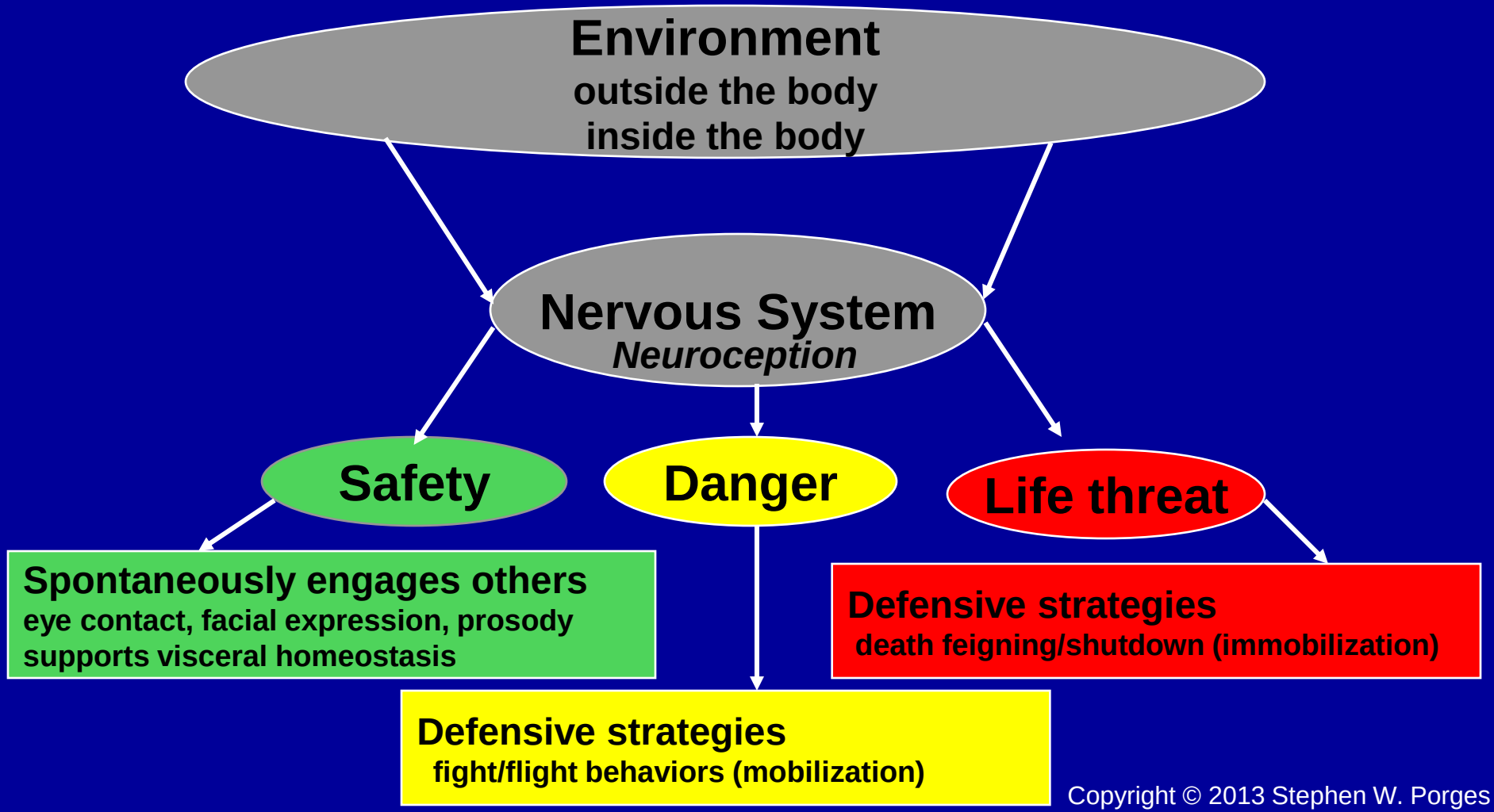
Music asTherapy: Part II

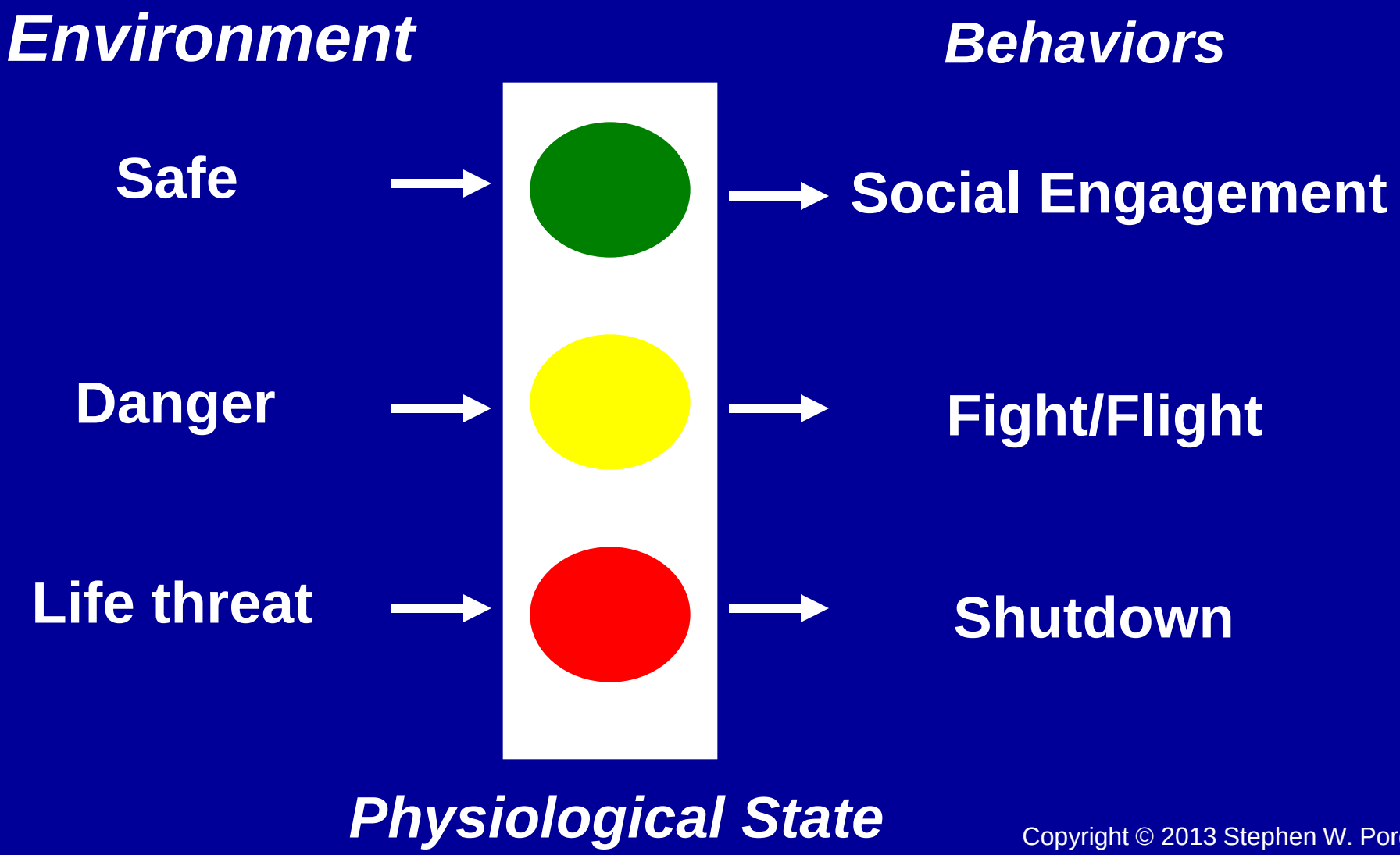
Exploring the common mechanisms mediating autonomic regulation, vocalizations, and listening

Stephen W. Porges, Ph.D.
Department of Psychiatry
University of North Carolina

The Quest for Safety:
Emergent Properties of Physiological State



Neuroception

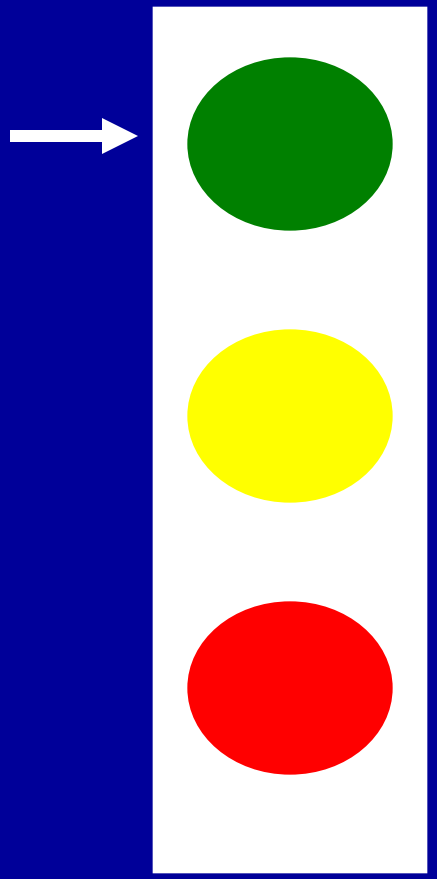


Neuroception

Environment

Behaviors

Safe



Social Engagement

Play

Loving Behaviors

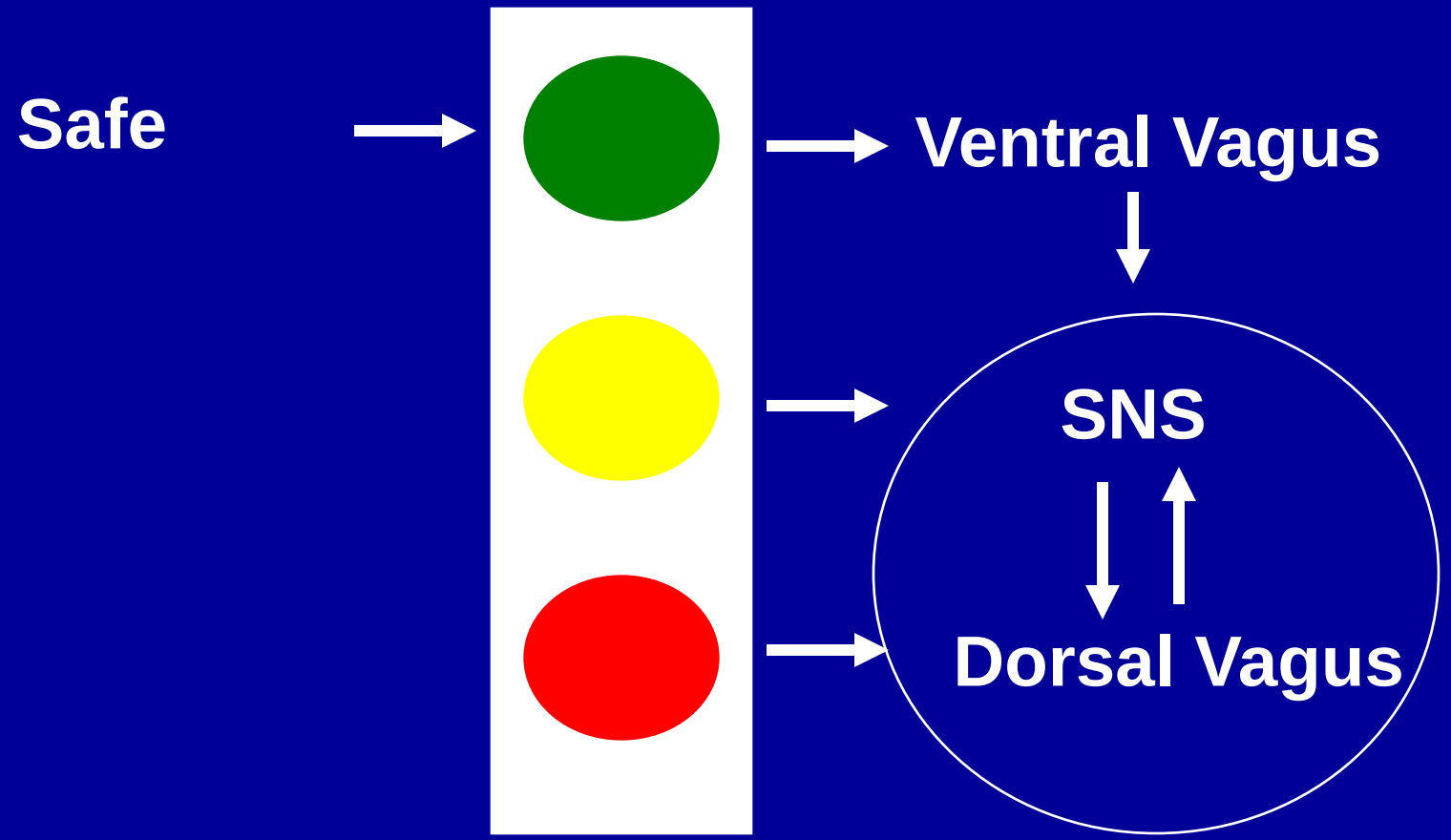
Physiological State

Neuroception:

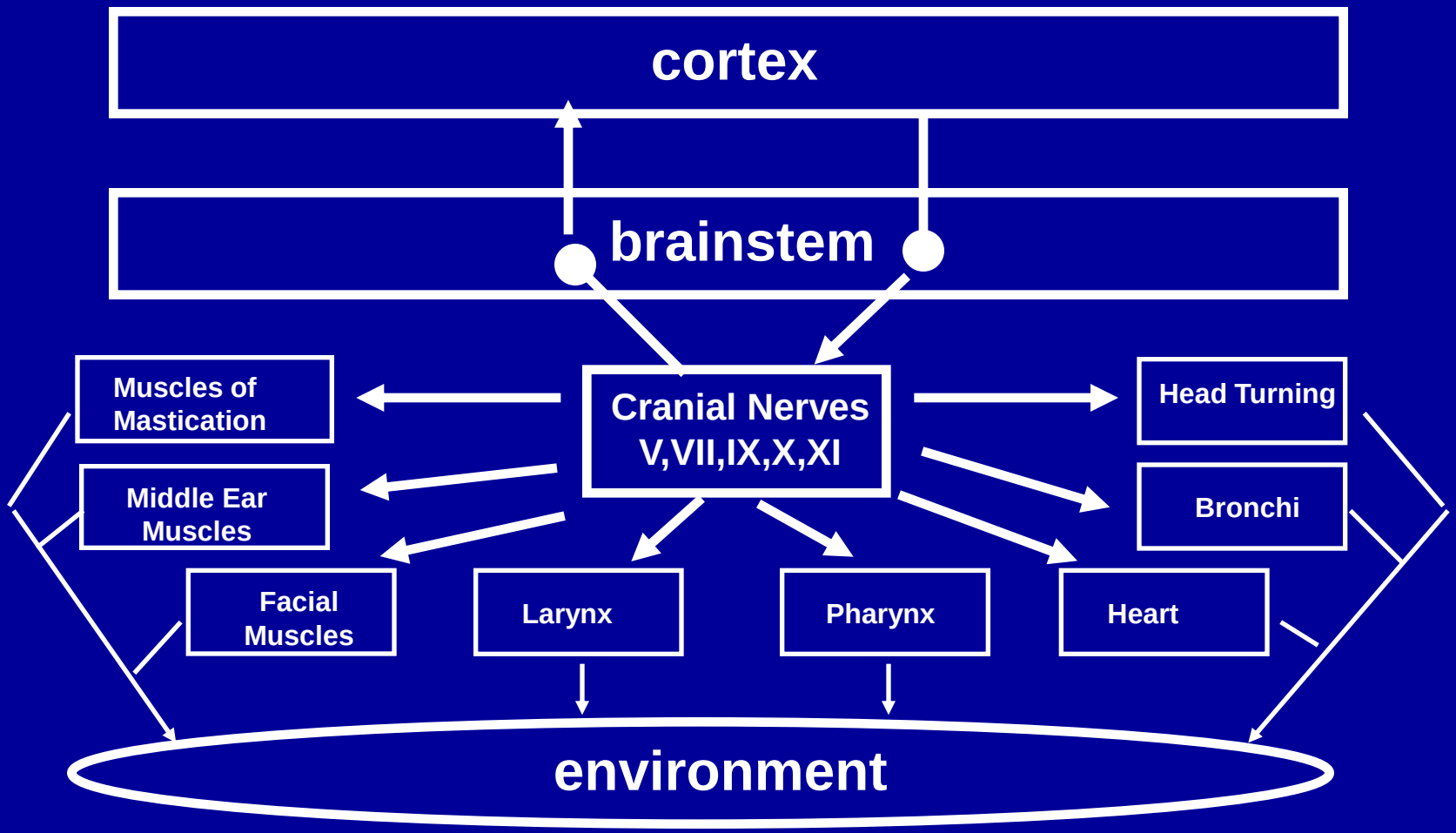
Promote mental and physical health

Environment

Visceral state



The Social Engagement System
(Mindfulness)



The Role of the Middle Ear:
Extraction of Human Voice

- Evolution and middle ear bones
- Transfer function of the middle ear
- Frequency band of perceptual advantage

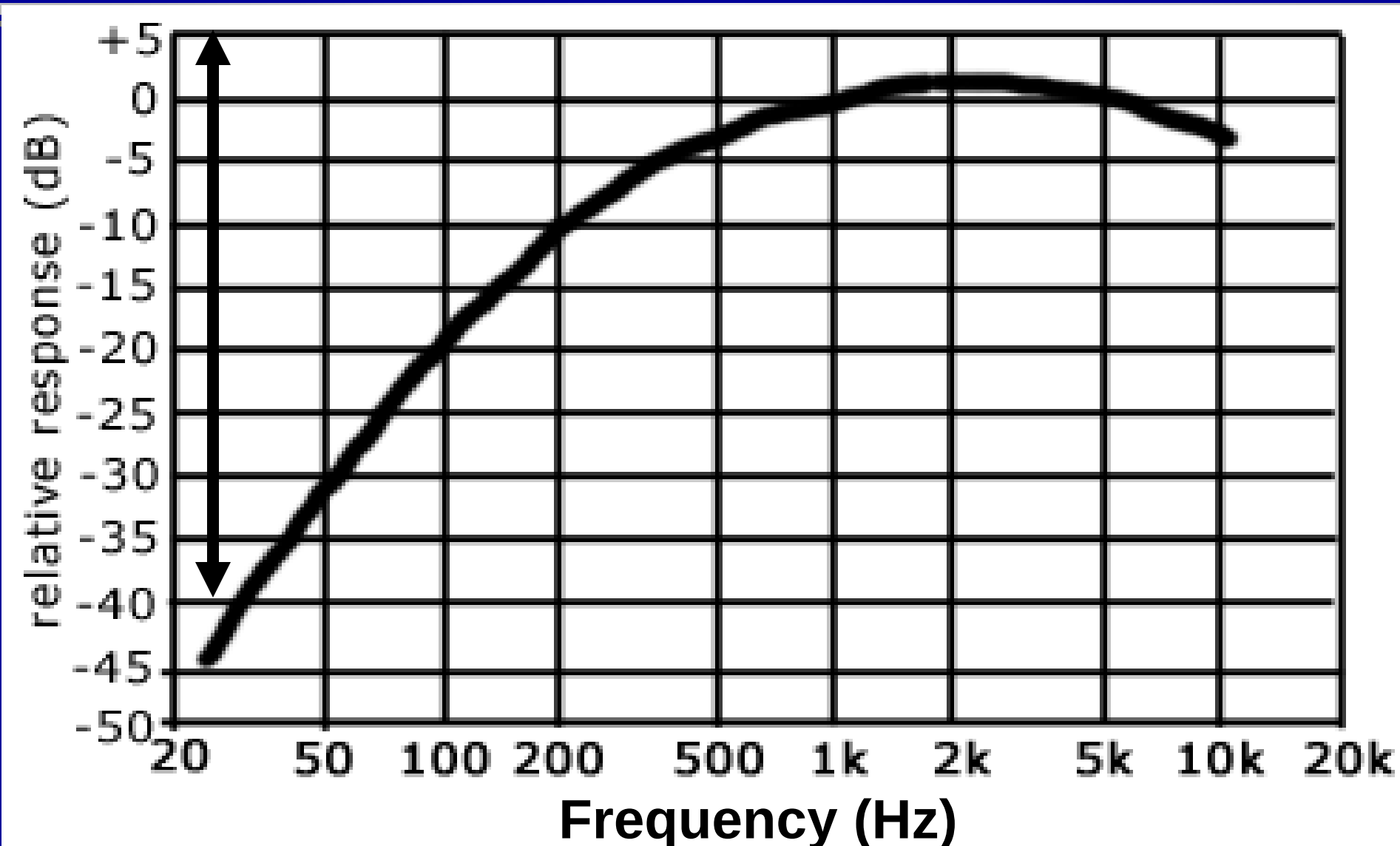
Detached Middle Ear Bone:
A mammalian feature

- Detached middle ear bones are a defining feature of mammals.
- Living mammal species can be identified by the presence in females of mammary glands. Since mammary glands and other soft-tissue features are not visible in fossils, detached middle ear bones are used.
- Without “detached” middle ear bones, low amplitude sounds in higher frequencies would not be heard. Thus, enabling mammals to communicate in a frequency band that is difficult to hear for reptiles.
- Without functioning middle ear muscles we are hypersensitive to the low frequencies that signal predator!

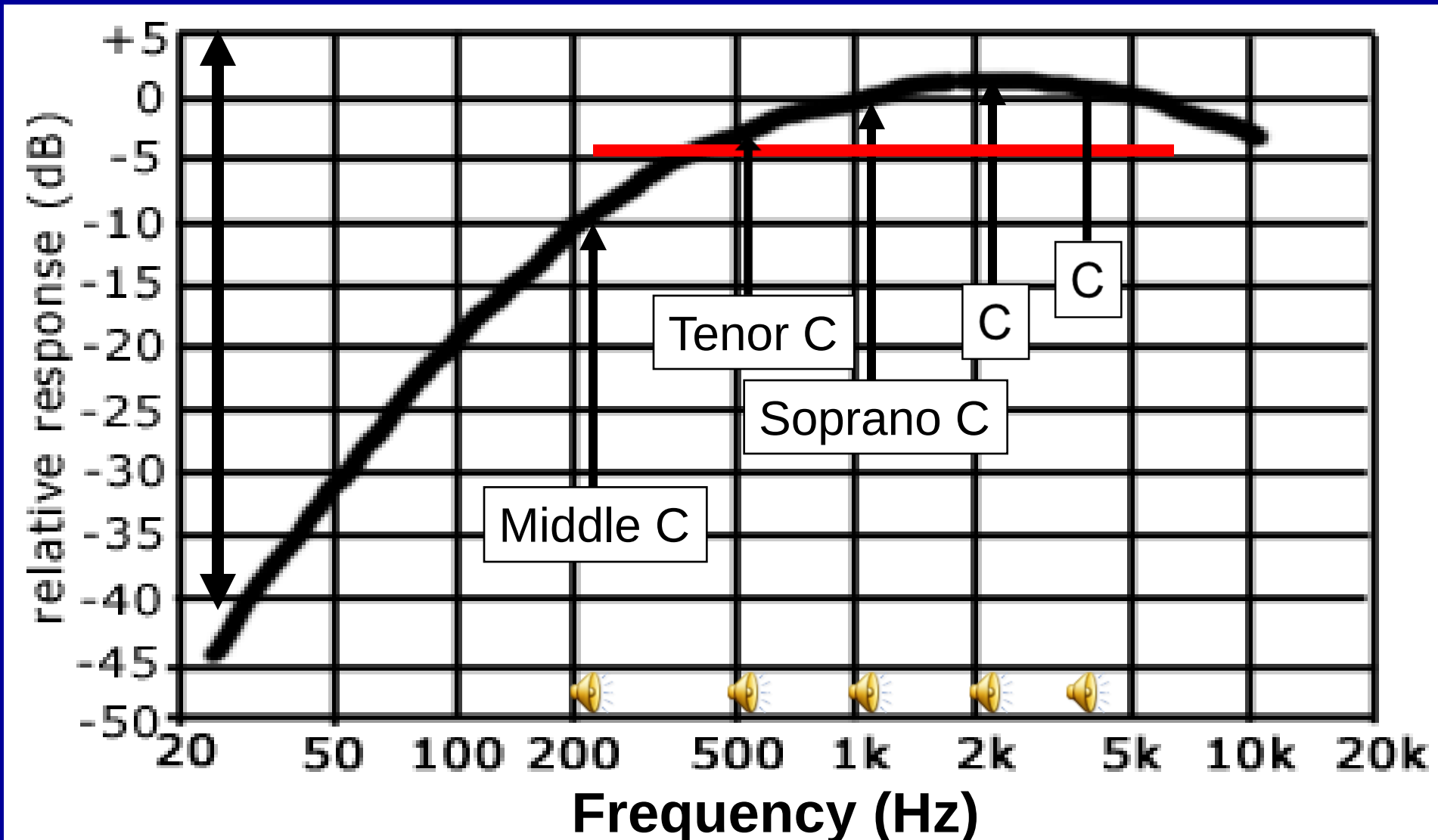
Bell's Palsy:
Lateralized Symptoms

- Drooping of the muscles of the face
- Inability to close the eyelid and to blink
- Difficulty chewing
- Twitching of the muscles
- Hyperacusis

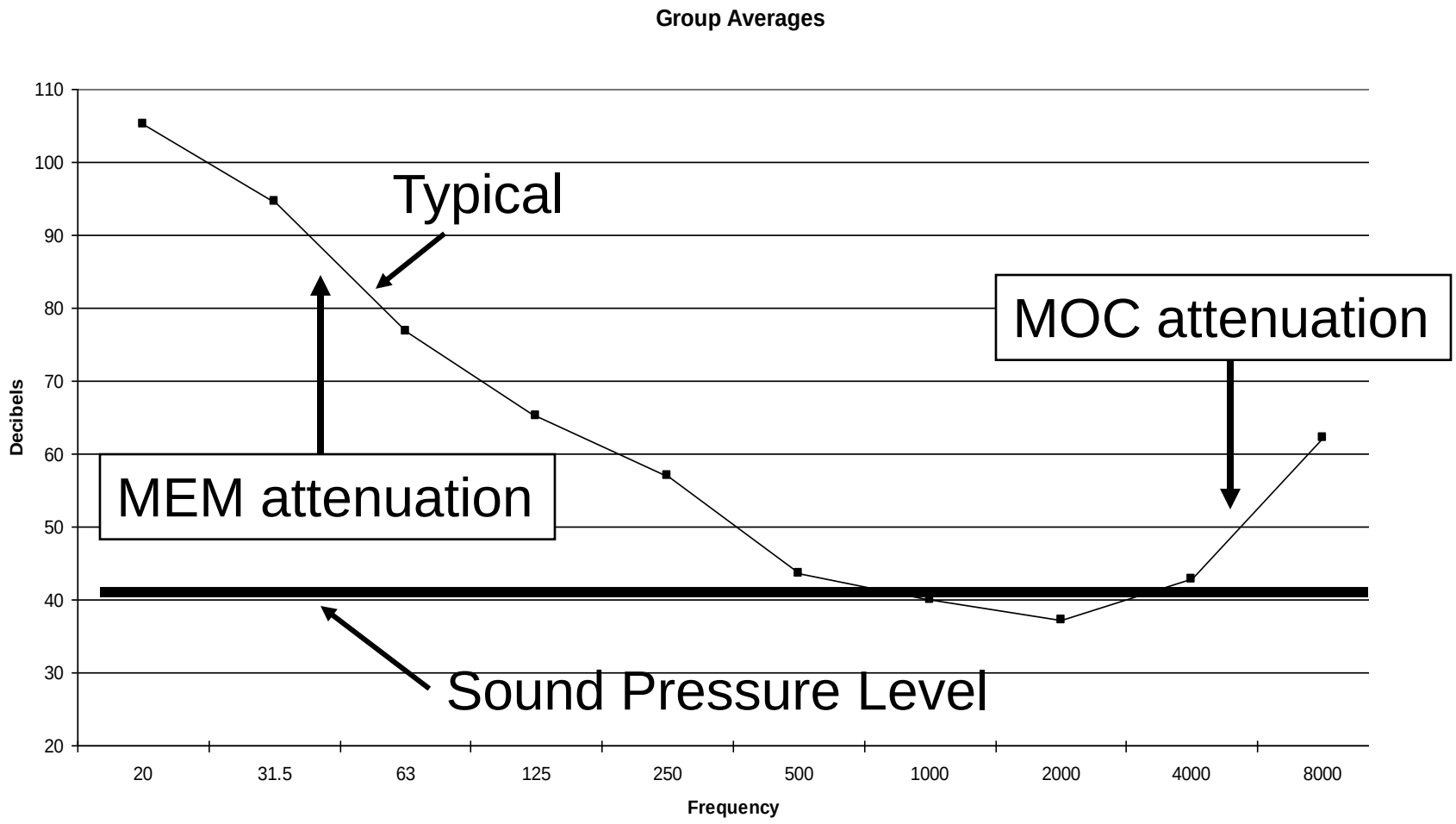
What Normal Ears Hear:
Low Frequency Attenuation



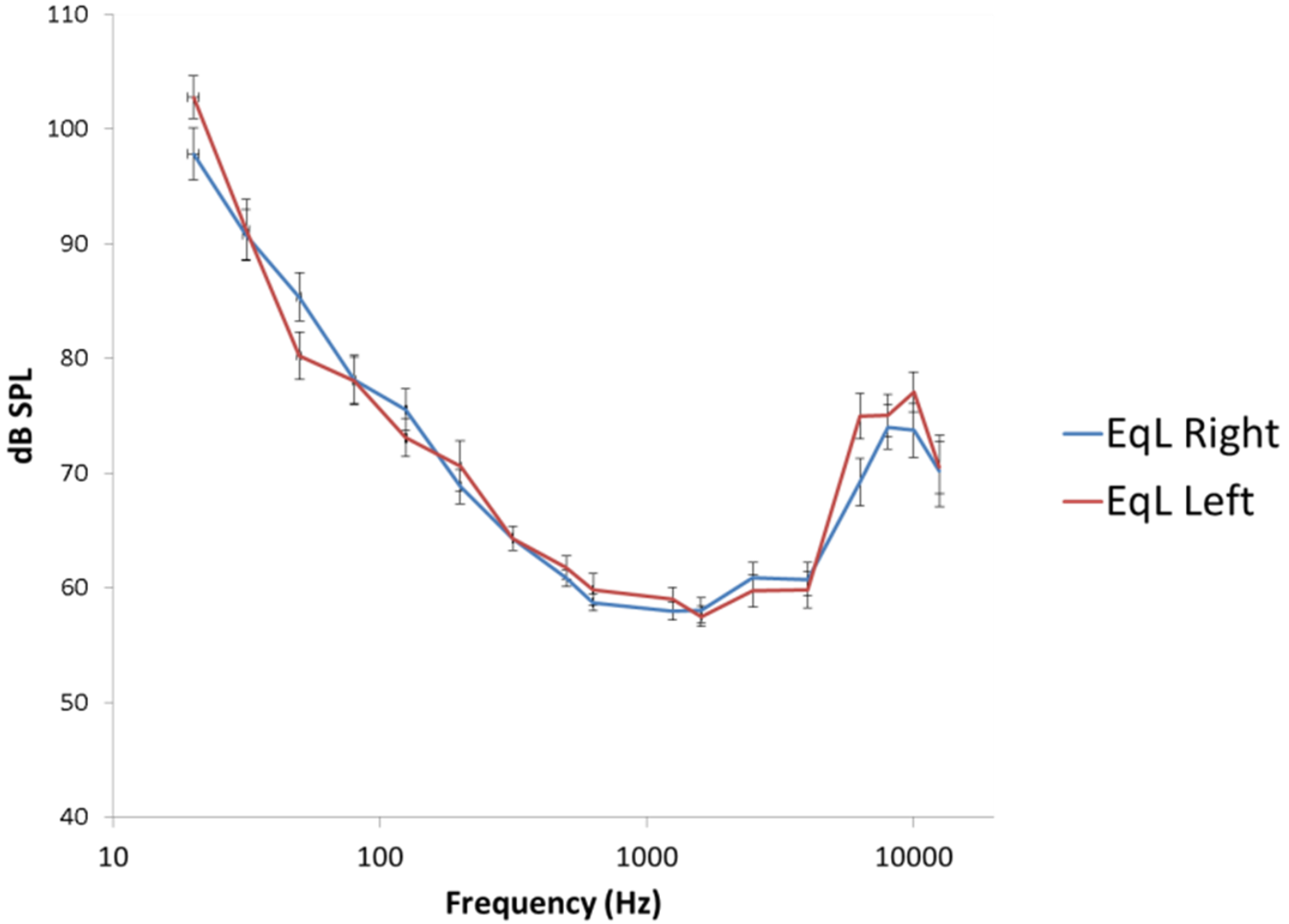
Articulation Index:
Determining intelligibility of voice



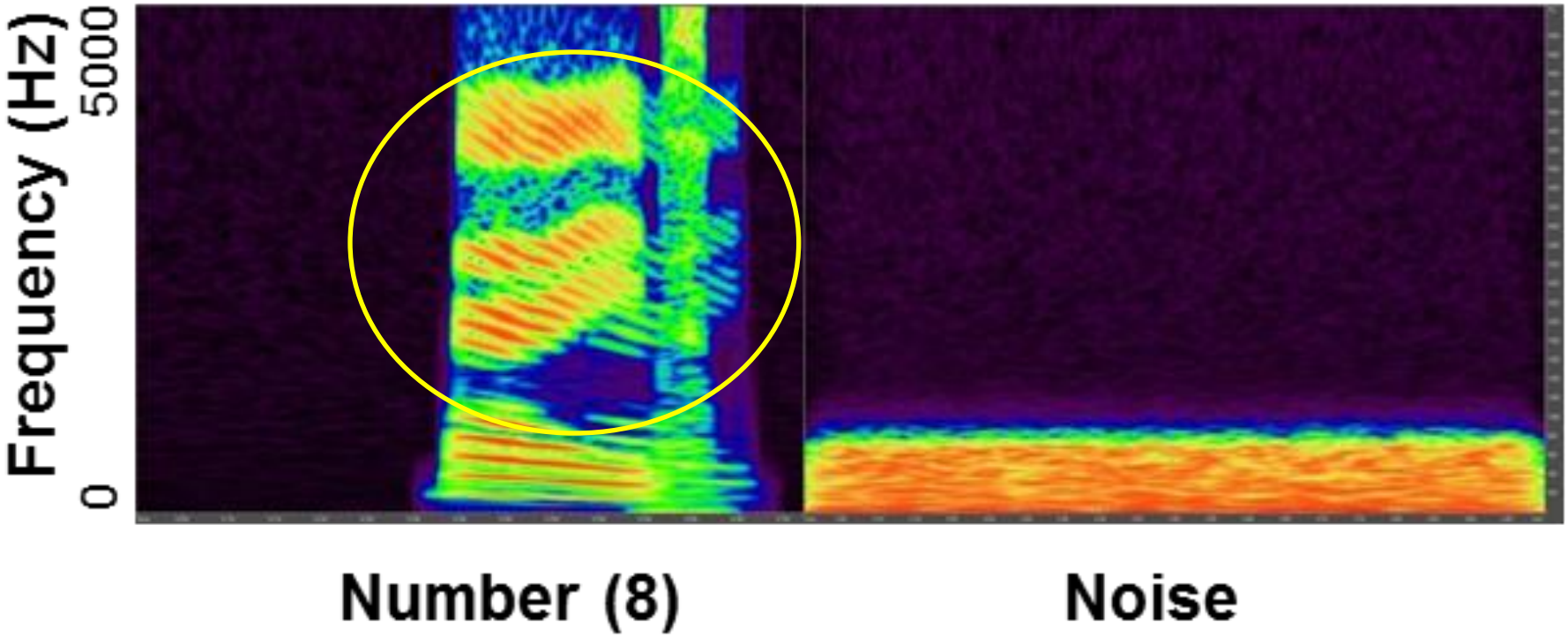
Equal Loudness Contours:



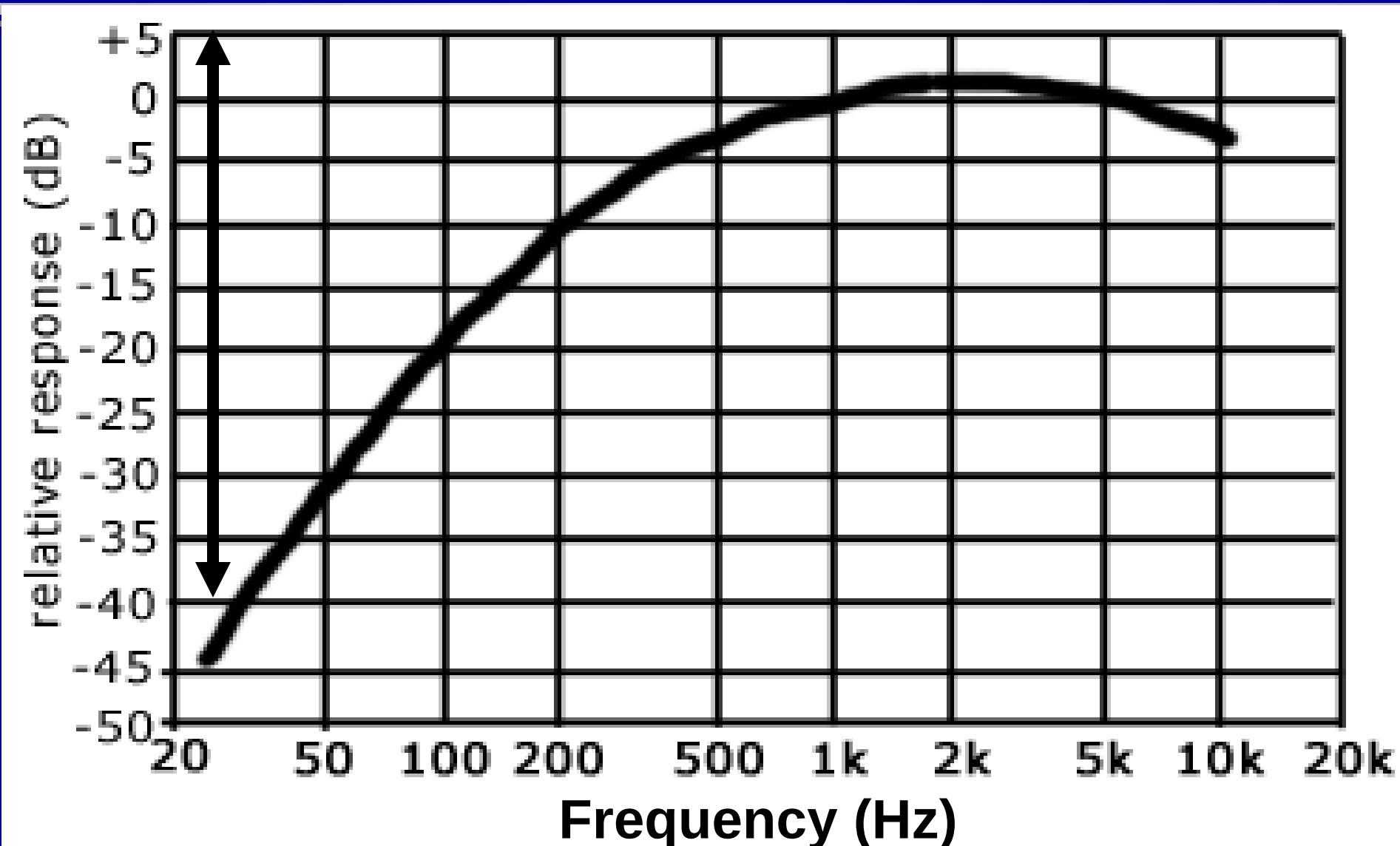
Equal Loudness Contours:



Frequencies of Social Communication



What Normal Ears Hear:
Low Frequency Attenuation



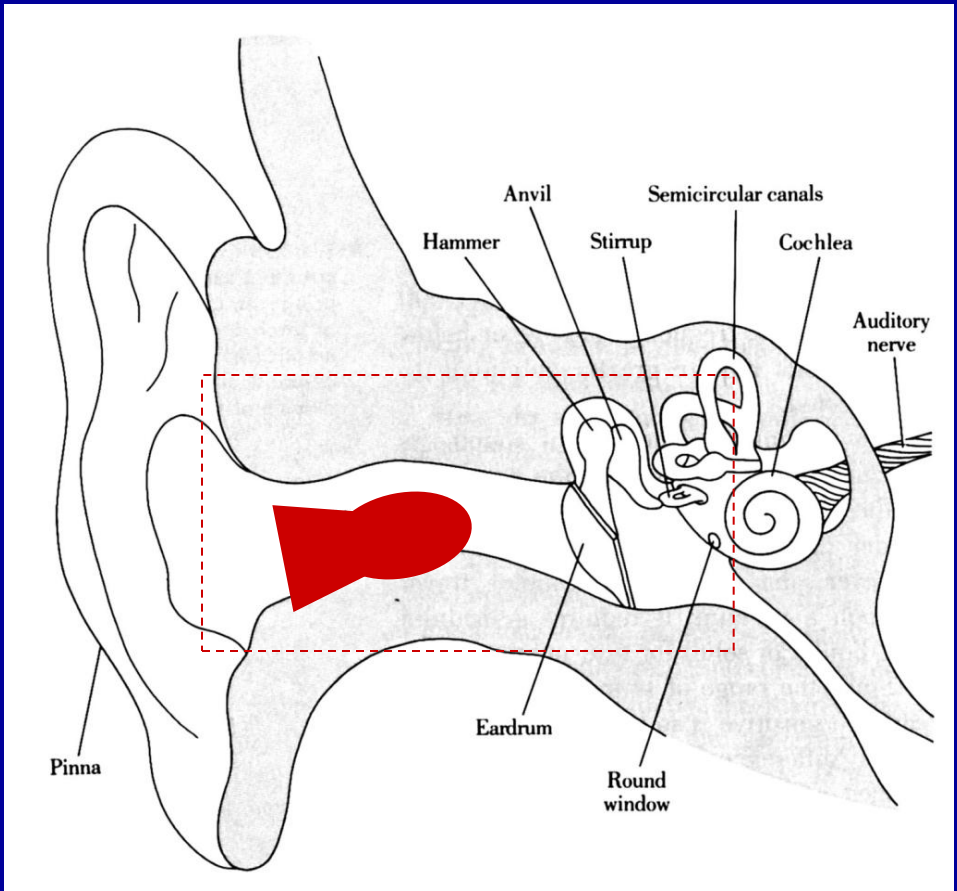
Auditory Anti-masking Mechanisms:

Extracting speech (music) from background sounds

- Function of the middle ear muscles (MEM)
  - » Attenuates low frequency sounds
- Function of the medial olivary-cochlear systems (MOC)
  - » Dampens high frequency sounds
- Consequences of MEM and/or MOC not functioning
- Relation of MEM to other physiological, neurological, psychological features
- Therapeutic “exercise” of MEM

Experimental Setup

Middle Ear Reflectance

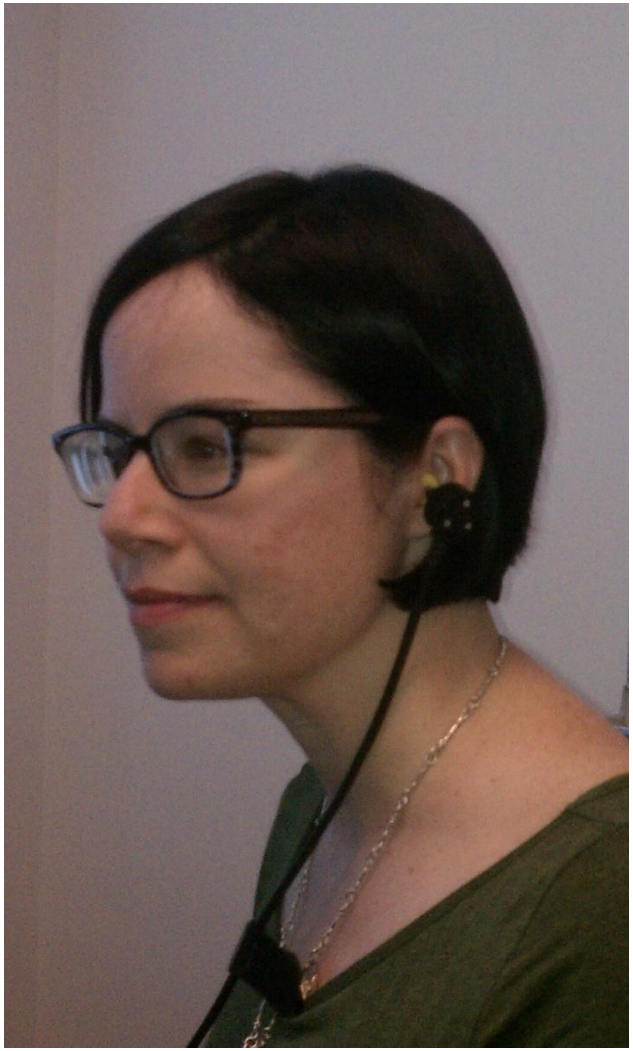


Perception

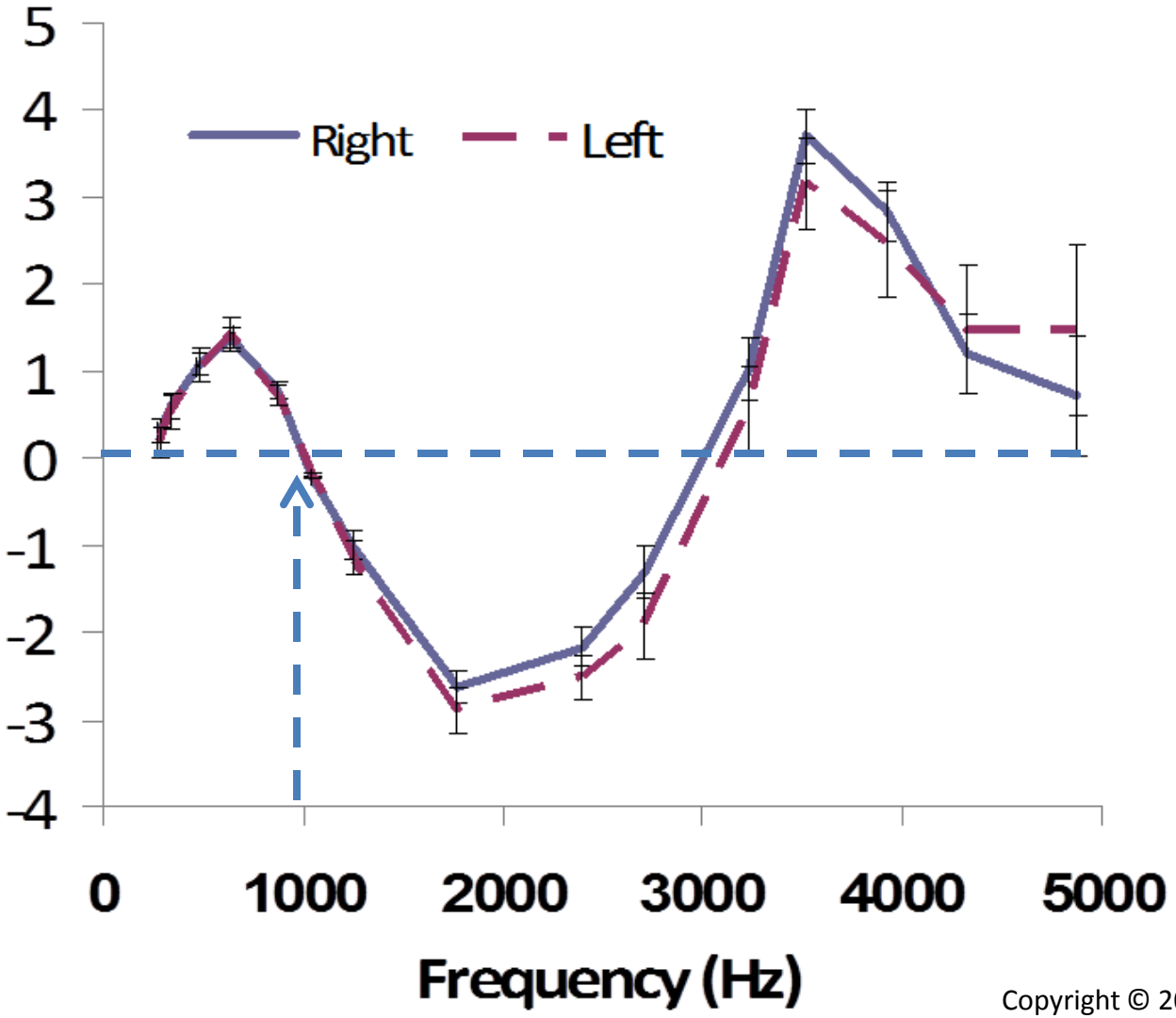
Monaural presentation and lateralized measurements of transfer function

Contrast with functional measures:

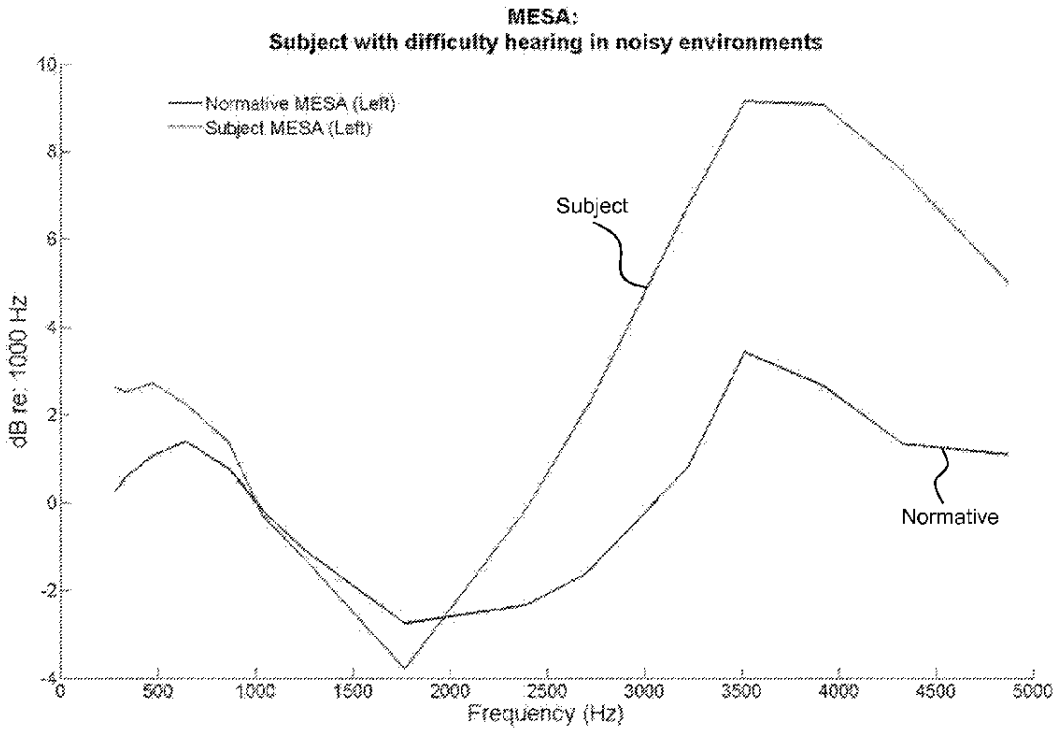
- Equal Loudness Contours
- Numbers in Noise



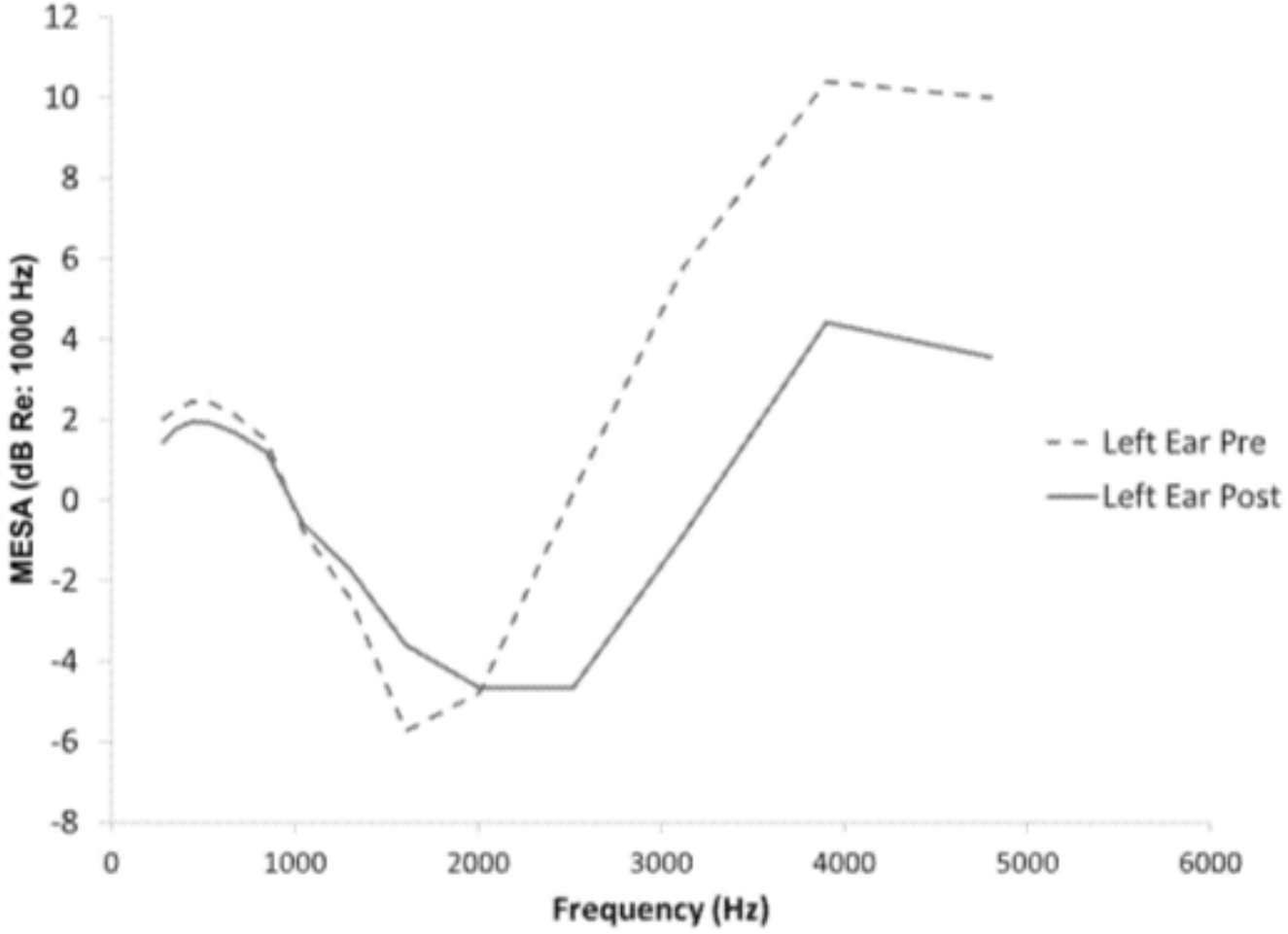
Middle Ear Sound Absorption



Title: METHOD AND APPARATUS FOR EVALUATING DYNAMIC MIDDLE EAR MUSCLE ACTIVITY

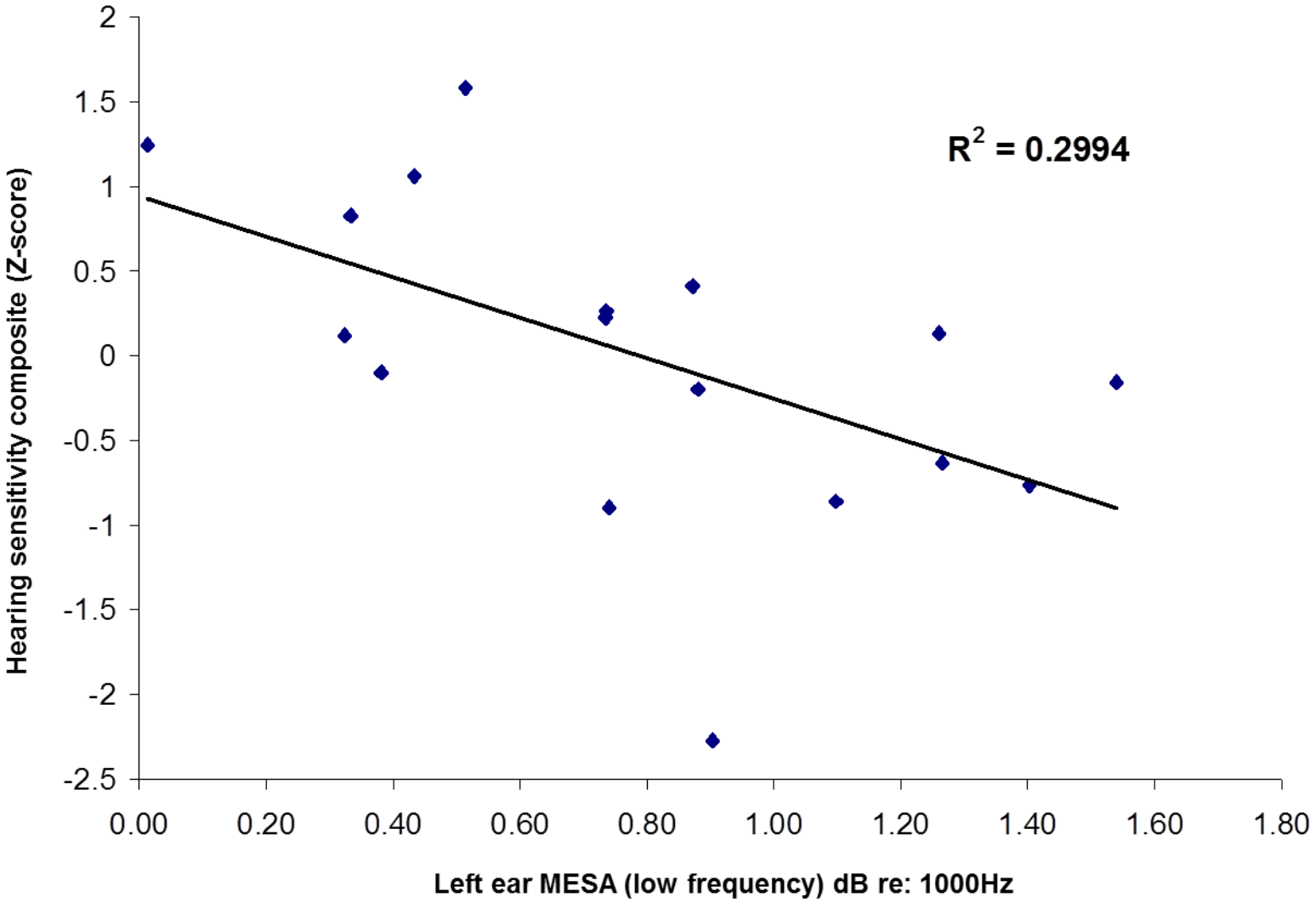


(57) Abstract: Provided are methods and devices for evaluating dynamic middle ear muscle activity in a subject. A probe is provided having a speaker and a microphone in sound-wave communication with an eardrum associated with the middle ear muscle of the subject. A sound wave is generated from the speaker and transmitted to the eardrum. The sound wave that is reflected is detected and a reflected sound wave property measured. The input sound wave may be comb input to fully extend ossicle movement in all available vibratory modes, thereby providing maximum information as to dynamic middle ear muscle activity.

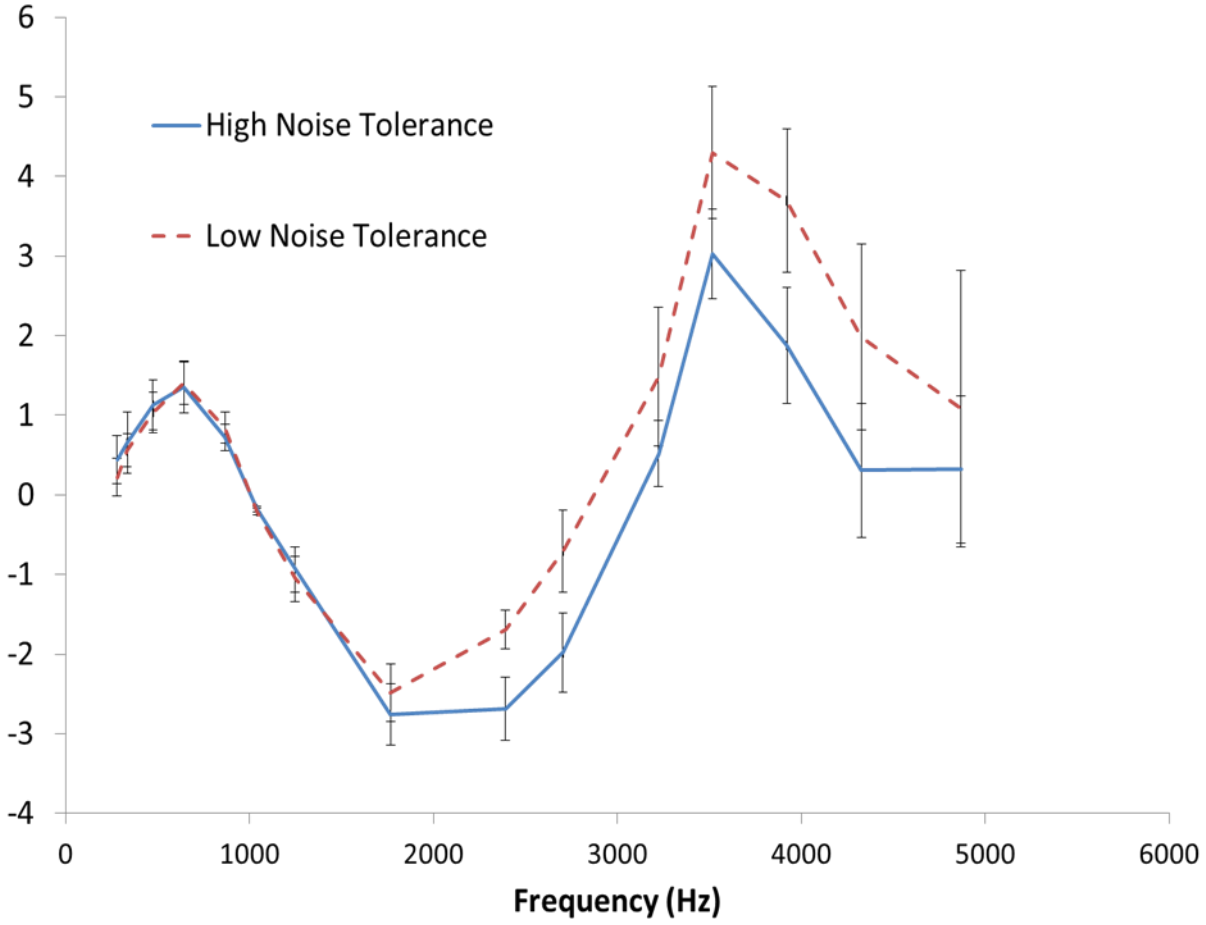

12
10
8
6
4
2
0
-2
-4
-6
-8
MESA (dB Re: 1000 Hz)
0
1000
2000
3000
4000
5000
6000
Frequency (Hz)
Left Ear Pre
Left Ear Post

Underlying Mechanisms of Auditory Hypersensitivities?

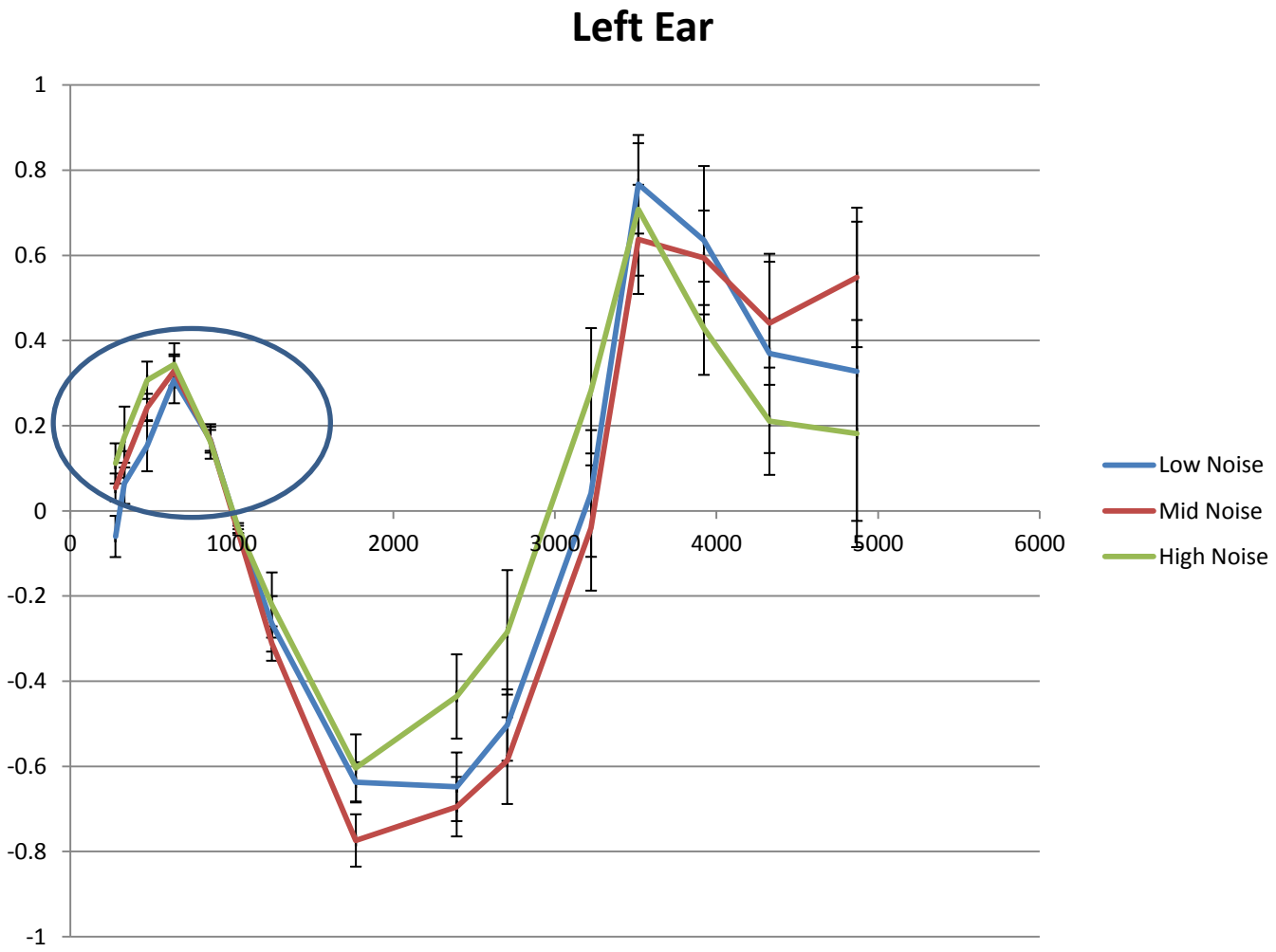
More reflected low frequency in left ear, less hypersensitivities to sound (self-report)



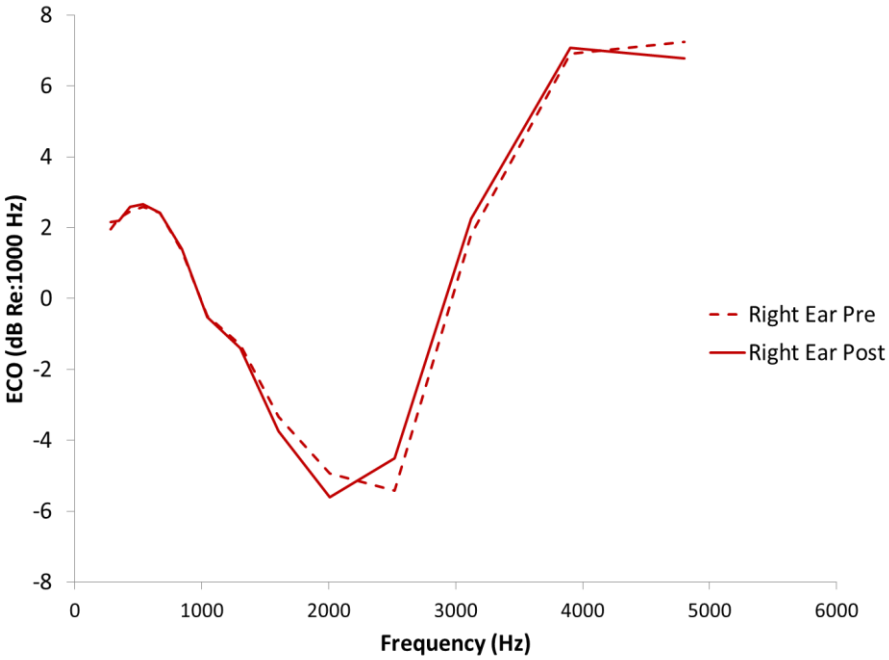
Greater middle ear muscle tension (greater mid-frequency absorption) , increased tolerance of noise (right ear)

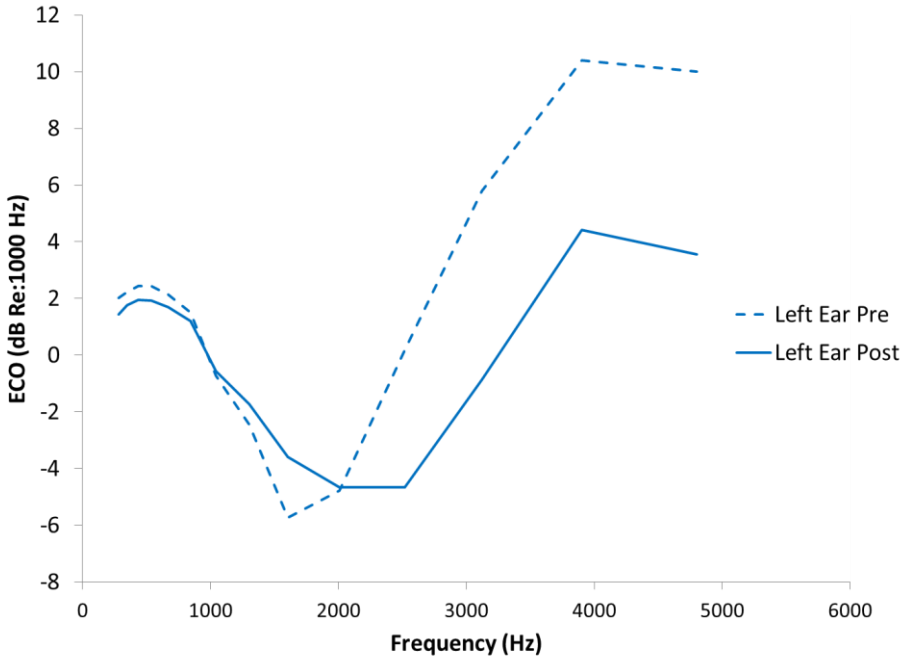


Greater middle ear tension (greater low frequency reflectance), increased tolerance for noise (left ear)

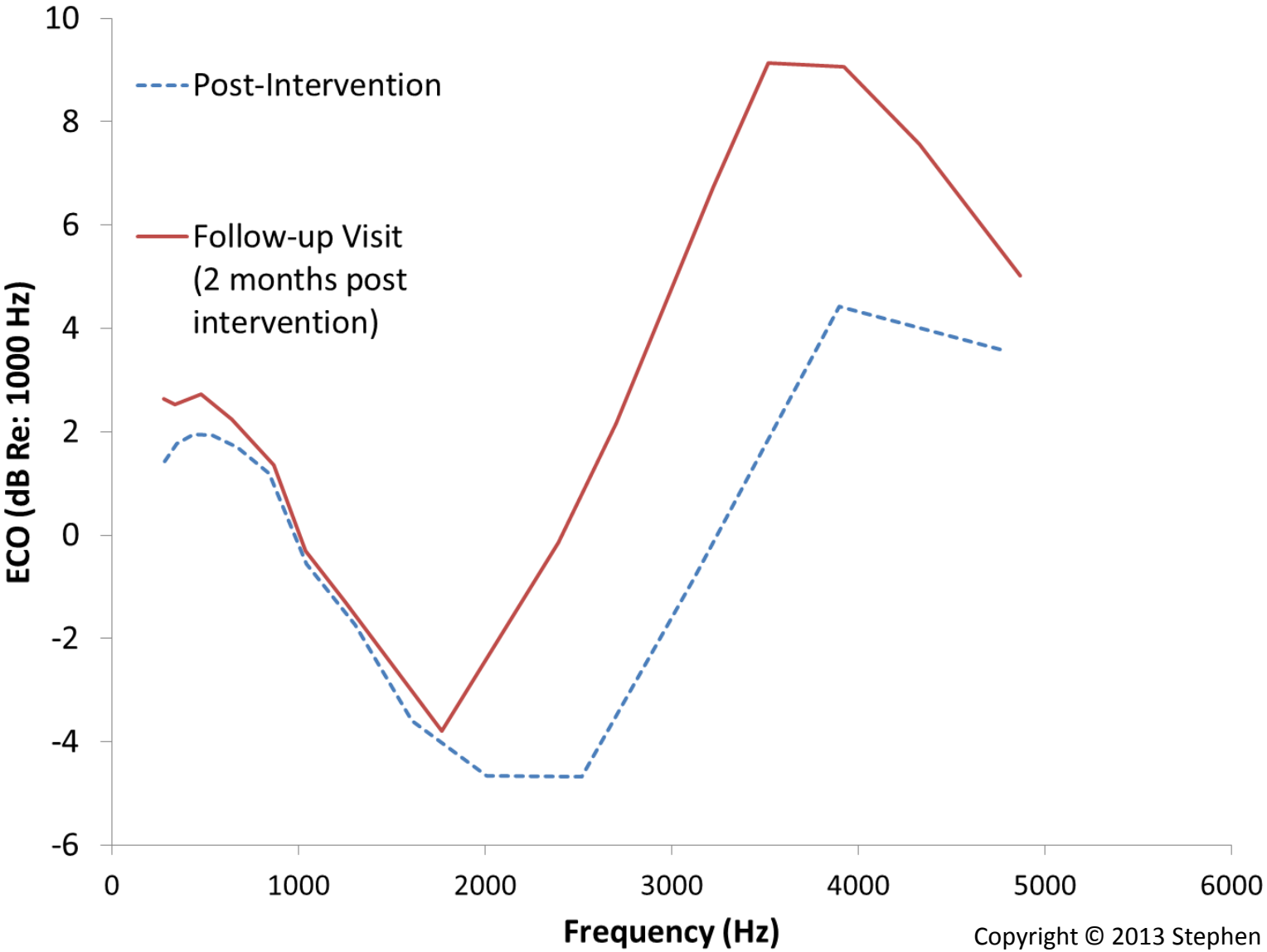


HAES001: Initial intervention. One week between measurements.

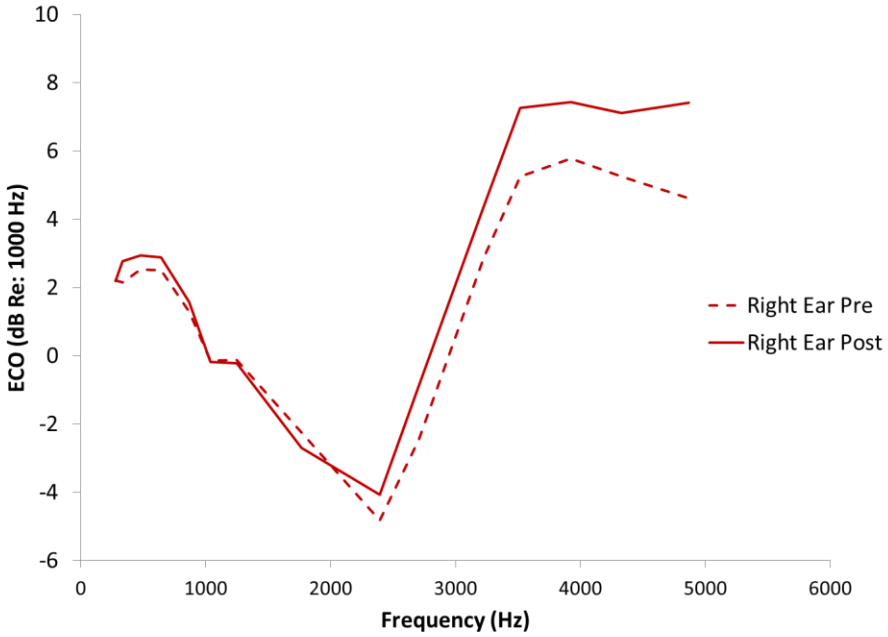


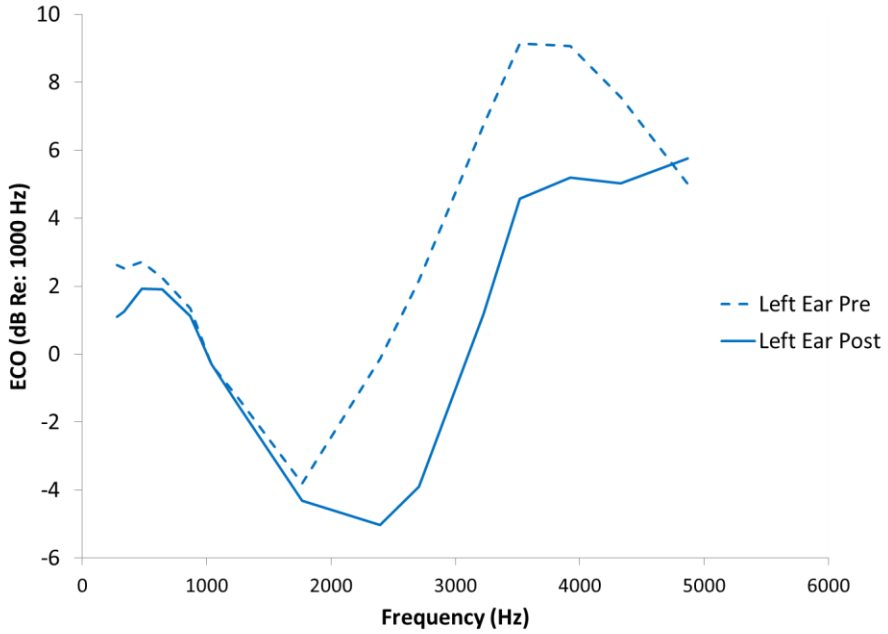


HAES001: Left ear. Two months between measurements.

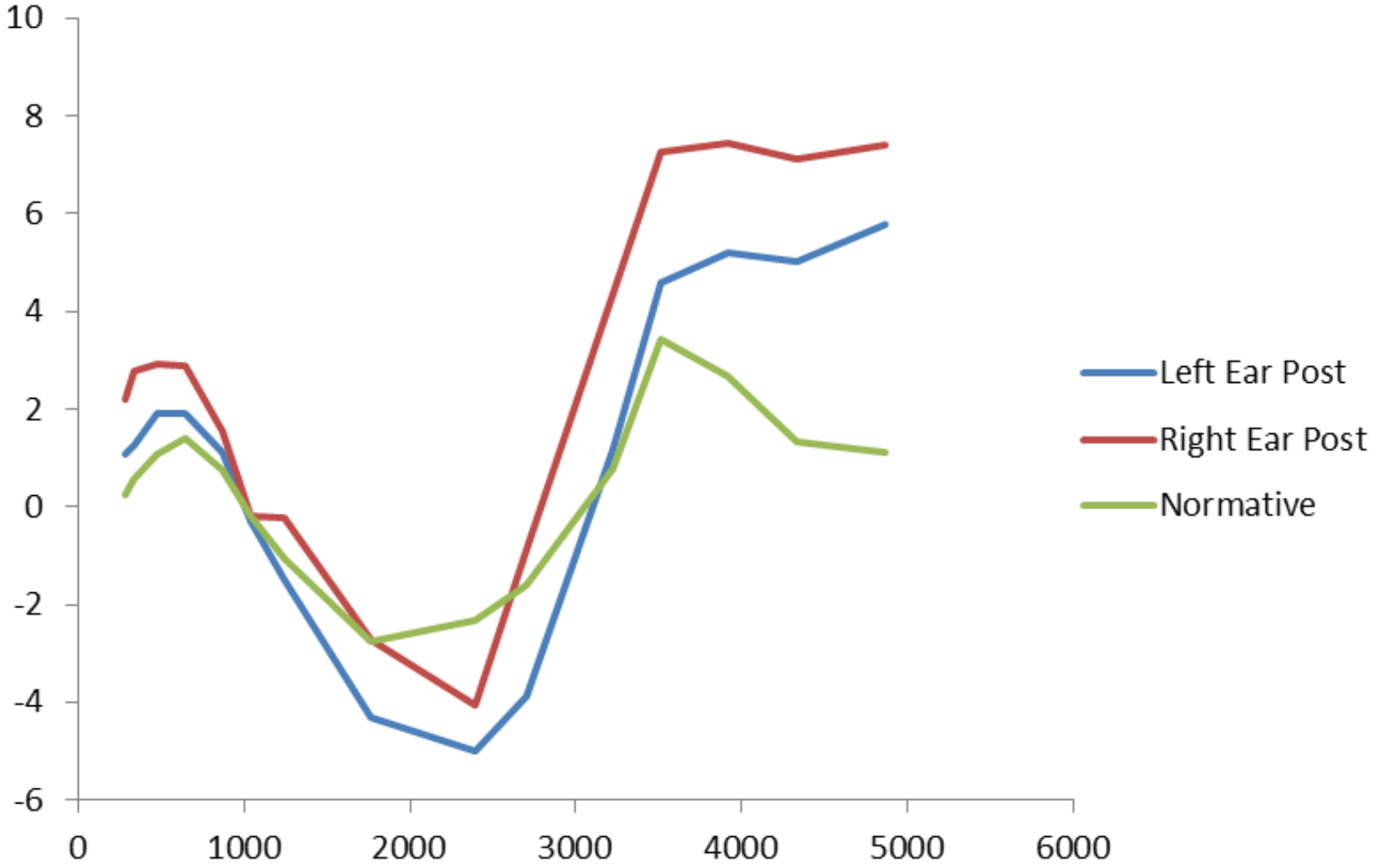


HAES001: Follow up visit. Three hours between measurements.



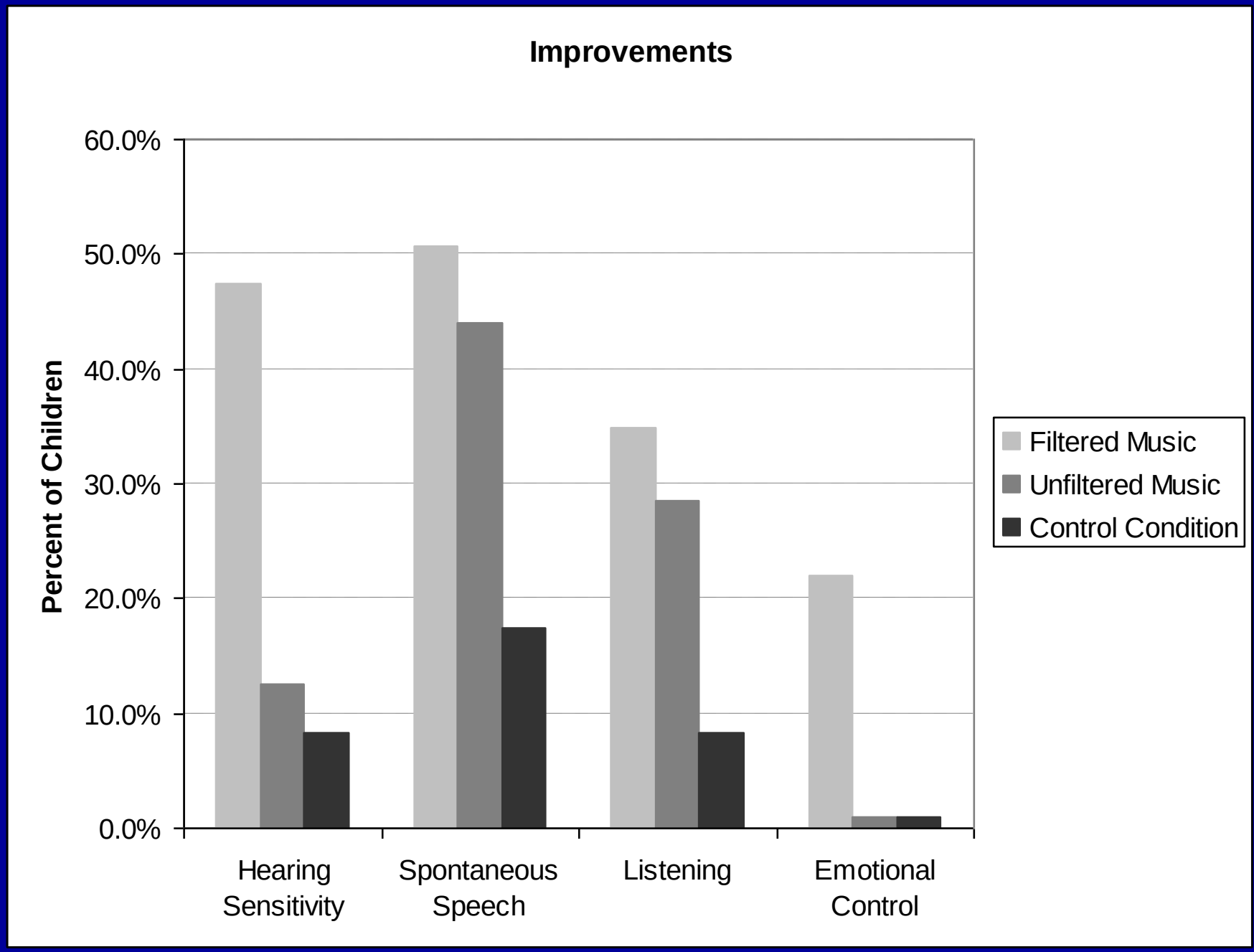


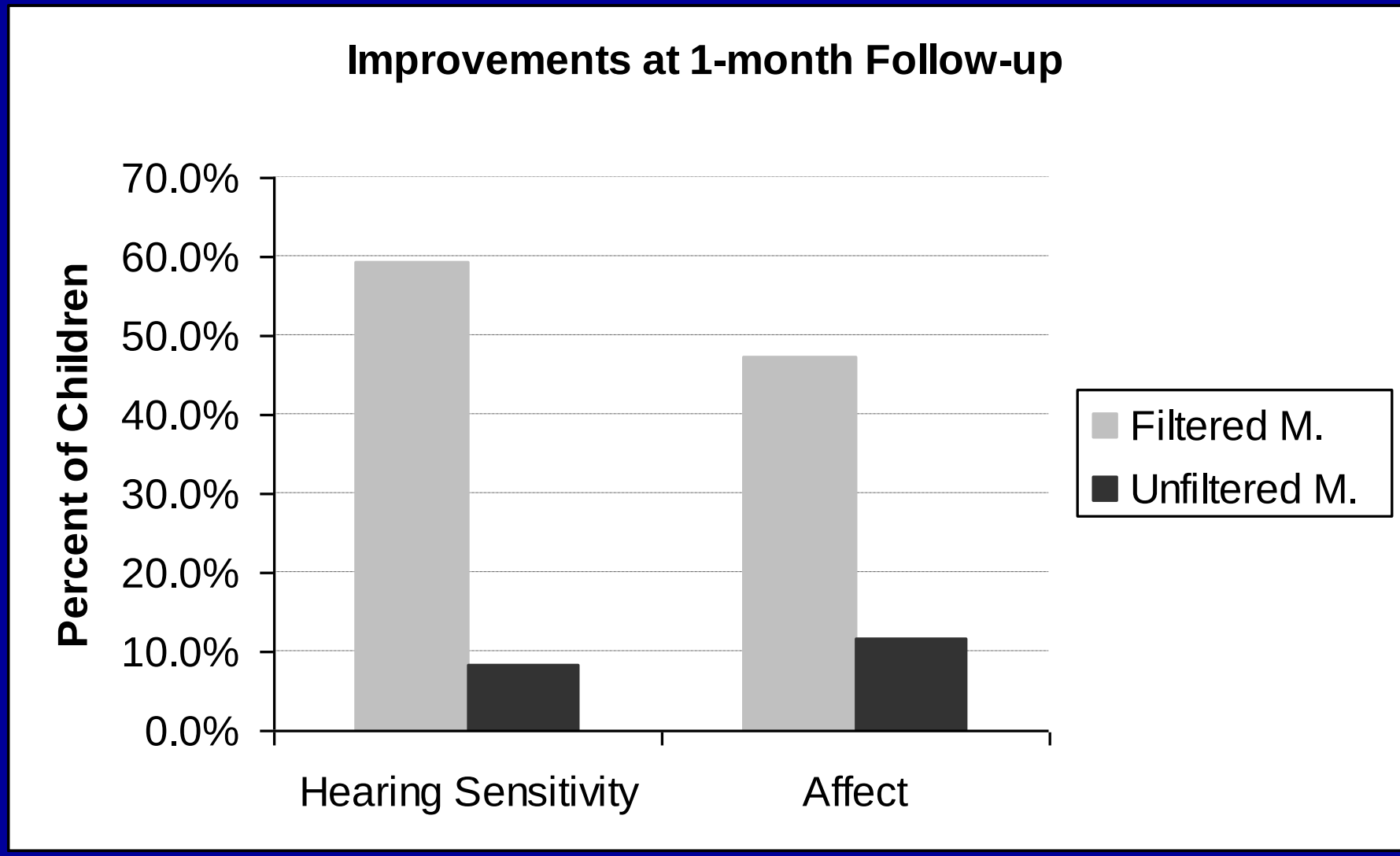
HAES001: Follow up visit. Summary.



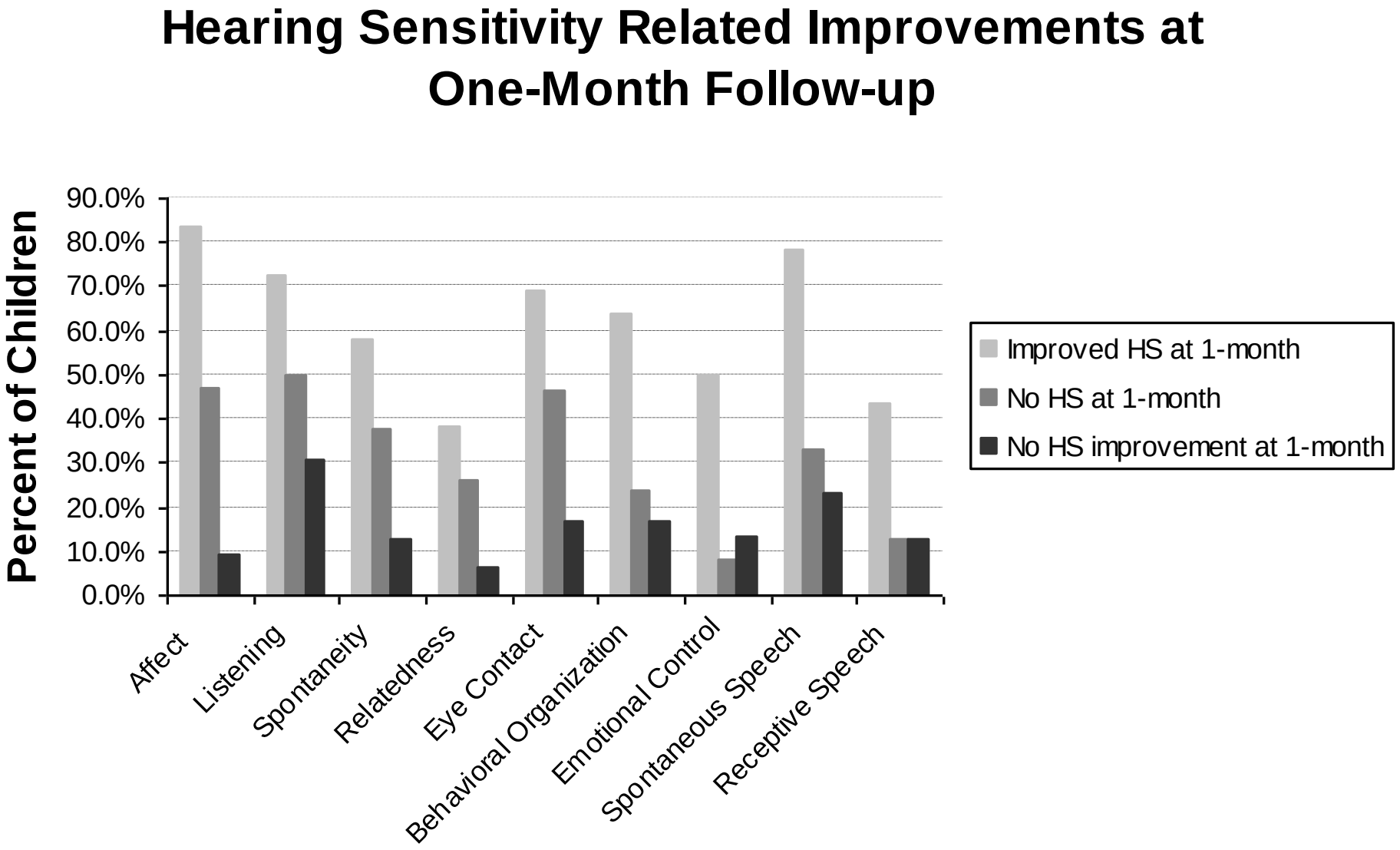
Can Sound Regulate State?

Examples?

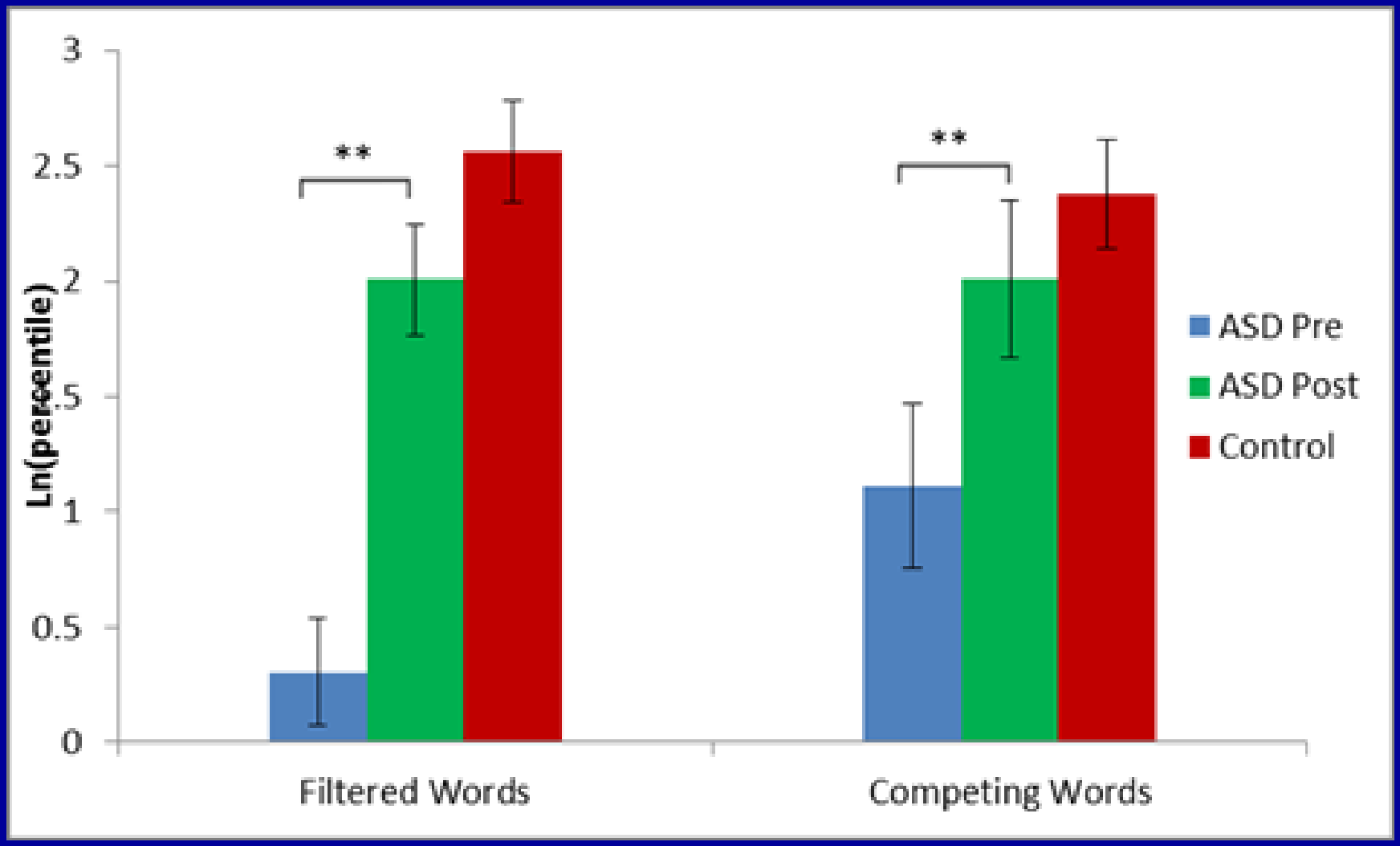




Outcomes:
When Hearing Sensitivities Improve



Auditory Processing: Autism



Sound and Neuroception

- Do the acoustic features of voice, music, or background noise influence our ability to feel safe?
- Do most effective therapists use “listening” as a portal of treatment?

Listening as a Methods to Feel Safe

- Acoustic features
  - Frequency band
  - Modulation of frequencies (e.g., prosody, melody)
  - Rhythm (heart beat, breathing, blood pressure-vasomotor)
  - (Syntax)

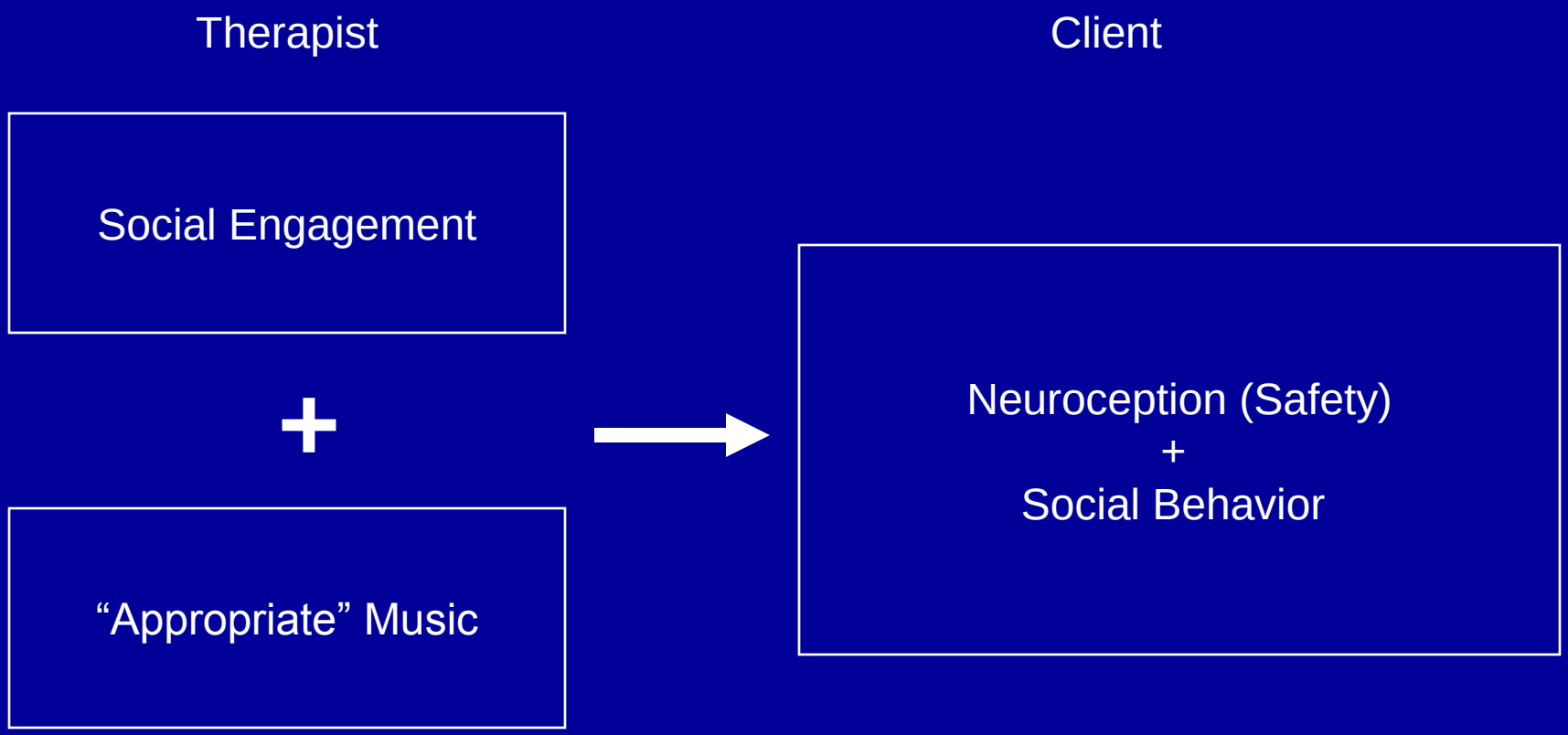
The Listening Project: Principles of Intervention

- **Principle 1.** ***Less*** is ***more*** (fragile system)
- **Principle 2.** The intervention must occur in a "safe" environment ("*neuroception*")
- **Principle 3.** The auditory system has an efferent component that actively ***select*** human speech and voice from background sounds (via medial olivary-cochlear pathways and middle ear muscles)
- **Principle 4.** Due to common embryological development in the nervous system, the cortical regulation required to select human voice will improve state regulation and social behavior (SVE)

Music Therapy:
re-constructing

1. Physical features of music emphasize modulation of frequencies exaggerating features of human prosody and trigger states of safety.
2. Low frequencies are associated with danger and predator and can trigger state changes that preclude the processing human voice.
3. Therapeutic engagement emphasizes face-to-face interactions, which require “exercise” of the striated muscles of the face and head (facial muscles, oromotor activity, laryngeal, pharyngeal, respiratory, and neck).
4. Therapy requires contingent interactions in which the role of “leader” is shifted among participants.

Music Therapy: A Polyvagal Perspective



The Biology of Music

Our nervous system evolved to detect intonations in a specific frequency band. Prosodic voice and music capitalize on this phenomenon.

Tempo is linked heart rate. Tempo is associated with the heart rate needed to conduct the activity characterized in the music such as a march or lament.

Phrasing is based on breathing rates (3 to 8 seconds) and even endogenous blood pressure “waves” (10-20 seconds).

Although there is limited research, it is plausible that manipulating tempo and phrasing can influence the physiological of the listener.

Prosody

- Prosody describes the perception of feelings expressed in speech.
- Predates the evolution of human language.

Prosody

Prosody describes the perception of feelings expressed in speech, and was recognized by Charles Darwin in The Descent of Man to predate the evolution of human language: "Even monkeys express strong feelings in different tones — anger and impatience by low, fear and pain by high notes."

Sound and Neuroception

- Composers use different acoustic frequencies to express their musical narrative.
  - Frequencies of human voice (especially female) signal safety
  - Lower frequencies signal predator.

Can Sound Regulate State?

- Do the acoustic features of voice, music, or background noise influence our ability to feel safe?

Can Sound Regulate State?

- What are the influences of frequency band (e.g., bass, no bass) and modulation of frequency (e.g., melody, prosody)?
  - Chants
  - Popular examples
    - Disney
    - Barry White
    - Rap
    - Lullabies

Music and Emotion:
Peter and the Wolf (Prokofiev)

Music and Emotion:
Peter and the Wolf (Prokofiev)

What emotions (pleasant or unpleasant) do the sounds represent?

- ***Peter***
- ***Grandfather***
- ***Bird***
- ***Cat***
- ***Duck***
- ***Wolf***
- ***Hunter***

Safety and Fear in the "Frequencies" of Music

Bird – Flute
Cat – Clarinet
Duck - Oboe
Peter - Strings

Grandfather - Bassoon
Wolf - Horns

Hunters - Timpani (Kettle drums)

Listening to Music and Voice as Therapy

1. Does music share features with human voice?
2. Is there a biobehavioral basis to support the hypothesis that listening to music and/or human voice will facilitate social, emotional, and cognitive function?

“Visceral” Definitions of Sounds:
A phylogenetic interpretation

- Acoustic frequencies in well define frequency bands trigger select physiological states via neuroception.

- Modulated frequencies of human voice (especially female) signal safety

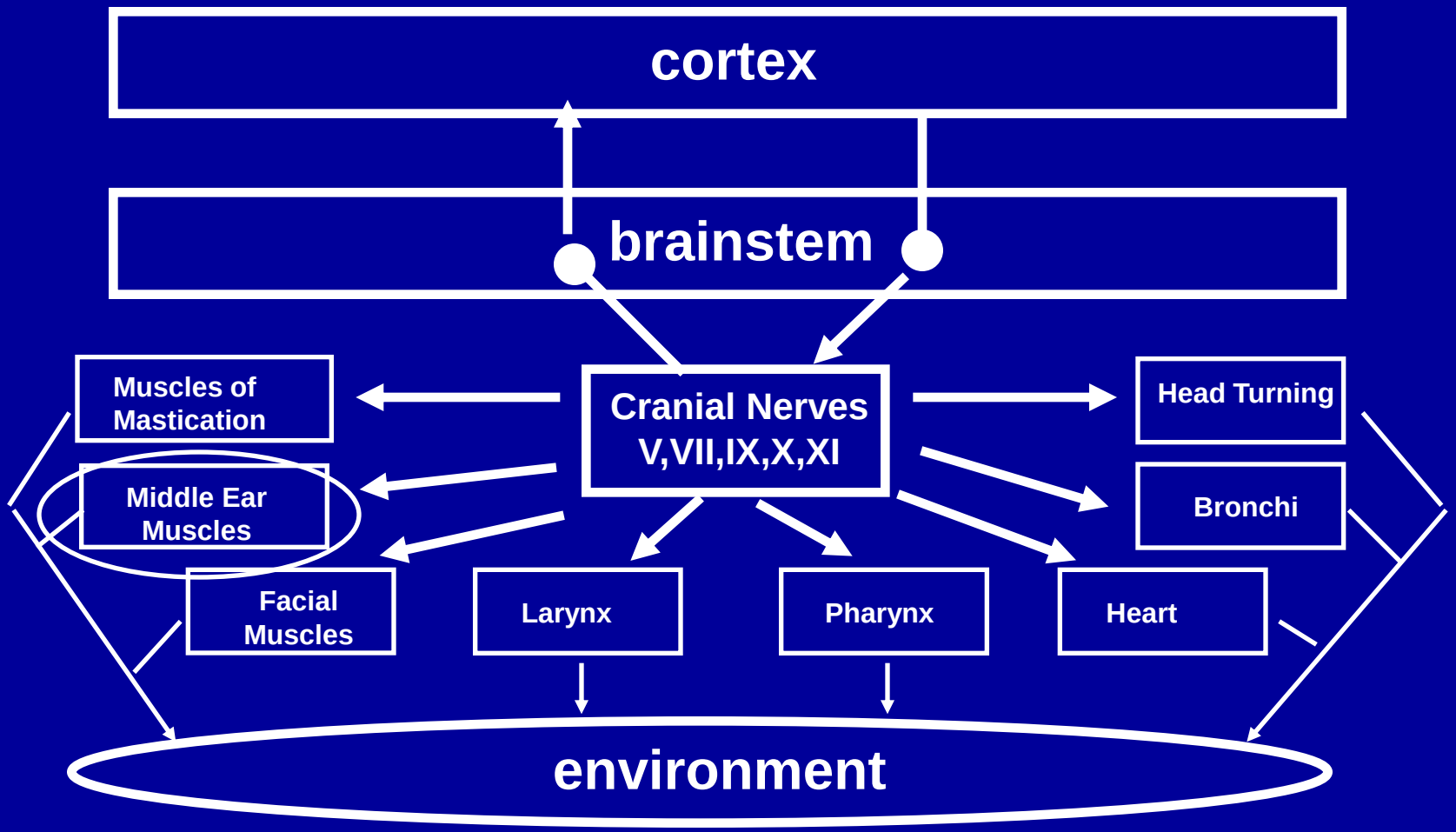
- Low frequencies (not requiring MEM) signal predator.

- High frequencies (not requiring MEM) signal pain or eminent danger.

Music and Human Speech:
Common "Neuroceptive" Features

- Our nervous system may process music similar to prosody in human voice.
- Music may be more salient than voice to neural "feature detectors" scanning the environment for risk.
- Vocal music (chants) might be very effective in triggering a neuroceptive state of safety and dampening defense systems.

Listening:
Accessing the Social Engagement System



What happens when the middle ear muscles are not working correctly?

The Polyvagal Theory and the Social Engagement System

Neural mechanisms link middle ear muscles to facial expression, prosody, social awareness, and state regulation.

Can physiological state changes influence the function of the middle ear muscles?

Are auditory hypersensitivities a signal that the entire Social Engagement System is compromised?

Listening and Health

- There is a biobehavioral basis to support the hypothesis that listening to music and/or prosodic human voice will facilitate access to the neural circuits that promote social behavior, emotional regulation, and health.