Aging
&
Making Sense of Sound

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Disclosures

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Equity in Synaural, Inc., a company working to develop a user-friendly measure of auditory processing.

Conflicts of interest:
None
Aging and Making Sense of Sound

**EAR**
- presbycusis
- hair cell damage
- synaptopathy

**BRAIN**
- central hearing loss

**Action:** feed the brain the best signal from the ear

**Action:** activities to promote CNS strength and plasticity

**Factors that make an older adult successful at hearing in noise**
SOUND...
Attributes of a “seen” object

Shape ... sphere

Dimensionality ... 3D

Color ... yellow

Solidity ... yes

Pattern ... none

Movement ... no

Transparency ... no

Texture ... fuzzy

concrete
Attributes of sound

- Pitch: high
- Intensity: loud
- Timbre: crunchy
- Timing: fast
- Consonance: dissonant
- Attack: gradual
- Location: straight ahead
- Movement: left to right

abstract fleeting
Auditory Processing Speed

< 1 ms!

Left Ear  Auditory Brain  Right Ear
Auditory system

Cochlea → CN → SOC → NLL → IC → MGB → Aud. Cortex

visual system

Retina → lateral geniculate → Vis. Cortex

connectivity to non-auditory centers

Malmierca, Encycl Comput Neurosci 2015
Making sense of sound

Kraus & White-Schwoch, Trends Cog Sci, 2015
Normal Inner Ear

Auditory Nerve

To Brain
To Brain

Damaged Hair Cells and Synapse

Auditory Nerve

Damaged Synapse

Kujawa & Liberman J Neurosci 2009
Take ear and brain into account

Individualized biological data
otoacoustic emissions

Hz

dB

kHz

25 5 1 4 8 16

audiometry

QuicksIN HINT WIN

audiometry

rat
AGING

HEARING IN NOISE
Hearing in Noise engages Cognition

Moore et al., 2014, PLoS ONE
Hearing in Noise - Sound Processing in the Brain

Normal Hearing Thresholds

- Excellent
- Poor

Adults with normal hearing thresholds

Time (ms)
Hearing in Noise - Sound Processing in the Brain

Hearing Loss

Older Adults - Hearing Loss
COGNITION

Memory
Attention

SOUND PROCESSING in the BRAIN
Pitch, Timing, Harmonics

LIFE EXPERIENCES
Music
Exercise

EAR
Audiogram
OAEs

Anderson et al (2013) Hear Res
Biological Aging

Breakdown in timing
Reduced inhibition
Increased spontaneous activity
Broader spatial tuning
Reduced cortical connectivity for spatial processing

Anderson et al., J Neurosci 2012
Caspary et al., J Exp Biol 2008
Engle & Recanzone, Front Aging Neurosci 2013
Recanzone et al, Hear Res 2011
Juarez-Salinas et al, J Neurosci 2010
Compensatory neurochemistry - protein expression

Reduced inhibition throughout auditory pathway

Reorganization of auditory and visual areas

Sharma & Glick Brain Sciences. 2016
Engle & Recanzone, Front Aging Neurosci 2013
Overton & Recanzone J Neurophysiol 2016
Hearing loss impacts cognition

![Graph showing the relationship between age and cognition with and without hearing loss.](image)

Lin et al. (2013) JAMA Int Med
Lin et al. (2014) Neuroimage
Feed the brain the best input possible
Hearing aid/device fitting
informed by biology

Unaided

Aided

Amplification boosts neural synchrony

Anderson et al. (under review)
Hearing device/processing strategy

Automated Fitting

Collect EEG to dozens of algorithms to find the best fit for the brain

That's the one!
HEALTHY AGING
STRENGTHENING SOUND PROCESSING

Lifelong

Initiated later in life

BILINGUALISM

MUSIC

Bien, gracias.

你怎麼樣？
Cognition strengthens sound processing consequences for hearing in noise.
HEARING IN NOISE

quiet

noise

review: Kraus & White-Schwoch, Neuroscientist, 2016
Initiated later in life

Listening in noise

pre

post

**

dB SNR

Neural response to sound

Fo

pre

post

* 

Russo, 2016, WCA Ryerson University; Neuromusic 2017
Initiated later in life

75 older adults

Brain Fitness Program

Pre-Testing

Educational Videos

Post-Testing

Anderson et al. PNAS, 2013
Anderson et al. Front Sys Neurosci, 2013
Initiated later in life

Hearing in Noise

- **Better** dB
- **All subjects**
- **Hearing loss**

Biology

- controls
- Brain Fitness
- neural timing

Anderson et al. PNAS, 2013
Anderson et al. Front Syst Neurosci, 2013
Caspary Ear and Hearing
Biological Aging is Individual

Variability

Neural sound processing

Skoe et al., Cerebral Cortex, 2015
Gray and Recanzone Evolution of Nervous System 2017
Summary

Nurture Eyes and Ears for healthy aging
Biology can inform training strategies, individualized care

Gaps

How does auditory aging begin?
- presbycusis?
- hair cell damage?
- synaptopathy?
- central hearing loss?
- combined effect of auditory and visual impairment?

What factors make an older adult successful at hearing in noise?
whole person care
Auditory Neuroscience Laboratory

Demonstration
Our Biological Approach