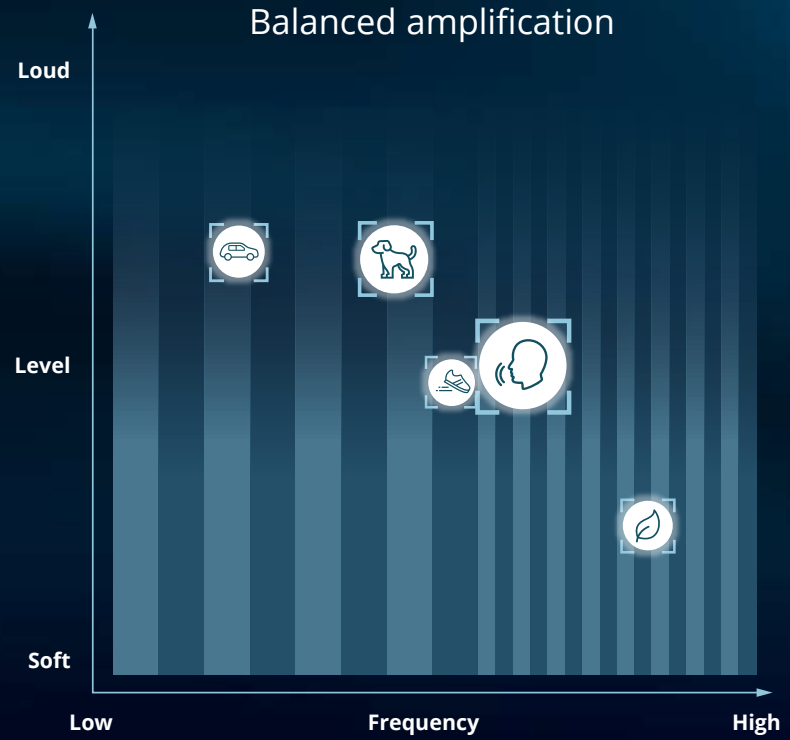
Leaving conventional compression behind

Sixfold increase in resolution*

Adaptive speed pilot

Maintains fine contrast and balance

*compared to Velox S



MoreSound Amplifier vs Conventional compression

Hearing Review August 2021

TECH TOPIC // SOUND QUALITY AND HEARING AIDS

Sound Quality and Hearing Aids

By DOUGLAS L. BECK, AuD, DANIELLE TRYANSKI, AuD, and BRIAN KAI LOONG MAN, MSc

A study using the MUSHRA protocol comparing Oticon More™ to two other premium hearing aids, combined with a recent UBS Evidence Lab report, suggests Oticon More offers top sound quality—a key element in customer satisfaction.

Pirsig[1] wrote *Zen and the Art of Motorcycle Maintenance* in 1974. The book quickly became an international

quality—softness, brightness, clarity, fullness, nearness, loudness, spaciousness, and total impression—as factors assessed in the

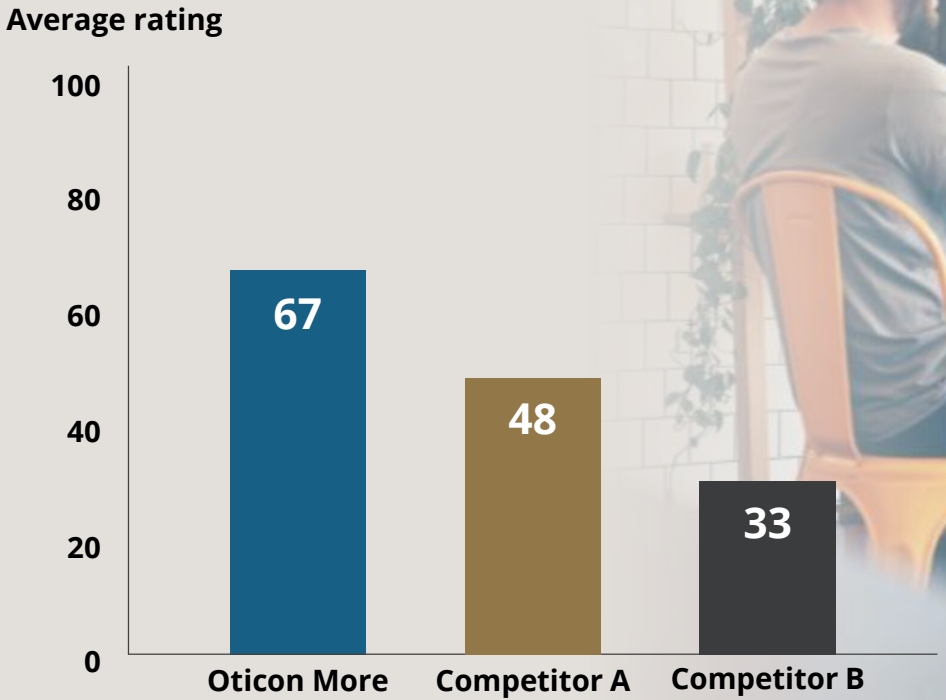
to hearing aid sound quality, the authors reported Oticon More™ was rated highest. Additionally, Oticon More (released January 2021) was seen as the most attractive product.

The Multiple Stimuli with Hidden Reference and Anchor (MUSHRA)

In 2015, the International Telecommunications Union (ITU)[7] described the Multiple Stimuli with Hidden

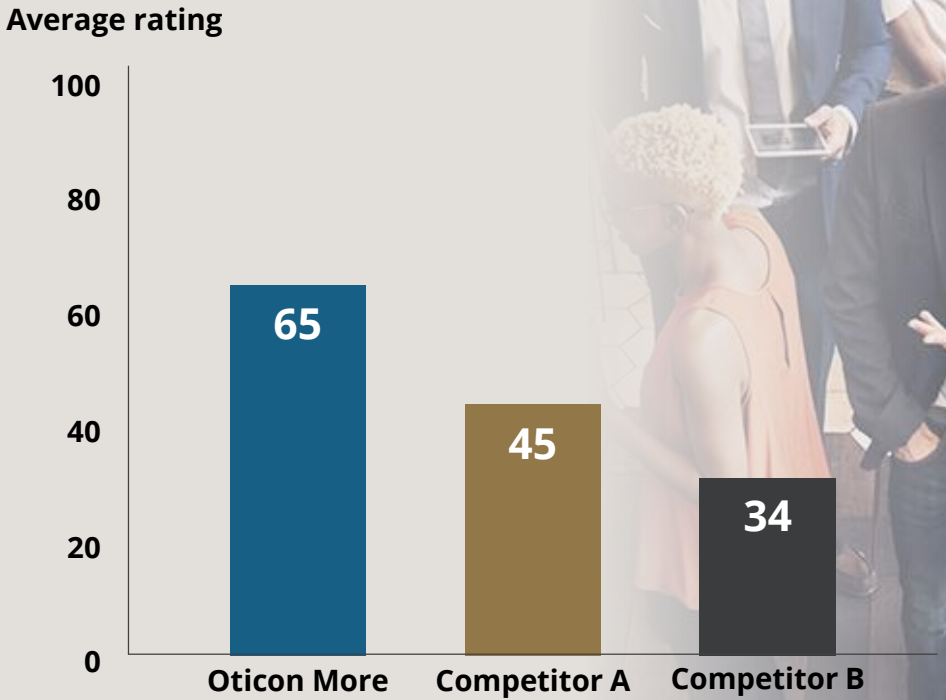

Oticon More is
preferred by
8
out of
10

Café scene results



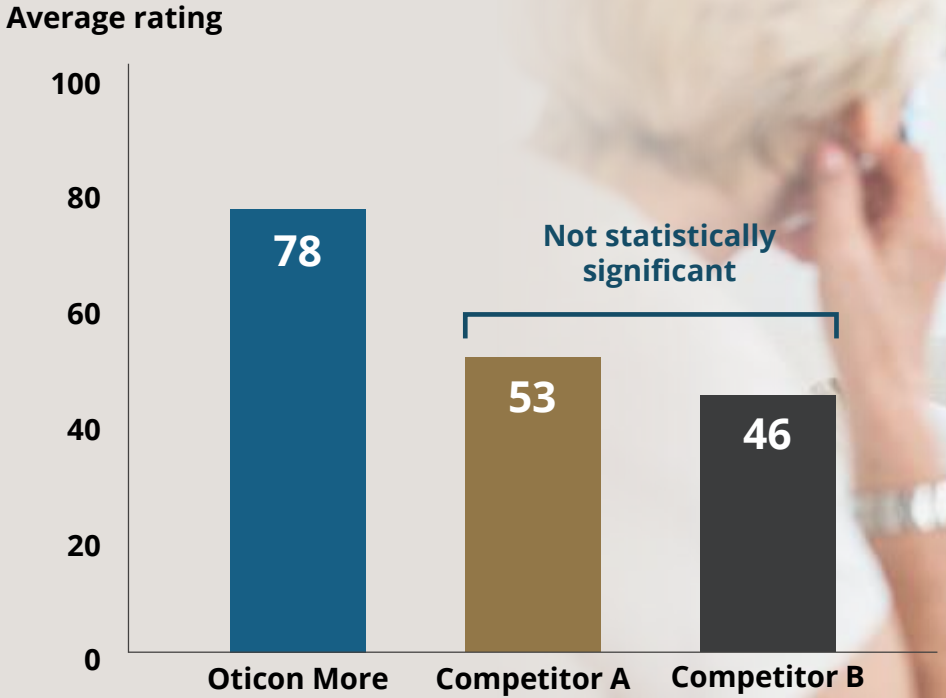
Man, Løve, and Garnæs, 2021

Canteen scene results



Man, Løve, and Garnæs, 2021

Facemask results



Man, Løve, and Garnæs, 2021

Conclusions

Once again Oticon More outperforms competition

There is a **significant preference for Oticon More** across environments

8 out of 10 prefer Oticon More over premium competition

Oticon More gives the brain access to more nuance and clarity – making it the preferred device

Man, Løve, and Garnæs, 2021

Flexer and Madell (2014)
Pediatrics and Hearing and Change . Flexer C, Madell J. (2014) Why Hearing is Important in Children. Chapter 1, in Pediatric Audiology Diagnosis, Technology and Management. Second Edition. Editors: Jane Madell and Carol Flexer. Published by Thieme.
http://www.audiology.org/news/pediatrics-and-hearing-and-change

Access to the brain through audition is essential to maximal brain development…

The brain can only organize itself based on the stimuli received….

The degree of hearing loss ought not determine functional outcome…

Performance with technology is what will determine functional outcome.


That's all Folks!

Questions

oticon