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 with normal hearing and 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).
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.

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...
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).

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 hearing 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.
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.
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

\[ C = P + S \]

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

Exercise increases neurogenesis.

demo’d conclusively late 1990s by Dr. Fred Gage, Salk Institute.
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.
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

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

OMNI: 41%
DIR: 31%
No Difference: 28%

n = 1599
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?)
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).
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?
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.ihsinfo.org/convention
Thank you!

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