

Cognition-Friendly Amplification

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Ideas, concepts, themes...



sadly....



Listen Fast!

Ideas & Concepts:

All Men Are Created Equal

Do Unto Others As You Would Have Them Do Unto You

One Small Step For Man, One Giant Leap for Mankind

Ask Not What Your Country Can Do For You

We Have Nothing to Fear But Fear Itself

TOP-DOWN

**Executive Functions, Cognition,
Auditory & Speech Processing,
Memory (short and long-term),
Rational Thought & Reason...**

BOTTOM-UP:

**Non-linguistic sounds, clicks
pure tones, psycho-acoustic stimuli,
Phonemes,
Pre-cognitive acoustic stimuli**

**Balancing Act
TD:BU processes**

**When BU sensory-input is compromised,
TD must work harder to
maintain
balance.**



TD & BU balance changes as we age...

Young people w/normal hearing & normal cognition successfully process multiple sensory input.

Cognition is finite.

Multi-Tasking.

Attention.



Driver distractions:

2009 National Highway Traffic Safety Administration

80% of crashes have distraction within three seconds of the crash!

Leading Distractions:

- Cell phone use.**
- Reaching for an object.**
- Looking at objects outside.**
- Reading.**
- Applying makeup.**

Humans are Dynamic

In 1800, life expectancy 37 years.

In 1900, life expectancy 50 years.

In 2009, life expectancy 79 years.

**Life expectancy increased 50% in
100 years, DOUBLED in 200 yrs.**

From Page 324, *The Singularity –When Humans Transcend Biology*. Ray Kurzweil, 2005
CDC 2008 (very similar numbers)

Demographics Summary: Living longer in an older community! (USA)

**From 1990 and 2000, over age 85 yrs
grew TWENTY TIMES faster than those
between ages 15 and 44 years.**

(CDC, 2008).

Oct 20, 2009 Medical News Today:

<http://www.medicalnewstoday.com/articles/168061.php>

50 active years after 50 via University of Leeds.

**half the babies born in wealthy
nations will live to 100 years.**

Alzheimer's Disease:

Alzheimer's Disease (AD) is the most common dementia.

Between 65 and 74 years, 3% has AD.

Between 75 and 84, 19% have AD.

Above age 85, 50% have AD.

Prostate Cancer Incidence:

One third of all American men over age 50 have microscopic signs of prostate cancer.

By age 75, almost 75% of American men have cancerous changes in the prostate.

National Cancer Institute. *Understanding Prostate Changes: A Health Guide for All Men*. Washington, DC: Public Health Services; 1998. US Dept of Health and Human Services. NIH publication 98-4303.

Diseases associated with aging (partial list) from Centers for Disease Control

[Alzheimer's disease](#)

[Oral health](#)

[Osteoporosis](#)

[Depression](#)

[Diabetes](#)

[Elder abuse/neglect](#)

[Shingles vaccine](#)

[Falls](#)

[H1N1 virus](#)

[Heart disease and stroke](#)

[Hearing loss](#)

[High blood pressure](#)

[Lung cancer](#)

[Mental health](#)

[Nutrition](#)

[Clinical preventive services](#)

[Cholesterol](#)

[Colorectal cancer](#)

[Prostate cancer](#)

[Pneumonia](#)

[End-of-life preparedness](#)

[Smoking](#)

[Substance abuse](#)

[Suicide](#)

[Tobacco use](#)

[Vision loss](#)

[Arthritis](#)

[Breast cancer](#)

[Motor vehicle-related injuries](#)

[Cervical cancer](#)

Synergy

Negative Synergy

Negative Synergy

**confusion
frustration,
isolation.**

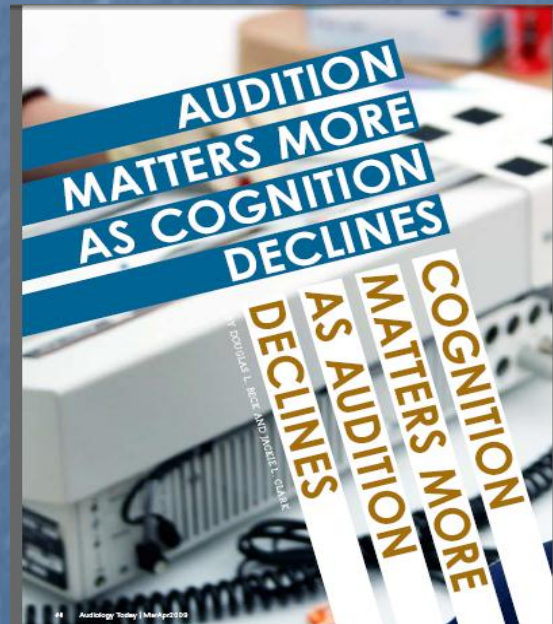
What happens when auditory decline and cognitive decline co-exist in the same person?



Audition Matters More as Cognition Declines: Cognition Matters More as Audition Declines.

Audiology Today March/April 2009

Beck & Clark



Nobody lives in a sound booth

Patients live in a world where cognition, attention, memory and audition interact and each plays a critical role in listening.

Listening ...
is where hearing meets brain

Hearing Professionals speak about HEARING.

We need to speak about LISTENING.

**And...with LISTENING,
the topic expands
exponentially...**

Listening involves....

knowledge, language, memory, thinking,
knowing, problem solving, intellectual capacity,
applying knowledge to new situations...

“How Cognition Might Influence Hearing Aid Design, Fitting and Outcomes”
Pichora-Fuller, Kathleen, November 2009, Hearing Journal

LISTENING is more challenging in noise and more challenging with fluctuating voices.

LISTENING is more challenging for people who perform less well on cognitive tests, and they do even worse in noisy backgrounds.

LISTENING is more challenging while multi-tasking.

Memory Matters

Speech occurs over time and **working memory** must retain sounds/phonemes/words....

Speech Processing & Working Memory

Final words can change the whole meaning.

Speech rate up to 5 syllables/sec, rate is set by the talker, externally paced task (Welford, 1983).

Working Memory and Novel Word Learning In Children With Hearing Impairment and Children with Specific Language Impairment. International Journal Language and Comm Dis. 2004, Vol 39, No 3. Forsberg, Lofqvist, Maki-Torkko and Sahlen (Sweden)

Best predictor of NOVEL WORD learning for children with hearing loss and for kids w/specific language imp was WORKING MEMORY.

Lunner, 2003:

72 subjects assessed for cognitive function based on working memory and verbal information processing speed.

VOLUNTEER?

Subjects with best working memory capacity were better able to identify and report processing effects of experimental hearing aids.

Cognitive ability may significantly impact hearing aid experience.

Humes, 2005

213 elderly h. loss subjects evaluated for auditory processing and cognitive function.

Cognitive function was the strongest predictor of individual performance differences.

Performance of auditory processing measures were more related to cognitive ability than auditory ability.

**The Role of Cognition in Age-Related Hearing Loss,
JAAA, July/Aug 2007, Fergus I.M. Craik**

After amplification difficulties w/ speech comprehension remain.

Outcomes depend on allocation of attentional processes.

Audibility may have an inverse relationship with cognition.

Age-related cognitive decline has profound impact on hearing and comprehension.

Cognition and Hearing Aids

Lunner, Rudner and Ronnberg,
Scandinavian Journal of Psychology, 2009

**Individual cognitive processing
resources may determine**

“listening success.”

**Signal processing to improve
speech understanding may be
dependent on working memory (WM).**

Cognition and Hearing Aids

Lunner, Rudner and Ronnberg,
Scandinavian Journal of Psychology (in press) 2009

$$\mathbf{C = P + S}$$

**Working Memory Capacity =
Processing Component & Storage Component**

**When processing and storage needs exceed capacity,
breakdowns occur (errors, slowing, distortions etc)**

What to do?

Train the Brain!

SKILL BUILDING

(aka BRAIN TRAINING)

AR

Listening and Comm. Enhancement (LACE)

EXERCISE

**NY Times April 30, 2010,
The Talents of a Middle-Aged Brain by Tara Parker-Pope
Interview w/ Barbara Strauch (author) The Secret Life of the Grown-Up Brain.**

Q- What can be done to keep your brain healthy and improve deficits, like memory problems?

A- Everything good for your heart is good for your brain. Exercise is the best thing you can do. Exercise increases brain volume, produces new brain cells in grown-up brains. Exercising your body helps your brain.

July 7, 2010, NY Times Online,
Gretchen Reynolds
"Phys Ed: Your Brain on Exercise"

Neurogenesis (creation of new brain cells)
happens in humans and animals.

Exercise increases neurogenesis.

demonstrated conclusively late 1990s by
Dr. Fred Gage, Salk Institute.

Exercise, Cognition, and Audition?

JAMA. 2008;300[9]:1027-1037 (Sept 3, 2008)

Nicola Lautenschlager MD et al (Australia)

Exercise improves cognitive function.

Investigated cognition & auditory processing. The Alzheimer Disease Assessment Scale — Cognitive Subscale (ADAS-Cog) to assess cognitive function.

138 subjects, 59 yrs and older w/memory problems, not dementia.

Group 1-usual care Group 2-usual care and exercise.

Group 2 improved cognitive function w/modest exercise (walking 20 mins/day).

Brains change over time...

Neural Plasticity

Auditory deprivation effect

Auditory acclimatization

Learning

Memory

Maturation

Efferent Nervous System

Cognitive Reserve

Managing The Aging Process:

Neurogenesis:

**Amygdala, Hippocampus.
(emotions & memory)**

**Halpern (2008) exercise, diet,
thinking, thought, puzzles and
cerebral work can help promote
neurogenesis in adults and can help
maintain a healthy brain.**

ASHA 2005...

**Training should exploit plasticity
and cortical reorganization.**

Train the brain.

Hearing is a sense,

listening is a skill.

We can teach & learn skills

Technology's Role?

Sensory-based percepts drive the process.

**If we maximize BU signal,
TD functions are easier & more efficient.**

Improved opportunity for LISTENING SUCCESS!

Our Challenge:

Beyond hearing.

**Improve the opportunity for
Listening Success?**

**THE TWO MOST
IMPORTANT FACTORS
IN LISTENING SUCCESS**



Audibility

Signal-To-Noise Ratio (SNR)

Signal-To-Noise Ratio

Smaldino & Crandell (2000):

Normal hearing kids need 10 dB better SNR than adults to perform at the same level. Hearing impaired kids need an additional 15 dB SNR.

Weihing (2005):

SNR MAJOR component of listening success.

Oticon ♦ Amigo



FM Made
Friendly



FM: MAJOR ADVANTAGES...

Reduces effect of background noise

Reduces the effects of distance

Reduces the effect of reverb

(see Beck, Doty-Tamasula and Sexton 2006)

**What else can we do
to achieve
Listening Success ?**

Intelligent Application of Automatics:

Engage (if and only if) SNR improves

Digital Noise Reduction

International Journal of Audiology

Bentler, Wu, Kettel & Hurtig (2008, Vol 47):

**Digital Noise Reduction: Outcomes from
laboratory and field studies.**

Lab-based ratings of EASE OF LISTENING
showed digital noise reduction
SIGNIFICANTLY better for
listening comfort.

Digital Noise Reduction & Speech Enhancement

(Dillon, Ching & Golding in PEDIATRIC AUDIOLGY, 2008, by Madell and Flexer)

Multiple studies over decades show adults prefer noise suppression for speech comfort, and to make noise less salient (prominent), despite noise reduction having little or no effect on WRS.....

Noise Reduction & Speech Enhancement (paraphrased...) (Harvey Dillon, Teresa Ching & Maryanne Golding)

Spectral changes from noise suppression
ALWAYS improve speech.

Therefore, we tentatively recommend noise
reduction systems be routinely
enabled for children of all ages...
just like adults.

**Effects of Digital Noise Reduction on Speech Perception for Children With Hearing Loss (2010). Stelmachowicz, Lewis, Hoover...
Ear & Hearing, Vol 31, No 3**

16 children ages 5 to 10 yrs w/mild-to-moderately severe SNHL

Goal: To examine the effects of digital noise reduction.

Test Stimuli: Nonsense Syllables, Words, Sentences in Noise

CONCLUSION:

Consistent with previous studies, NR does **not** have negative effect on perception of nonsense syllables, words or sentences for these children using SNRs of 0, +5 and +10 dB.

Wireless:

High speed transfer of information.

High speed exchange of information.

True binaural fittings.

Bluetooth, NFM,

Compare & Contrast R & L

What else can we do
to achieve
Listening Success ?

Feedback Management

Evolution of Feedback Approaches



- Turn down volume



- Limit the High Frequencies



- Notch the Response



- True Cancellation

What else can we do
to achieve
Listening Success ?

Extended Bandwidths in Hearing Aids
Beck & Olsen, Hearing Review,
October 2008

Improved spatiality.

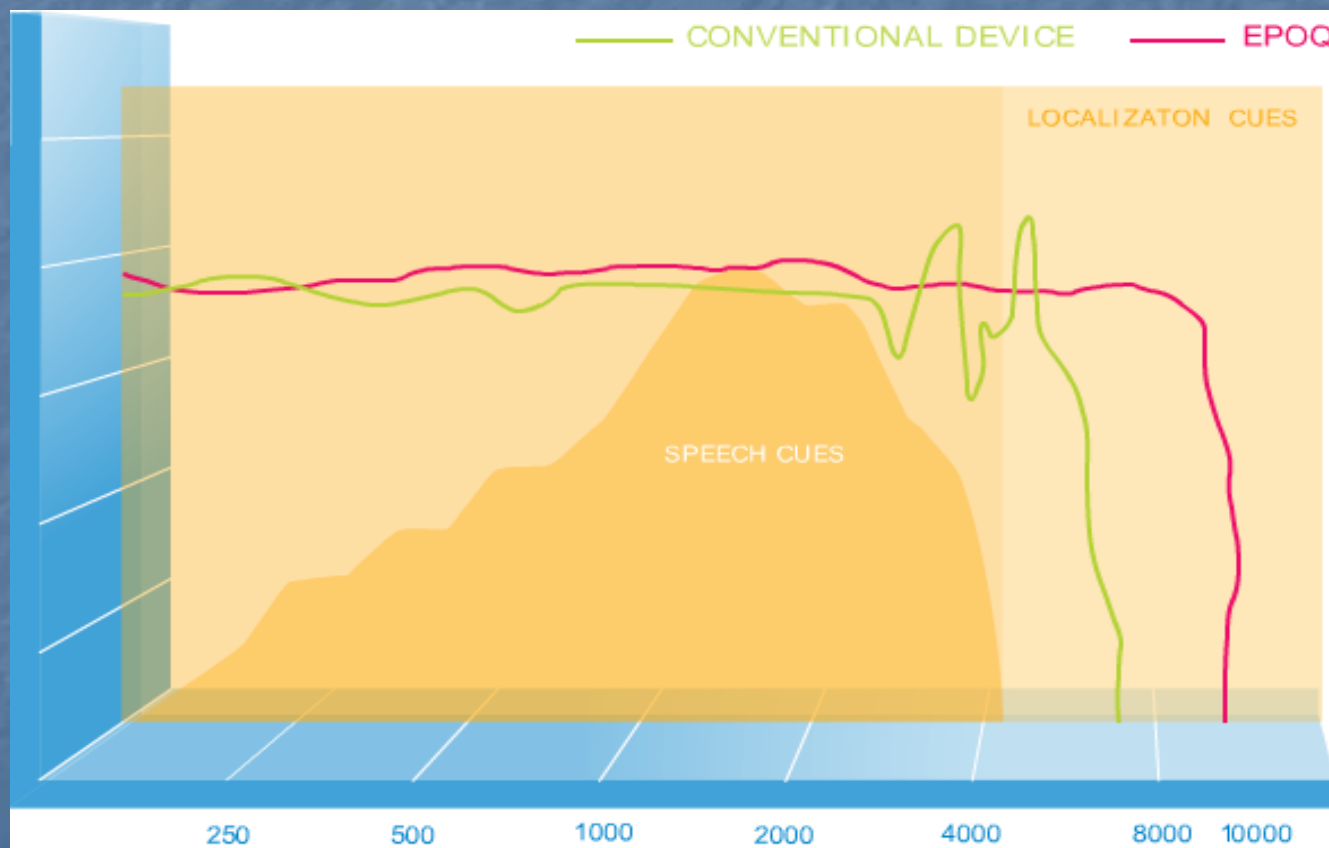
Improved Speech-in-Noise.

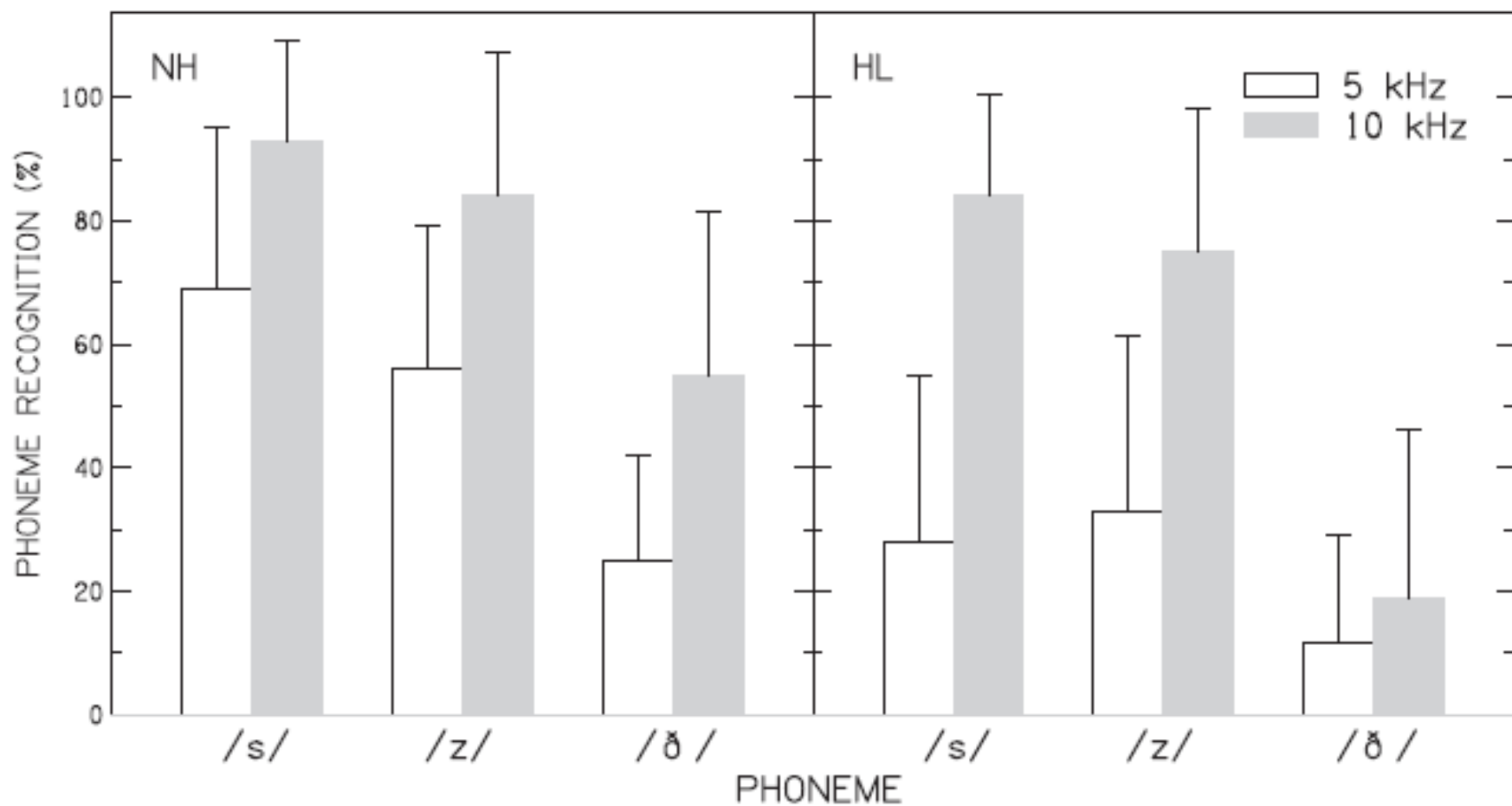
Improved Word Recognition Scores.

Improved music perceptions.

Improved sound quality.

Bandwidths to 10 kHz





What else can we do
to achieve
Listening Success ?

Directionality

Effective in a limited set of conditions

Speech in front, nearby.

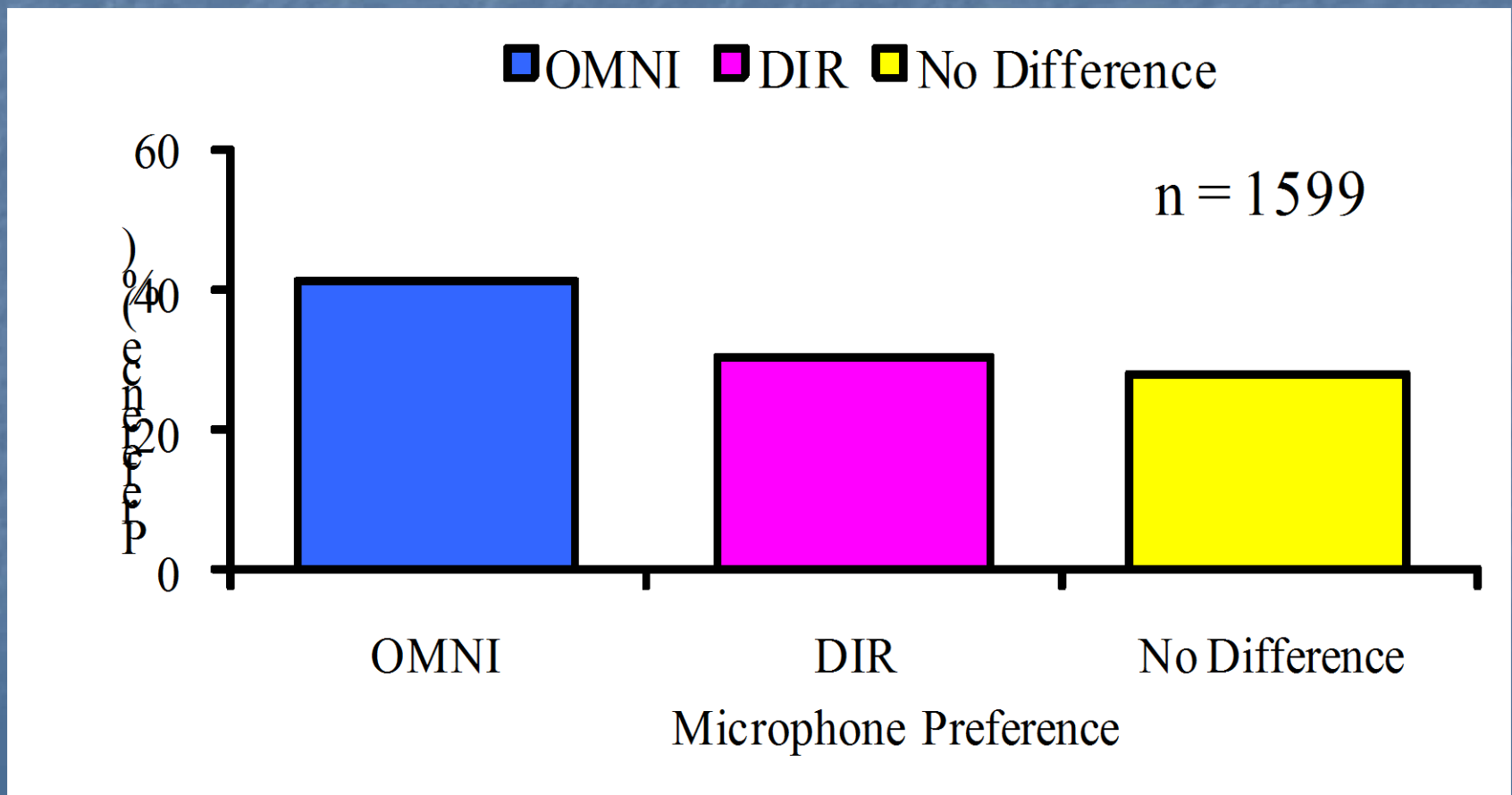
Noise present, back & side.

Reverberation not excessive.

(Walden et al 2003)

Microphone Preferences Across All Listening Situations

Walden, Surr, Cord & Drylund, 2003



Directional Microphones (paraphrased...)

(Harvey Dillon, Teresa Ching & Maryanne Golding)

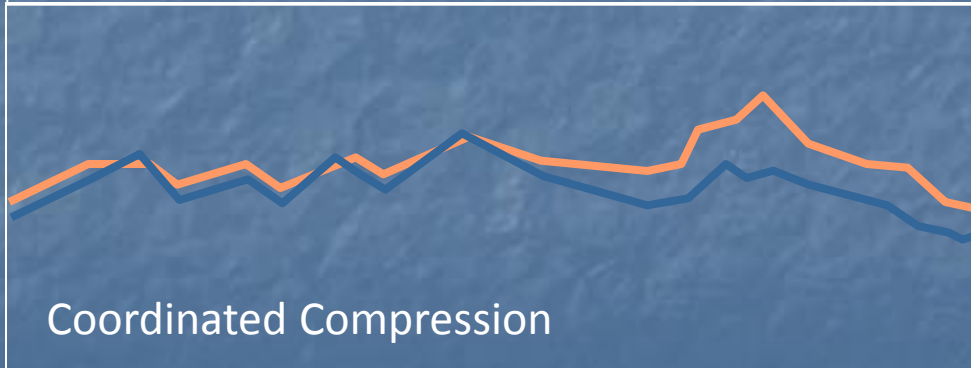
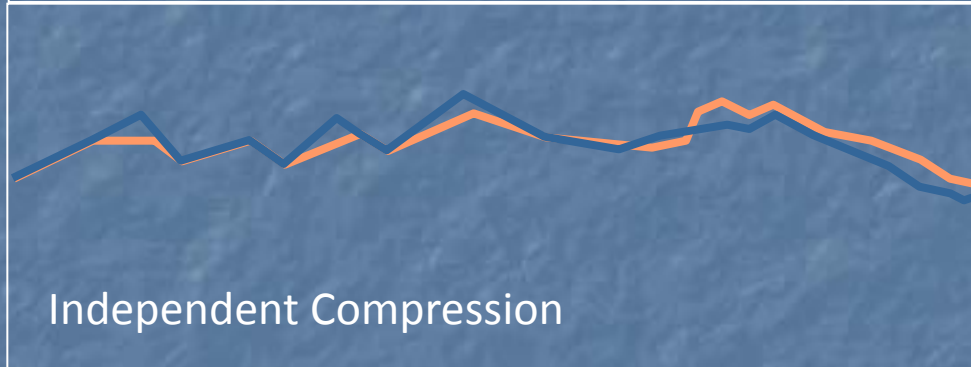
As of 2008, results at NAL based on efficacy of directional mics in real-life listening situations suggests...Once the child is old enough to turn their head to face the talker, enable directional mics to get better SNR.

Every sound has a spatial
signature

Yet we usually only address
spectral and amplitude
components.

New Compression Concept

**When two hearing aids
communicate,
coordinated compression can
better preserve spatial cues.**



Combining the best linear and
compression strategies?

What else can we do
to achieve
Listening Success ?

To understand speech in noise...

...identify the sound source

(what about traditional fits?)

Spatial Hearing and Understanding Speech in Complex Environments. Neher, Behrens & Beck. Hearing Review, Nov 08

Kidd et al (2005)...3 loudspkrs, 2 w/noise, 1 w/speech, knowing speech location increased correct response.

Schneider et al (2007)...similar to Kidd, knowing the location of the sound source helped attenuate impact of maskers.

Cameron et al (2006)...normally perceived spatial cues help suppress secondary signals (i.e., background noise).

Spatial Hearing.
Neher, Behrens & Beck.
Hearing Review, Nov 08

Three Primary Acoustic Cues for Spatiality:

Interaural Time Diff (ITD)

(< 1.5 kHz)

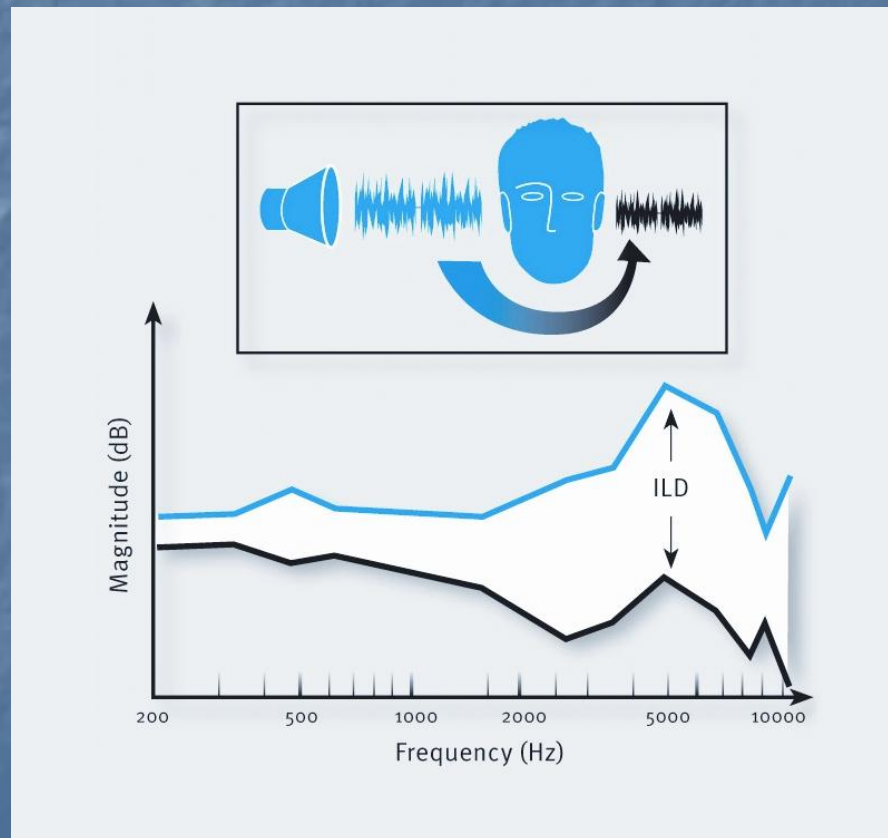
Interaural Loudness Diff (ILD)

(>1.5 kHz, can be 20 dB @ 6kHz)

Spectral peaks & notches

(mostly 4kHz and above)

**ILDs can be 5 dB at 1kHz,
20dB at 6 kHz**Based on Sivonen and Ellermeier (2006).
See: Behrens, 2008, Hearing Review, Vol 15, No 3, Pages 94-102



How important is spatiality?

What is the number one complaint of people (children in particular) with APD?

What is the number one complaint your patients tell you with regard to hearing aids?

What is the number one complaint that brings in your new patients?

Beck 2010...

Knowing WHERE TO LISTEN matters.

Michael Merzenich Ph D
British Academy of Audiology,
Liverpool, England, November 2009

NeuroScientist and Professor Emeritus UCSF

Known world-wide for brain plasticity research

PhD from Johns Hopkins Medical School (Physiology)

Recognition and Prizes from:

National Academy of Sciences

Ipsen Prize, Zulch Prize from the Max-Plank Institute,

Thomas & Alva Edison Patent Award, Purkinje Medal..

Contributed to more than 232 publications

Merzenich Paraphrased (DLB):

Hearing correction NECESSARILY drives neurological change.

Cognitive changes are BROADLY reversible.

Brains continuously change via input and stimulation.

Brain plasticity is modulated by ATTENTION and WORKING MEMORY.

**With regard to the AUDITORY DOMAIN,
we can improve at any age.**

**The CAPACITY for POSITIVE BRAIN CHANGE is
largely UNDER APPRECIATED.**

Cognition & Audition:

When we provide extended high frequencies, spatial cues, noise reduction, adaptive directionality, we provide a better bottom-up stimuli.

When the bottom-up signal is maximized the top-down system requires less brain power trying to untangle the input, communication is maximized.

Cognitive Friendly Amplification:

Hearing aids that maximize the SNR.

Hearing aids with directionality.

Hearing aids with extended bandwidth.

Hearing aids that preserve spatial cues.

Hearing aids that decrease annoyance.

Hearing aids that provide binaural hearing.

Hearing aids that people will wear.

Questions?

Download slides at
www.ihinfo.org/convention



59th
Annual **INS**
CONVENTION
& EXPO

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Thank you!

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PEOPLE FIRST