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UNDERSTANDING THE BENEFITS OF ULTRA-FAST PROCESSING ON A MOLECULAR LEVEL

Francis Kuk, PhD, FAAA
Director – ORCA-USA
VP – Clinical Research
WSAudiology



LEARNING OUTCOMES

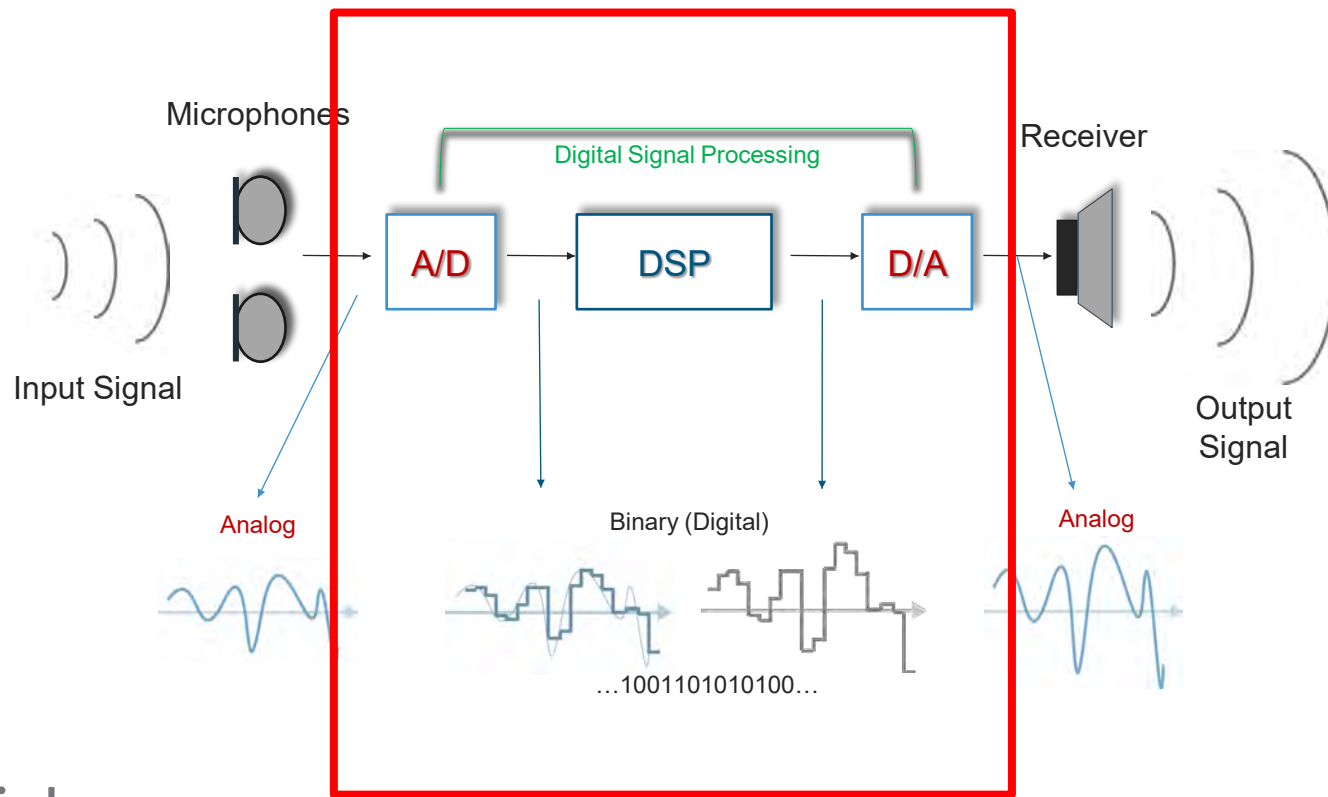
After this course, participants will be able to list:

- The mechanism in which ultra-fast (or ZeroDelay) processing preserves naturalness of sounds
- At least one instance where ultra-fast (or ZeroDelay) processing may aid in speech perception
- The EEG response that reflects the impact of ultra-fast (or ZeroDelay) processing

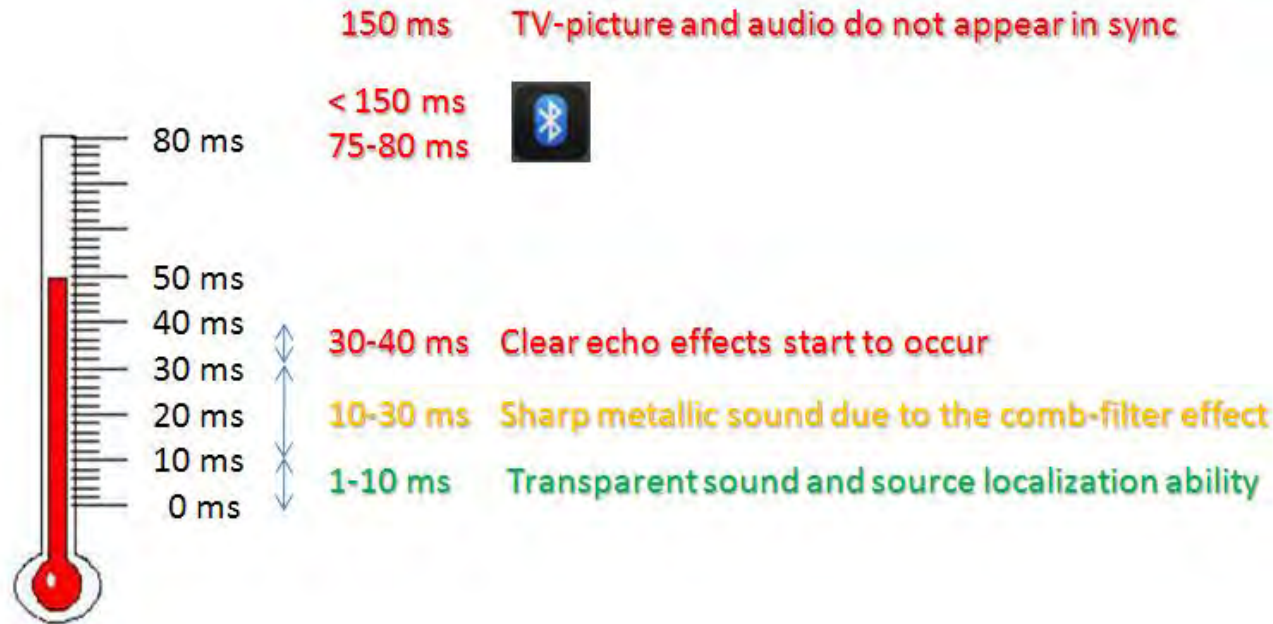
AGENDA

- Background of ZeroDelay technology (ultra-fast processing)
- Reported subjective benefits of ZeroDelay technology
- Acoustic measurements on ZeroDelay processing
- Neural representation of ZeroDelay processing
- Perceptual impact of ZeroDelay processing
 - Phonemic feature identification
 - Interactions with spatial cues
- Clinical implications

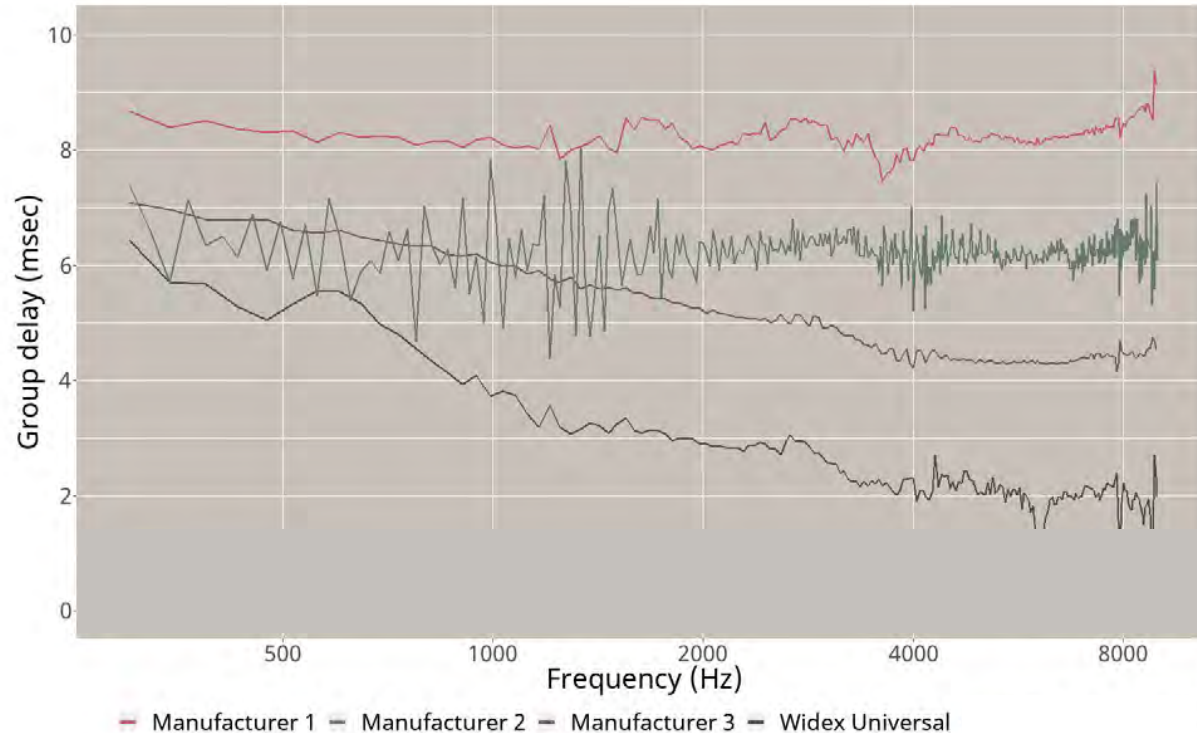
WHY IS THERE PROCESSING DELAY?



THE EFFECT OF DELAY ON PERCEPTION



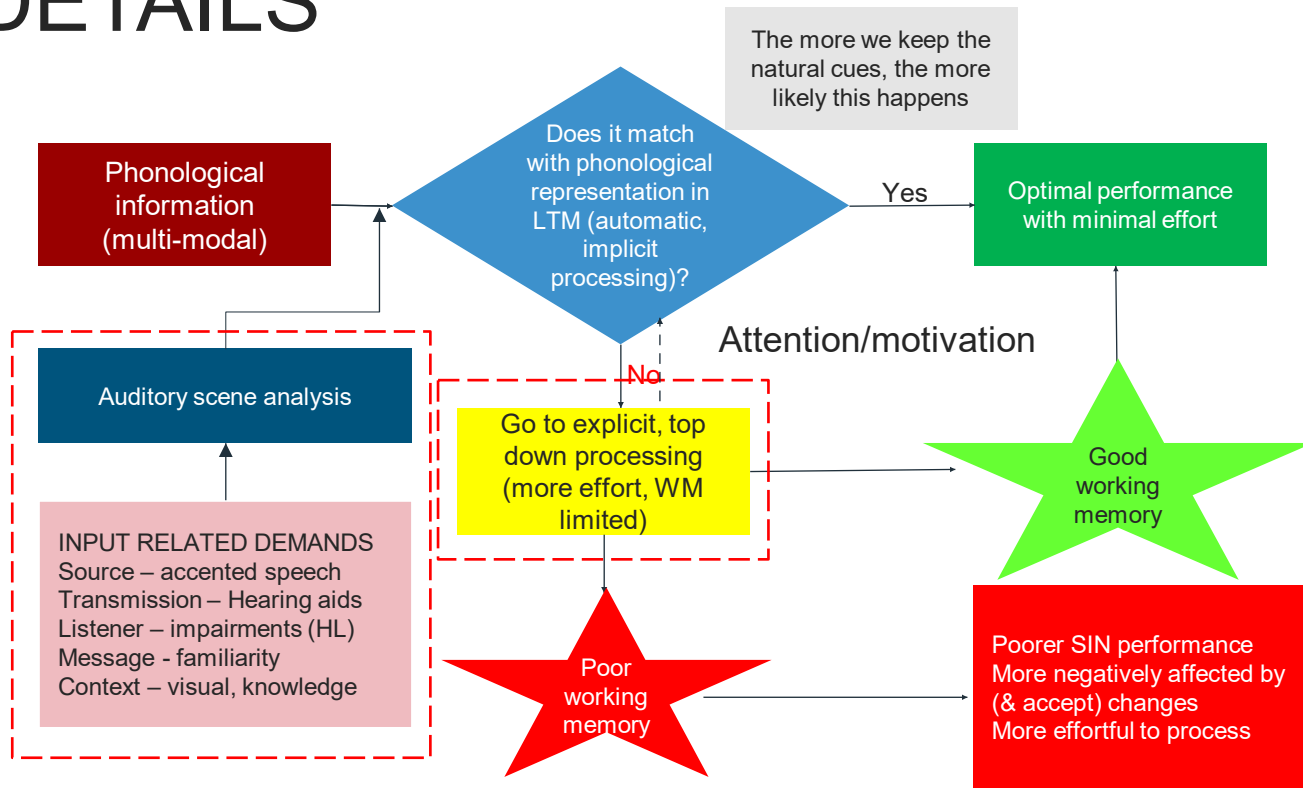
PROCESSING DELAY AMONG MAJOR HEARING AID BRANDS



IS ACCEPTABLE GOOD ENOUGH?



EASE OF UNDERSTANDING DEPENDS ON THE DETAILS



ORGANIC FOOD



ENERGY TAKERS ENERGY GIVERS

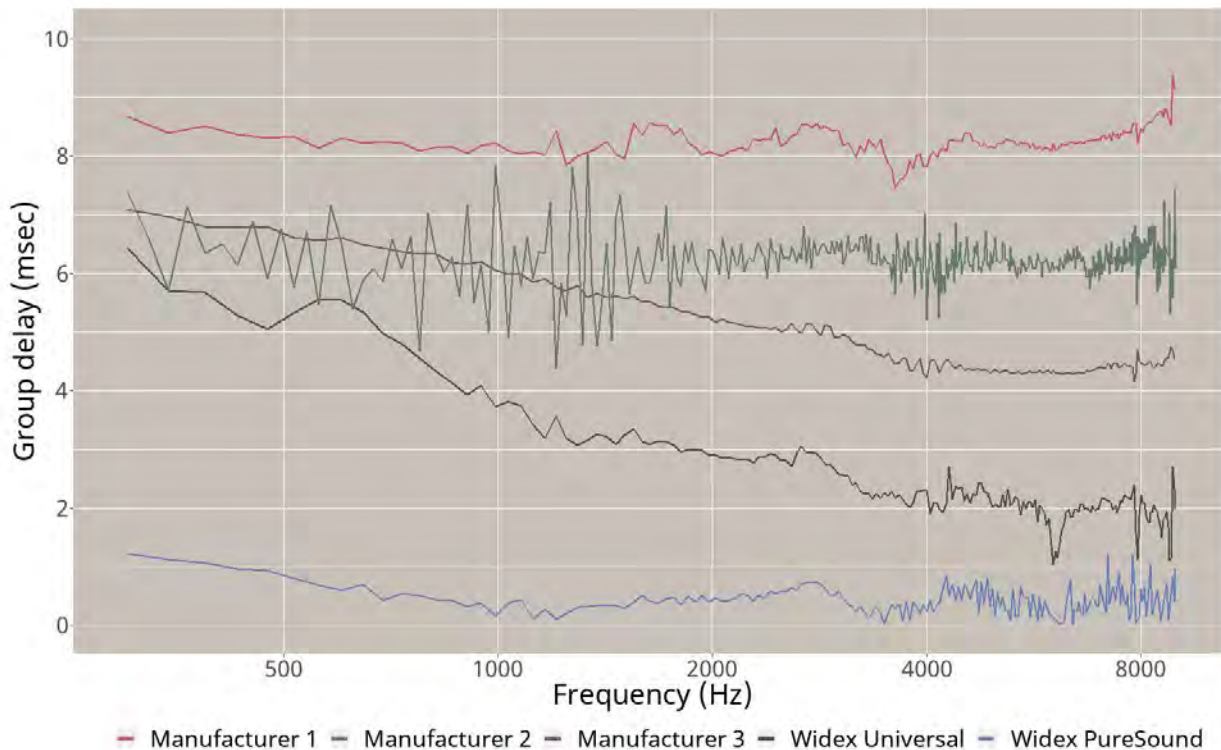


Focusing on the past
Inconsistent sleep
Mess and clutter
Sedentary time
Social media
Overworking
Dehydration
Screen time
Resentment
Negativity
Junk food
The news
Alcohol
Stress
Fear

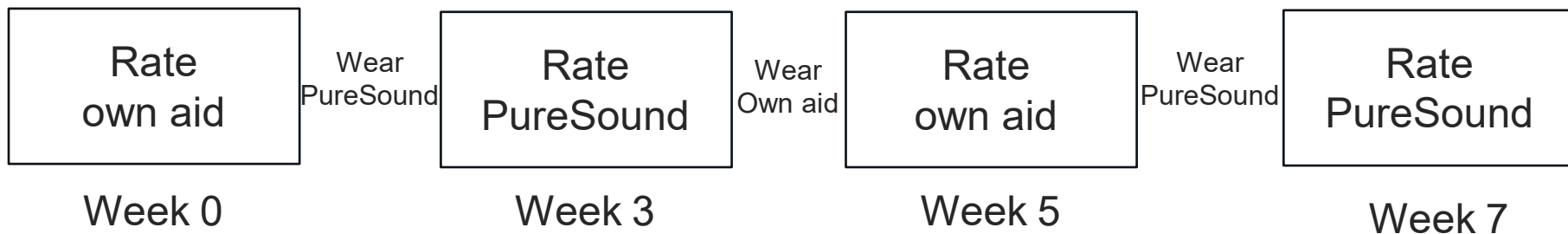


Music
Nature
Resting
Sunlight
Positivity
Gratitude
Hydration
Meditation
Movement
Breathwork
Community
Decluttering
Consistent sleep
Eating whole foods
Learning something new

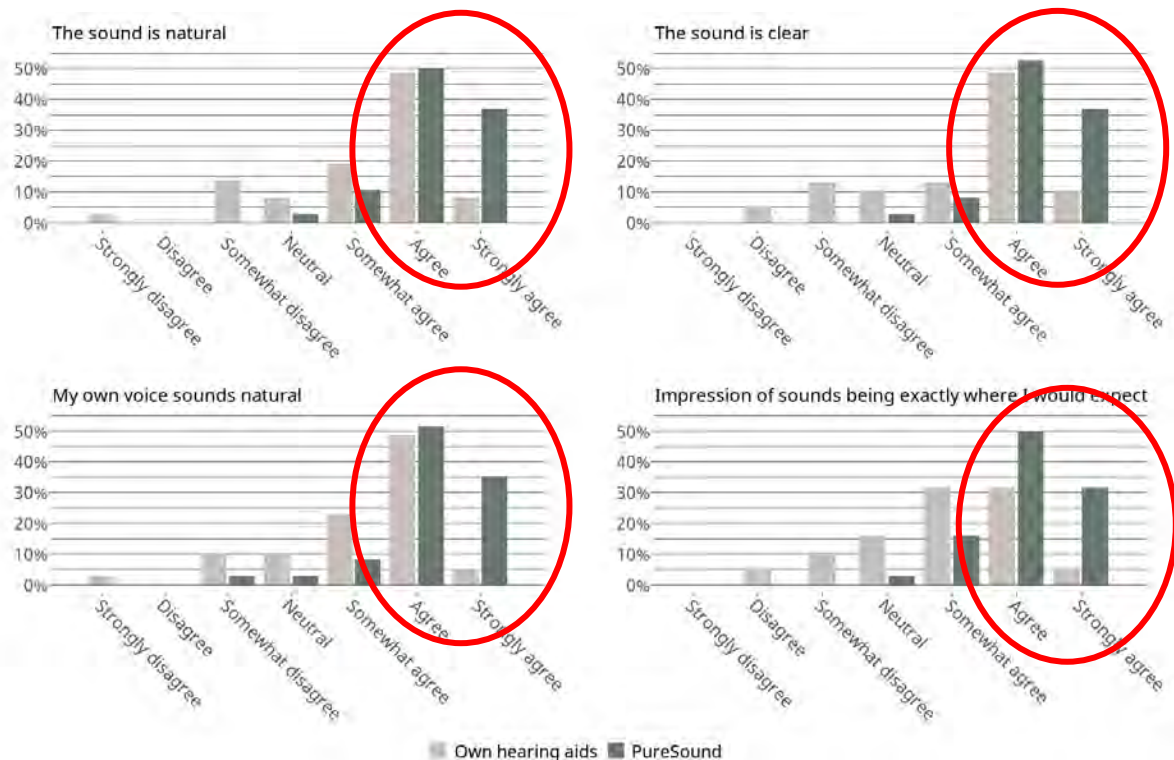
ZERO DELAY TECHNOLOGY (ULTRA-FAST PROCESSING) COMPARED TO OTHERS



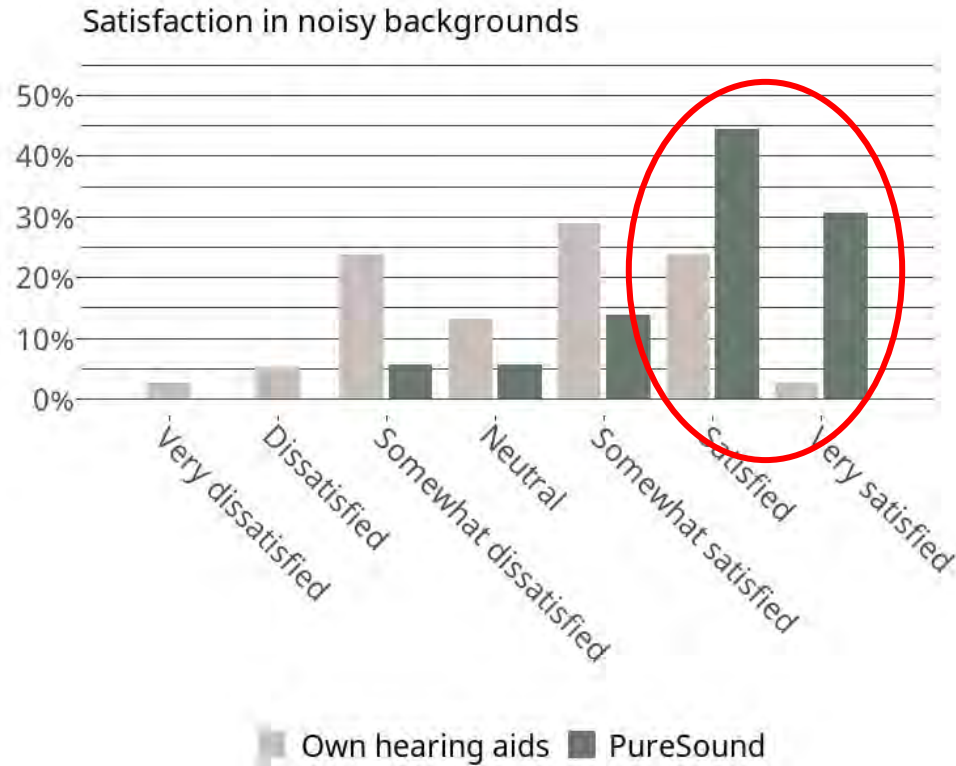
REAL-WORLD SUBJECTIVE RATINGS ON ULTRA-FAST PROCESSING (BALLING-WINTHER ET AL, 2021)



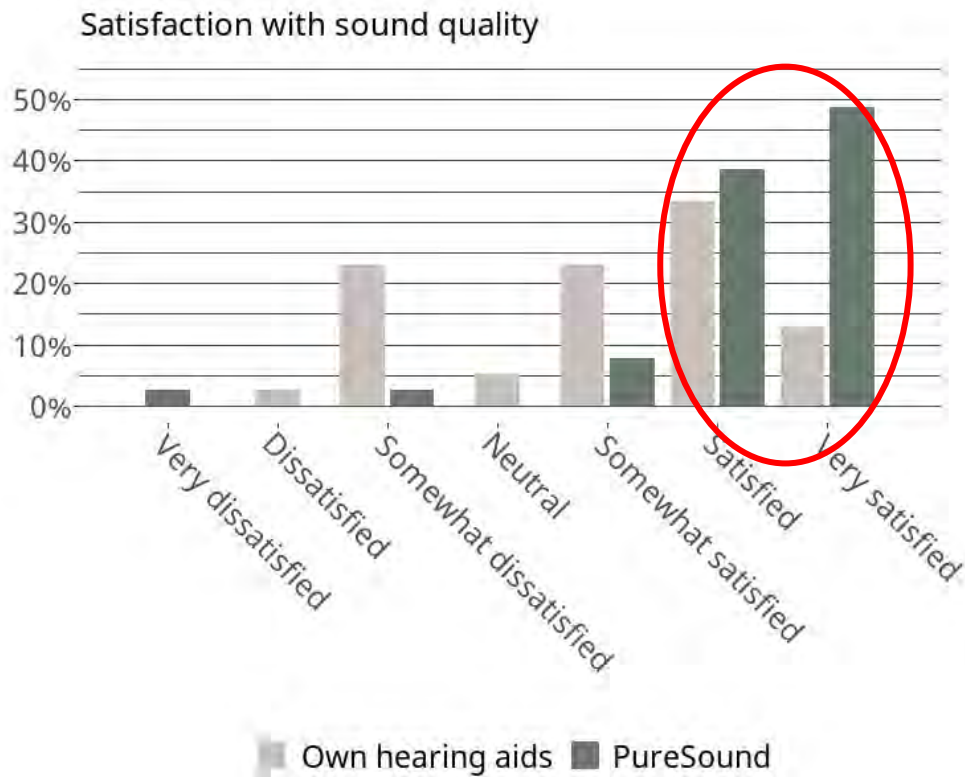
NATURALNESS PERCEPTION



SATISFACTION IN NOISE



SOUND QUALITY



**A MOLECULAR APPROACH TO STUDYING HOW
ZERODELAY PROCESSING PRESERVES THE
NATURALNESS OF SOUNDS**

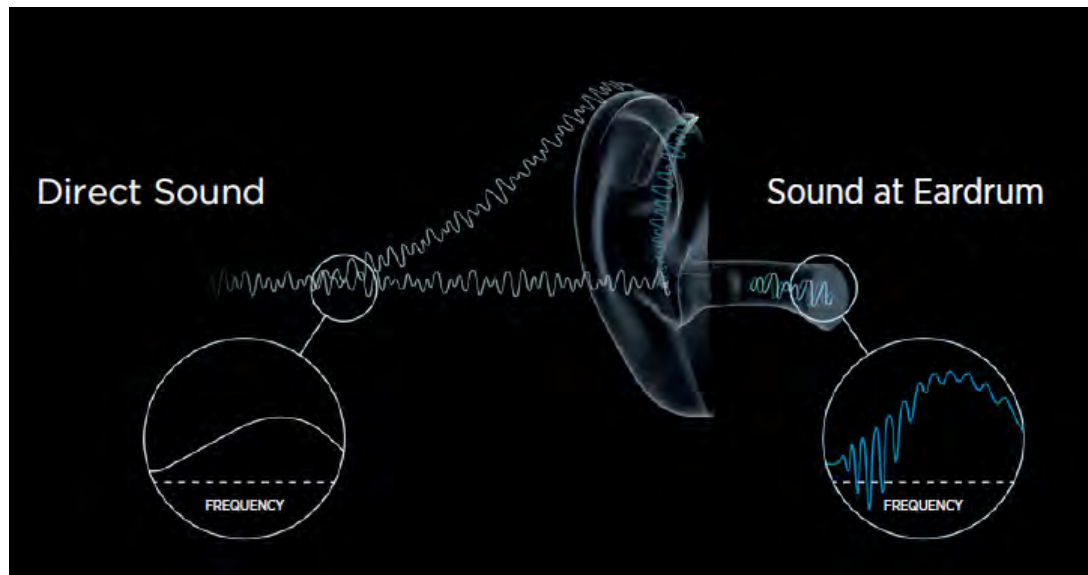
UNDERSTANDING HOW AND WHY

DO YOU KNOW WHO CLARA PELLER IS?

WHERE'S THE BEEF?!

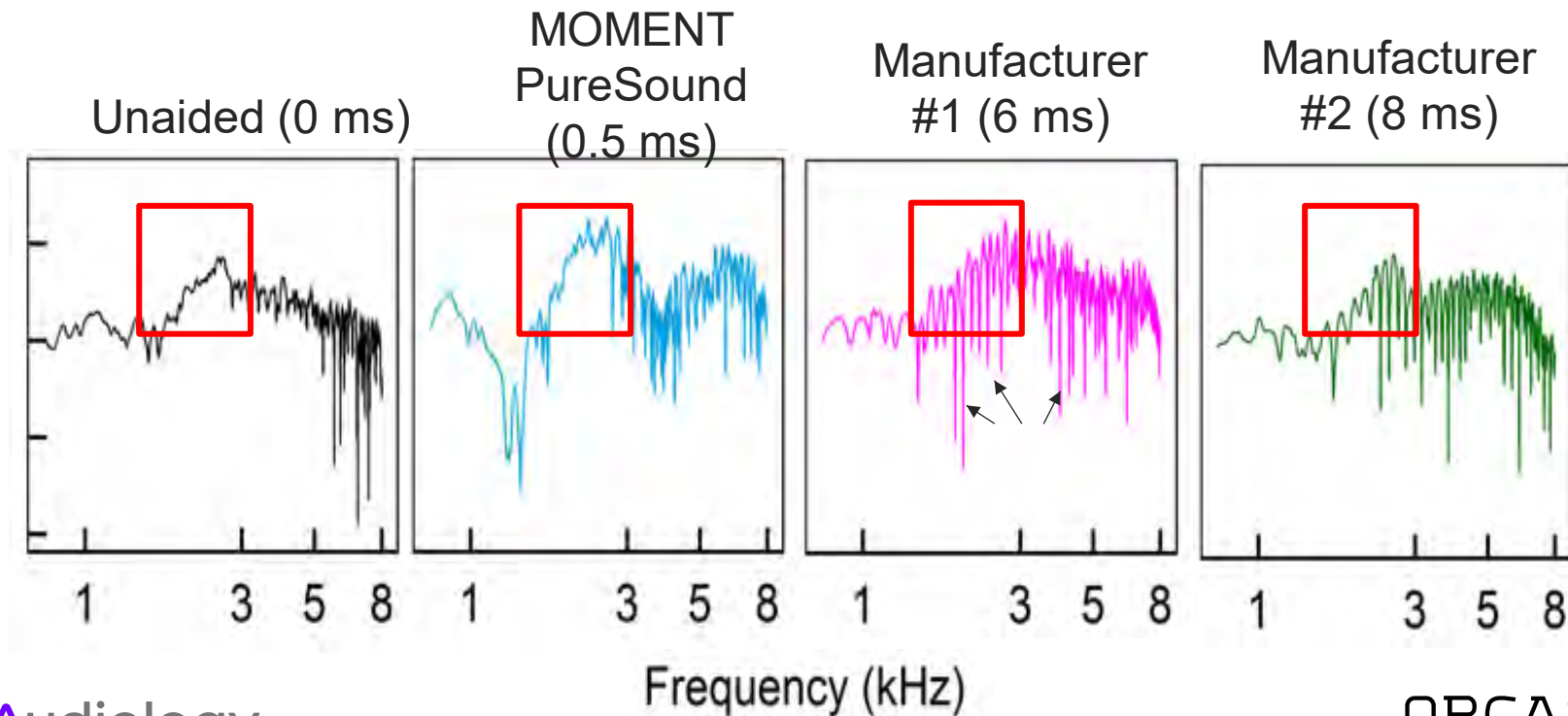
The benefit of ZeroDelay processing is most evident in **VENTED** earmolds/eartips. The results are likely **variable** among hearing aid wearers with greater acoustic impact in more **non-occluded fittings** (including open fit) and perceptual impact on those who **require and/or appreciate** the natural cues in sounds. People with a **mild-to-moderate** degree of hearing loss are likely the prime beneficiaries.

COMB-FILTERING: MIXING OF DIRECT AND PROCESSED SOUNDS

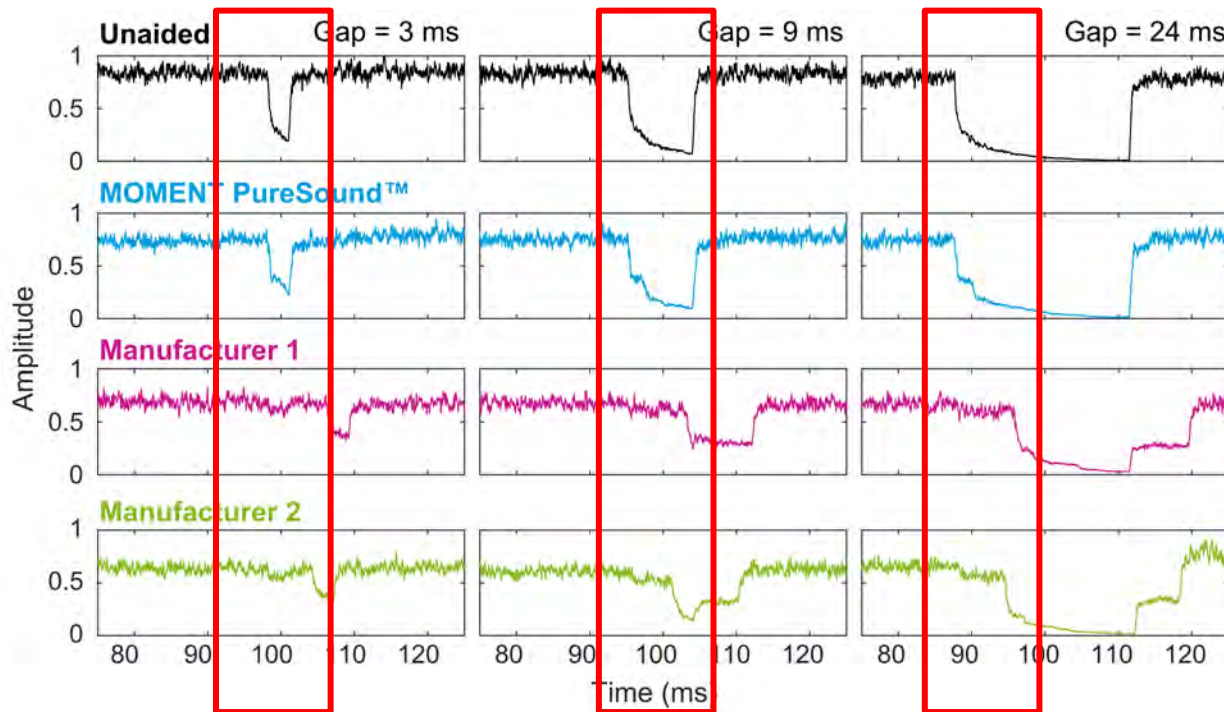


This occurs in **ALL** instant-fit eartips – double dome, tulip, and open, and vented custom earmolds.

SPECTRAL DISTORTION FROM PROCESSING DELAY

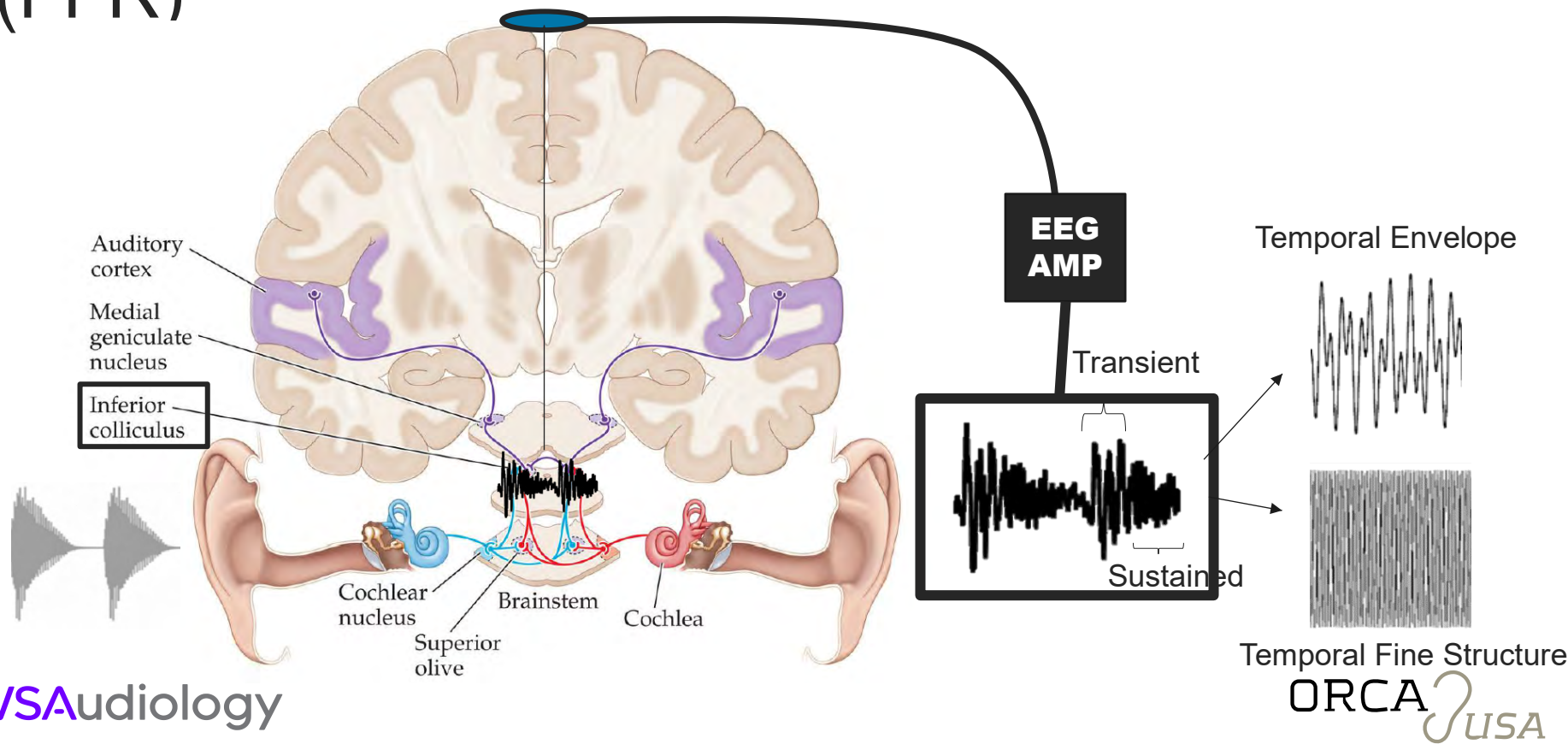


TEMPORAL DISTORTION FROM PROCESSING DELAY

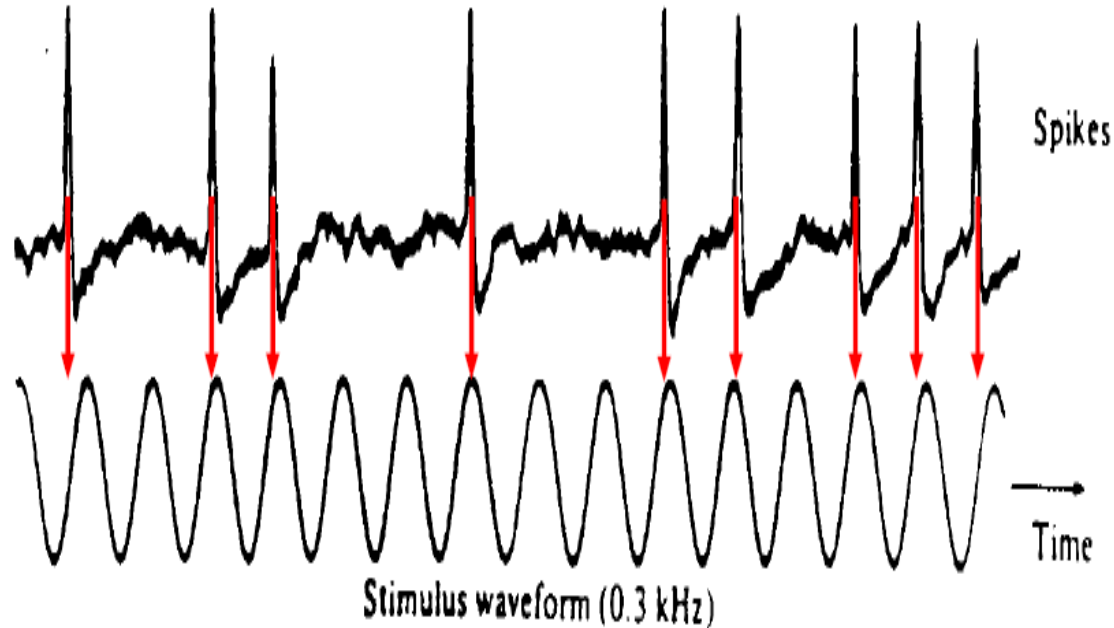


Showing ZeroDelay technology provides an acoustic advantage is ***necessary*** but not ***sufficient*** evidence to support changes at the neural (brain) level.

THE FREQUENCY FOLLOWING RESPONSE (FFR)



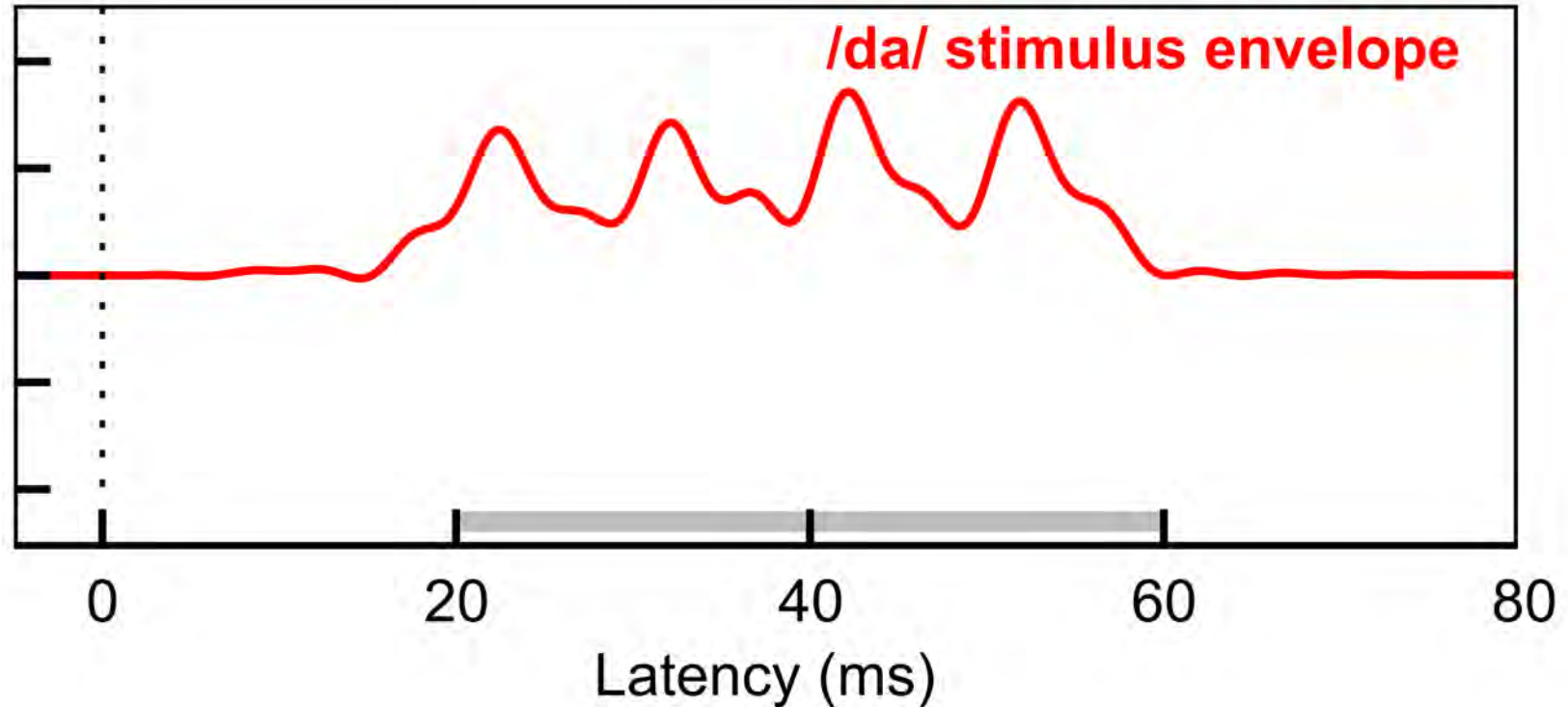
PHASE-LOCKING – HOW THE BRAIN CODES ENVELOPE INFORMATION



WHAT INFORMATION CAN WE GET FROM CODING OF TEMPORAL ENVELOPE?

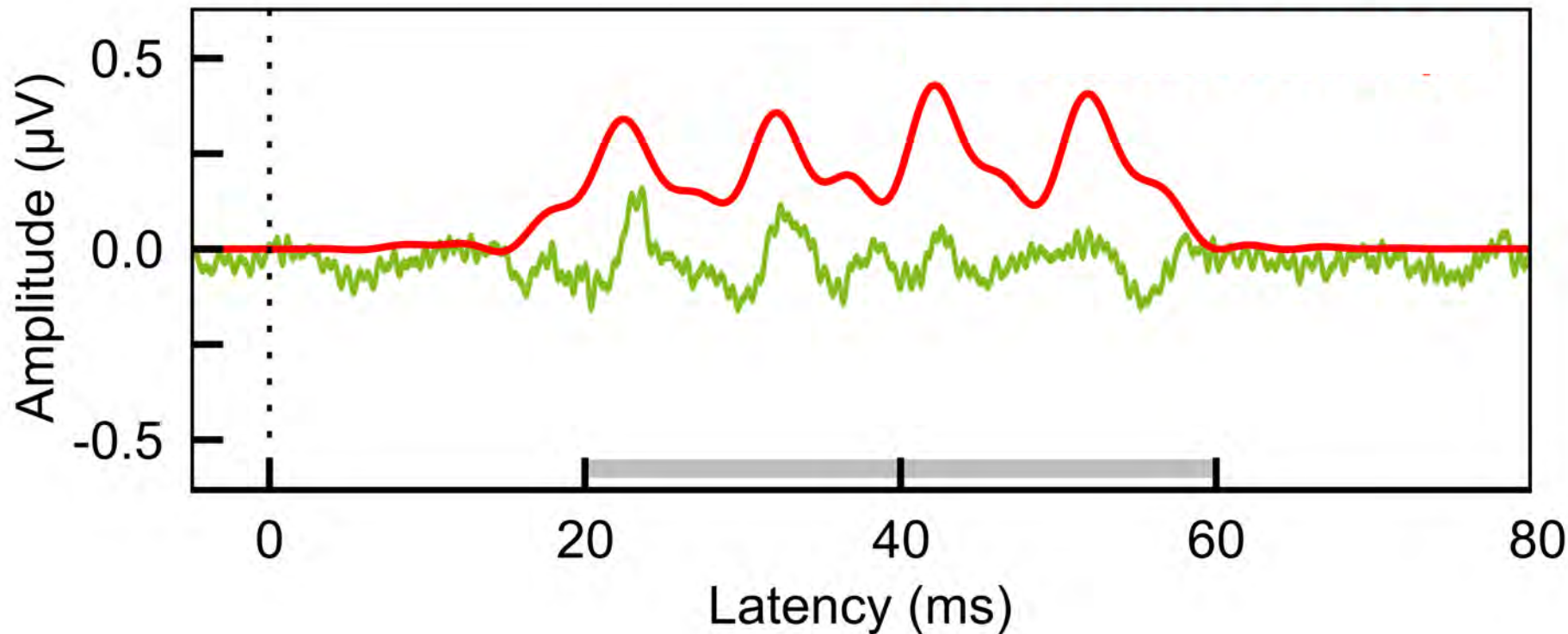
- EFR measures the phase-locking ability of the auditory system to the fundamental frequency (F0) of speech sounds at the brainstem level
 - EFR magnitude represents neural input modified by central influences. It reflects the goodness (sharpness) of the neural input to the brain
 - It correlates with a range of perceptual abilities
 - Speech in noise - The F0 cue is an important ASA cue for speaker identification in noisy situations
 - Musicianship
 - Training
- Aging, hidden hearing loss (w/normal hearing) and hearing loss decrease the goodness of the coding of temporal envelope

INPUT ENVELOPE AND EFR BETWEEN PURESOUND AND TWO PREMIUM HEARING AIDS



INPUT ENVELOPE AND EFR BETWEEN PURESOUND AND TWO PREMIUM HEARING AIDS

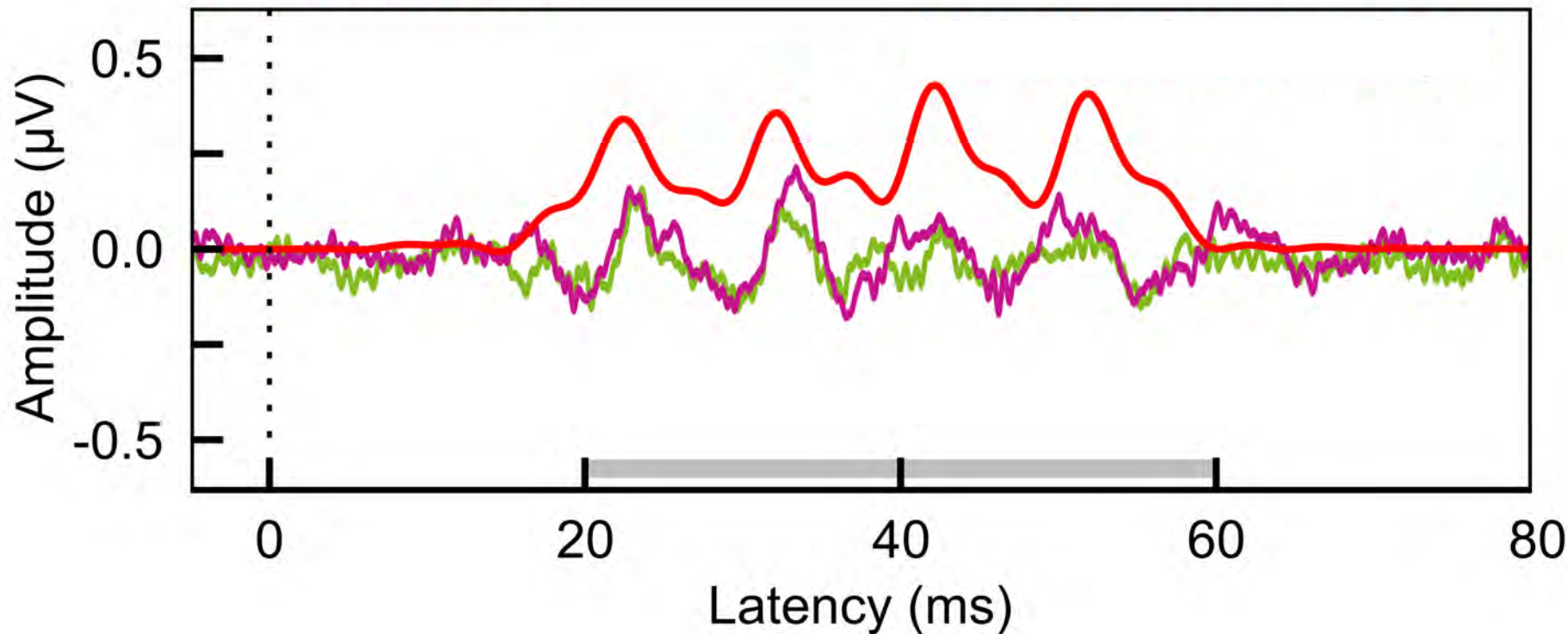
Manufacturer 1



INPUT ENVELOPE AND EFR BETWEEN PURESOUND AND **TWO PREMIUM** HEARING AIDS

Manufacturer 1

Manufacturer 2

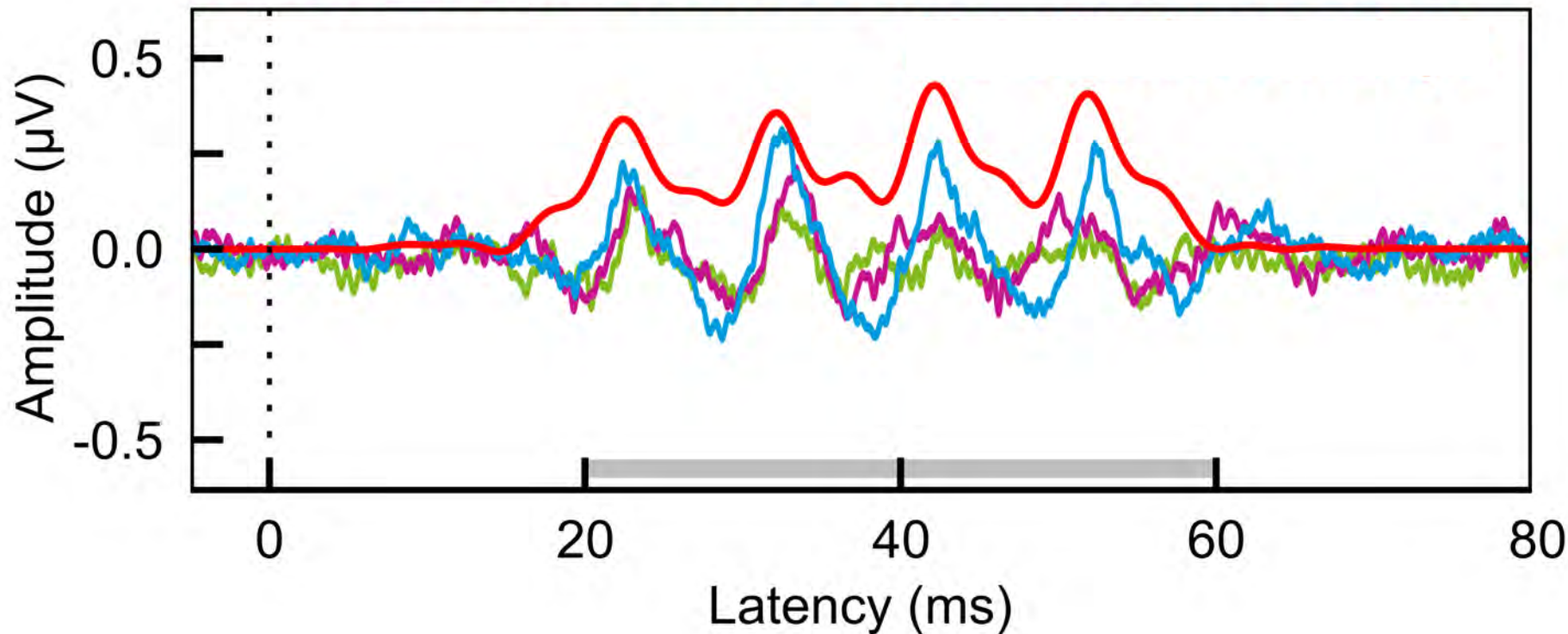


INPUT ENVELOPE AND EFR BETWEEN **PURESOUND** AND TWO PREMIUM HEARING AIDS

Manufacturer 1

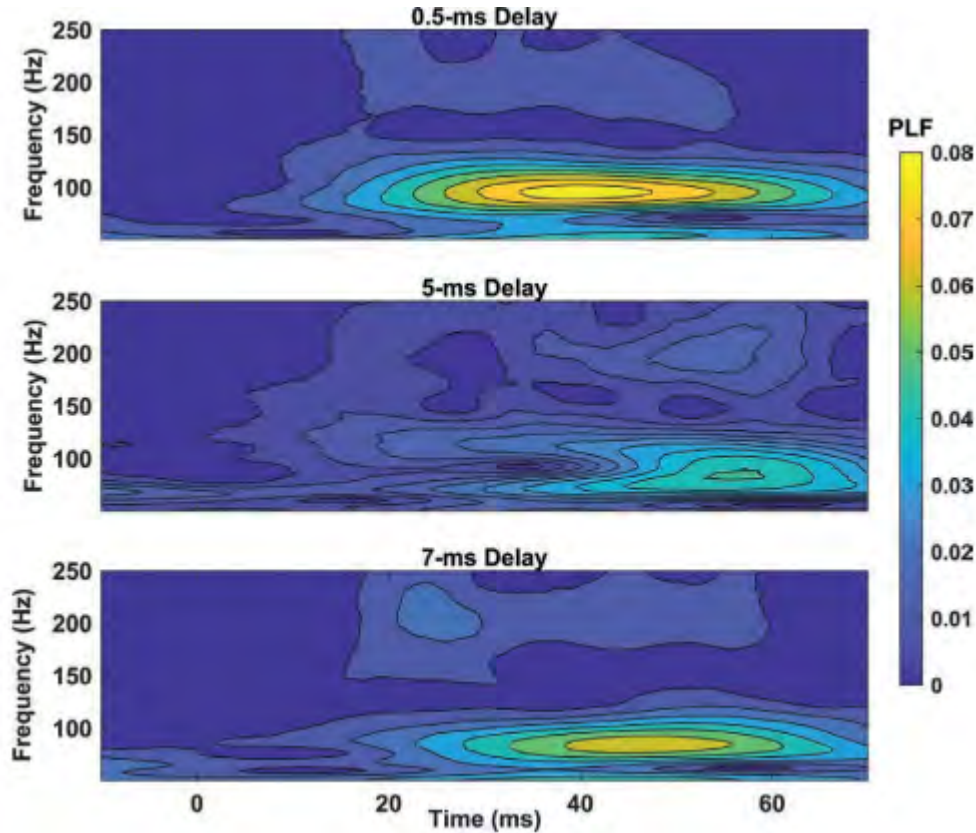
Manufacturer 2

Widex MOMENT™ with PureSound™

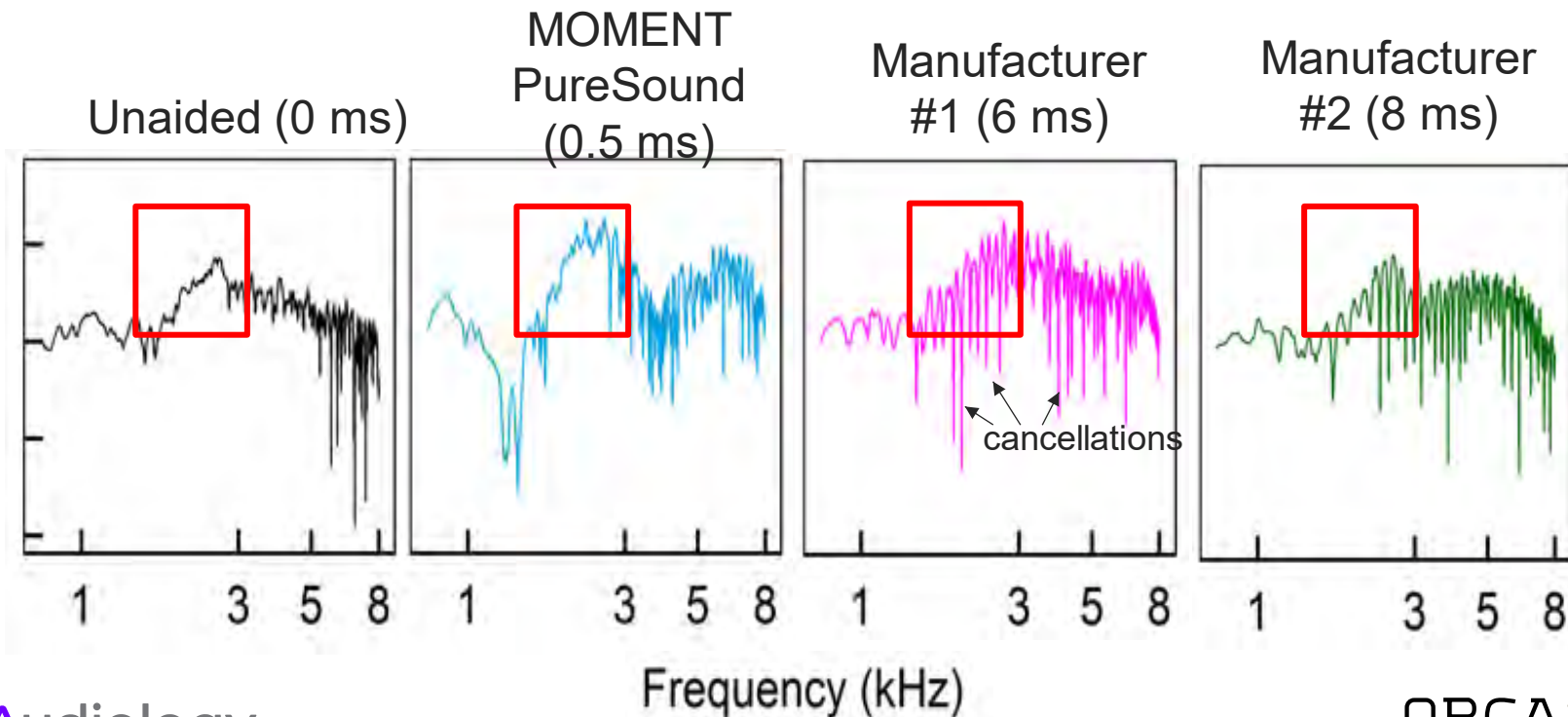


HEARING AID DELAY EFFECTS ON NEURAL PHASE LOCKING – *EAR & HEARING* JAN 2024

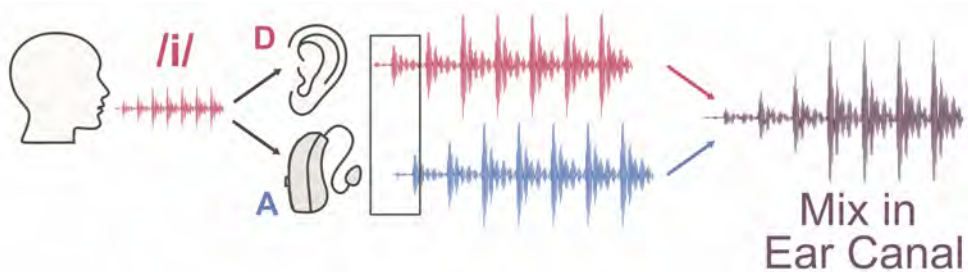
Mary Zhou, Rokhsana Soleimanpour,
Aakriti Mahajan & Samira Anderson



SPECTRAL DISTORTION FROM PROCESSING DELAY

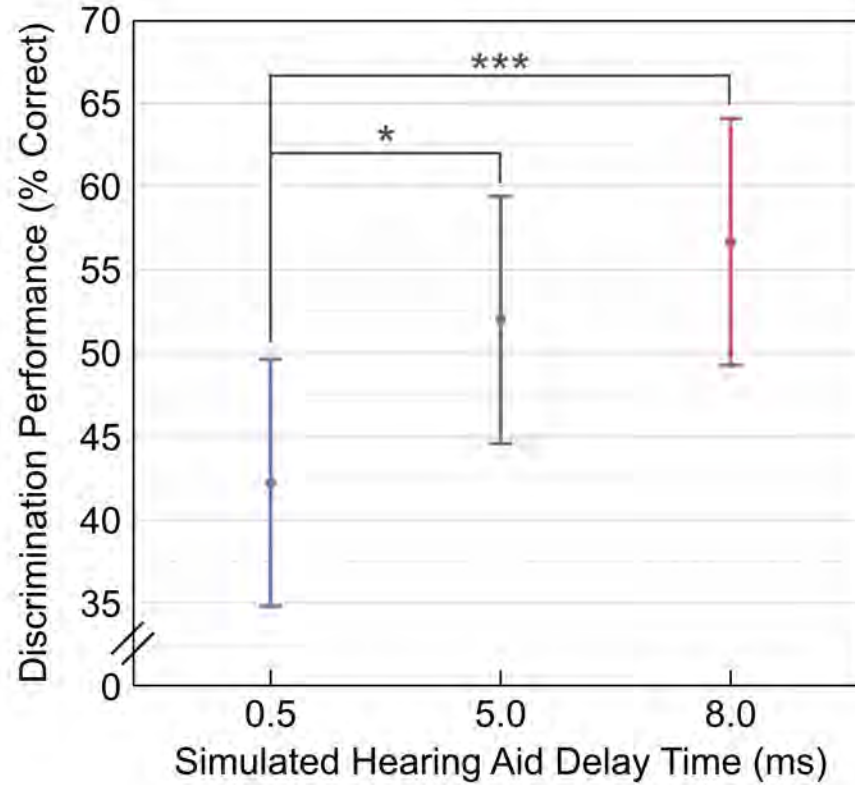


HOW MAY DELAY AFFECT SPEECH PERCEPTION – SPECTRAL “COLORATION”

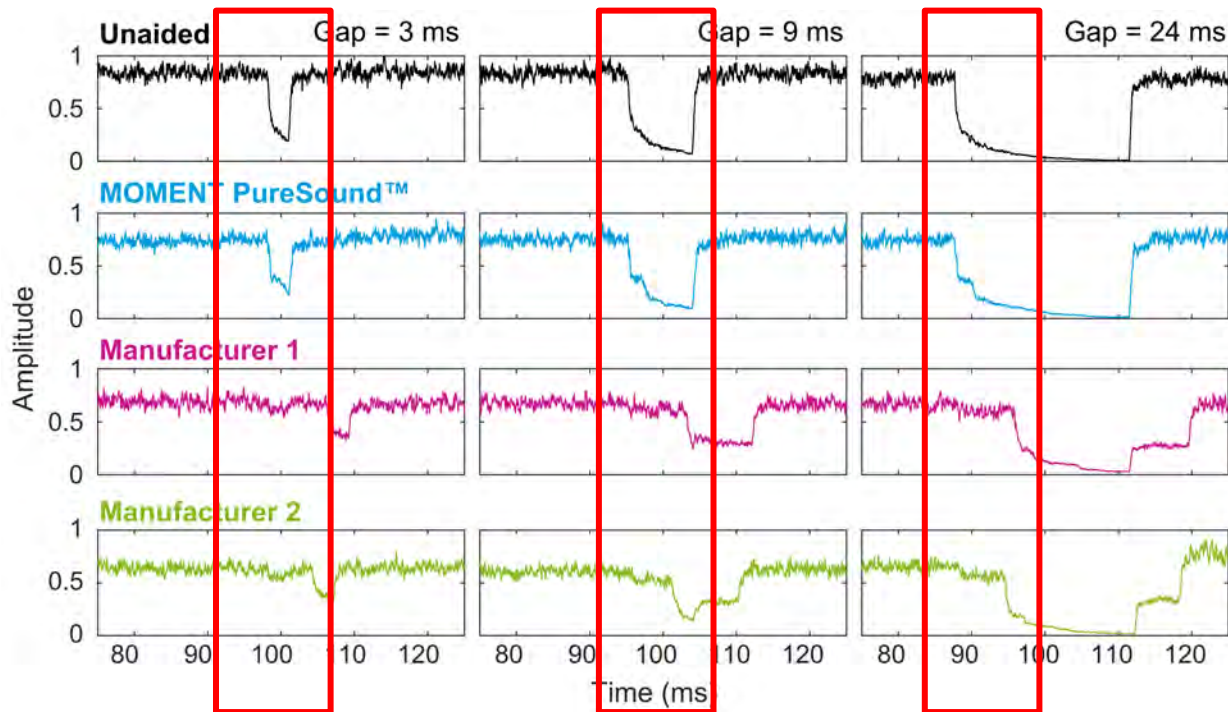


D = Direct Path A = Amplified Path

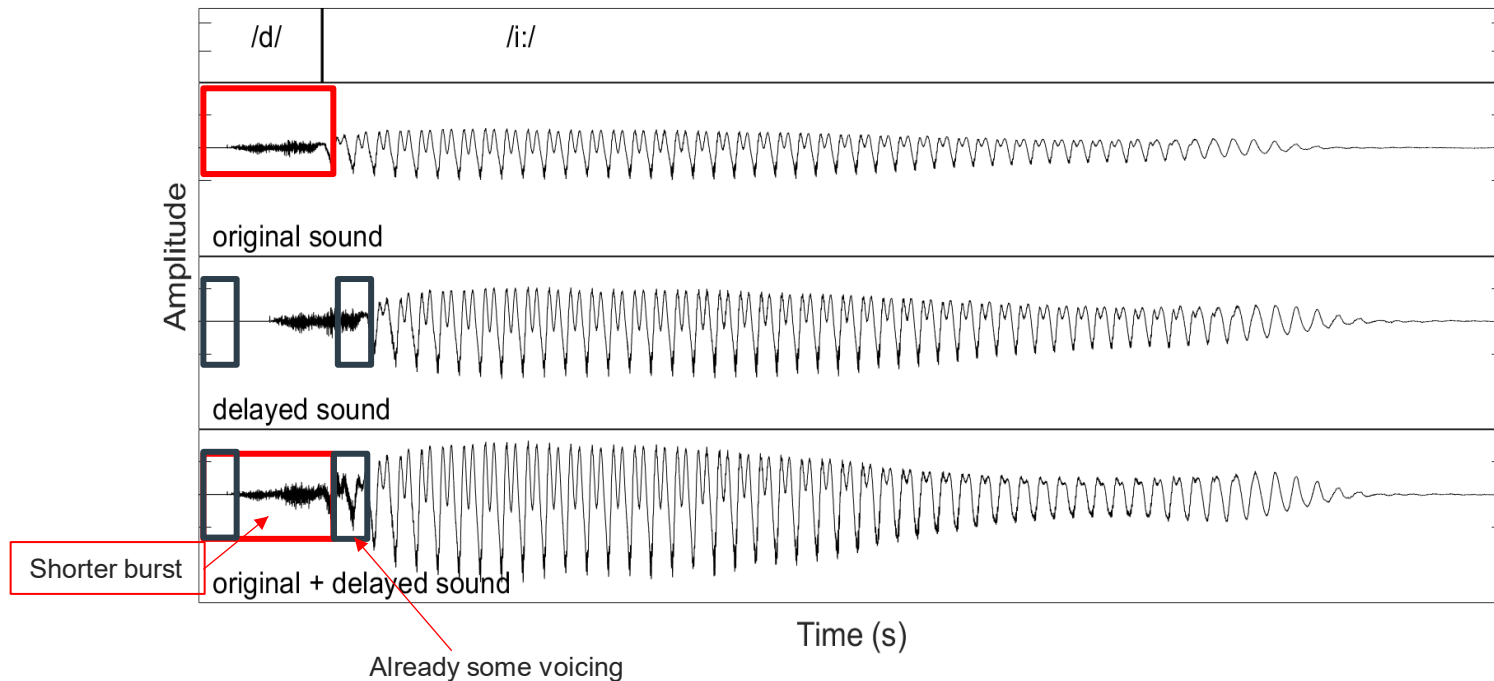
DELAY AFFECTS SPEECH PERCEPTION – VOWEL DISCRIMINATION (Slugocki et al, 2023)



TEMPORAL DISTORTION FROM PROCESSING DELAY



PROCESSING DELAY ALTERS THE ONSET OF SOUNDS



WHAT IS VOICE ONSET TIME?

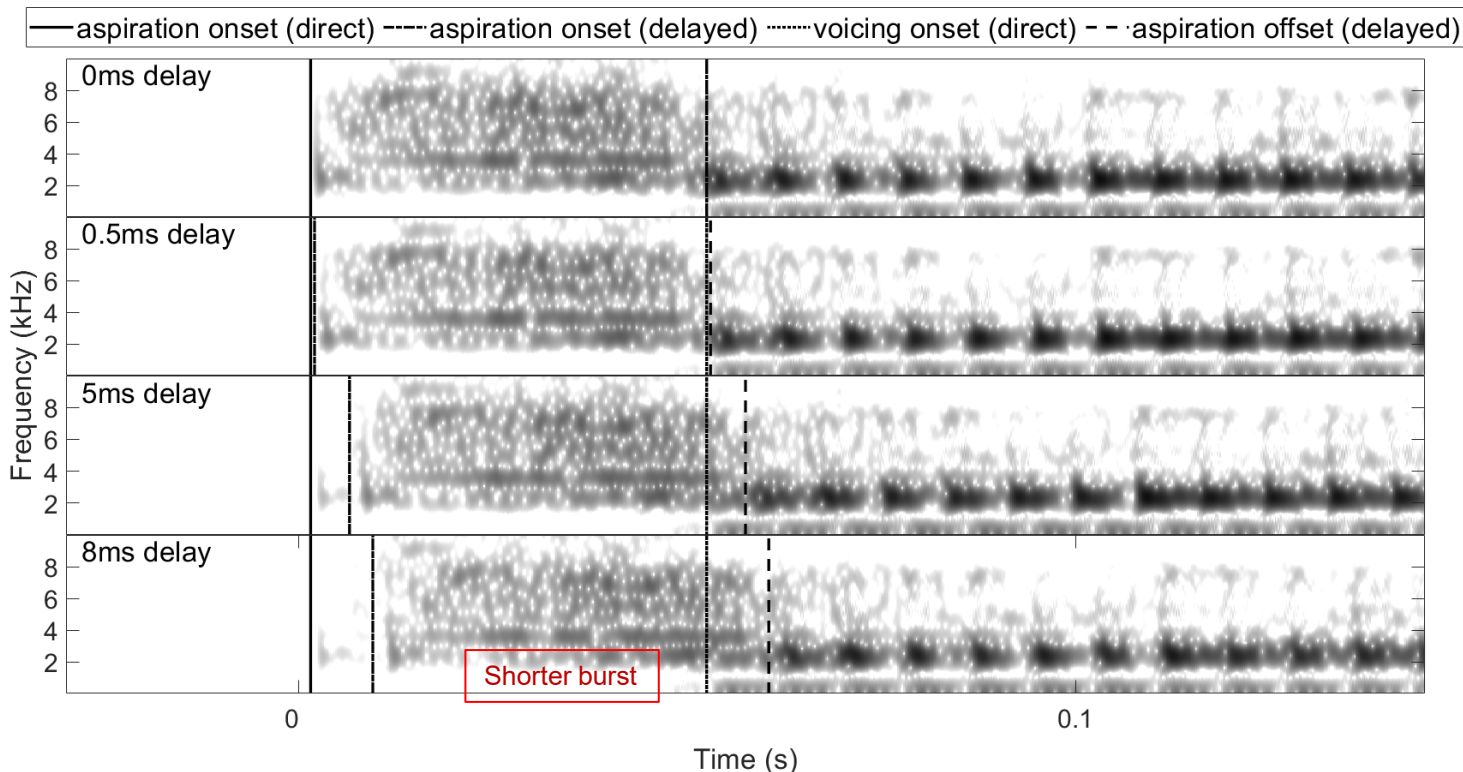


DIE



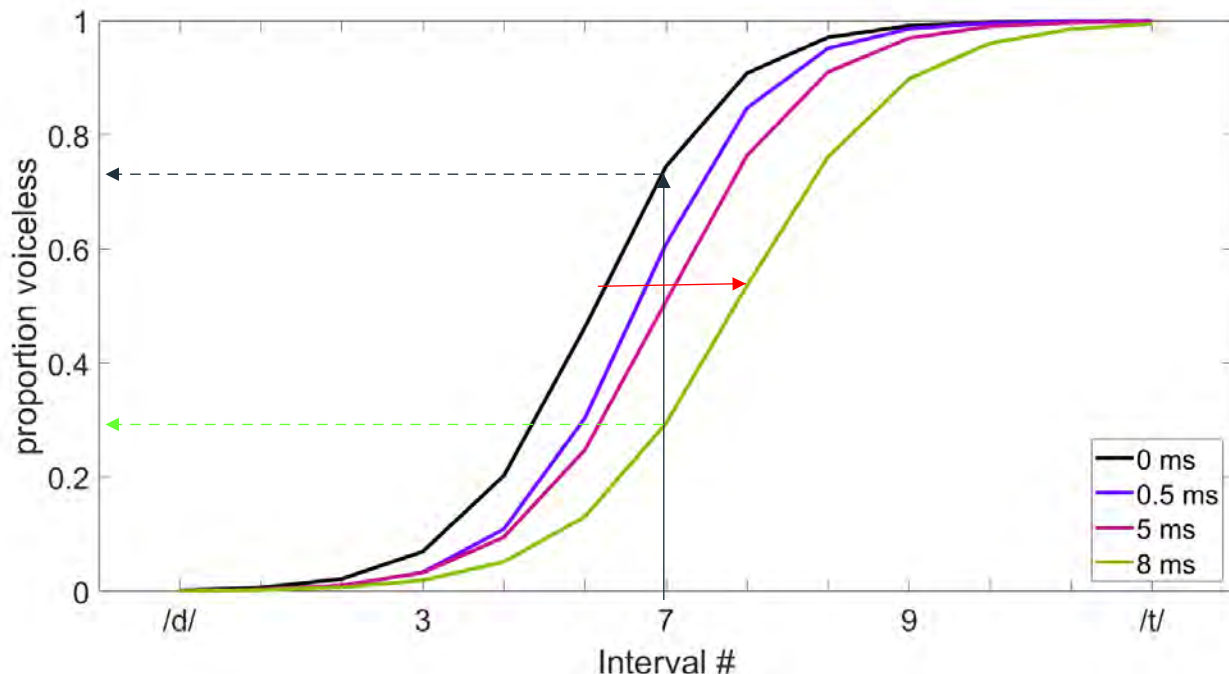
TIE

SPECTROGRAM OF DELAYED /di/



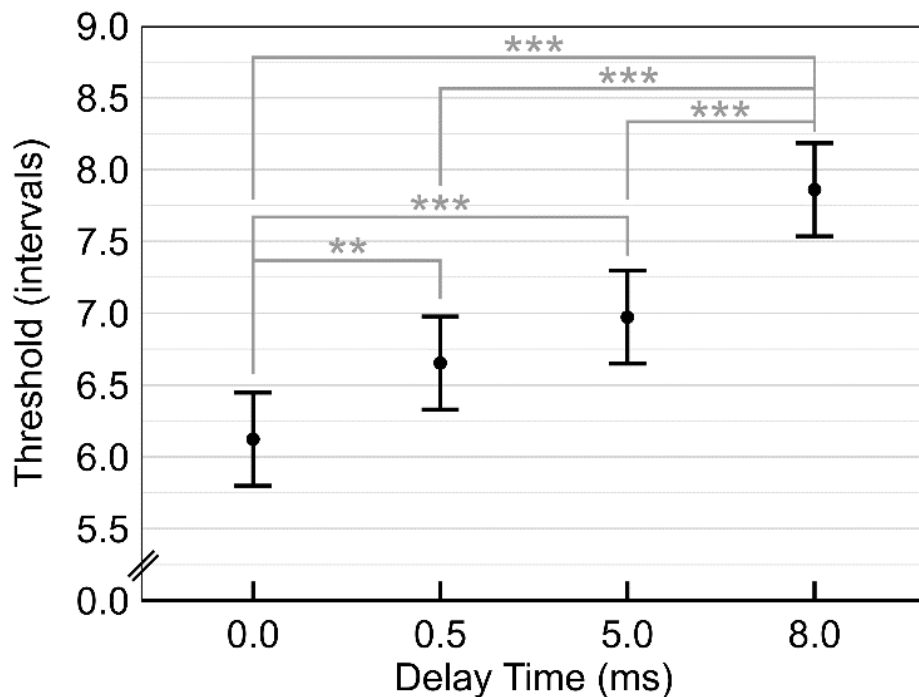
Delay could make the noise burst shorter, making it more voiced, and a voiceless sound voiced; or depending on the audibility of the direct noise burst, lengthens the noise burst and make it more voiceless

RESULTS ON CATEGORICAL PERCEPTION OF /di/ VS /ti/ CONTRAST



Interval (#)	VOT (s)	Aspiration intensity (dB re: interval #13)
1	0.030	-8.00
2	0.033	-7.33
3	0.037	-6.67
4	0.040	-6.00
5	0.043	-5.33
6	0.047	-4.67
7	0.050	-4.00
8	0.053	-3.33
9	0.057	-2.67
10	0.060	-2.00
11	0.063	-1.33
12	0.067	-0.67
13	0.070	0.00

STATISTICAL SIGNIFICANCE ON CATEGORICAL PERCEPTION



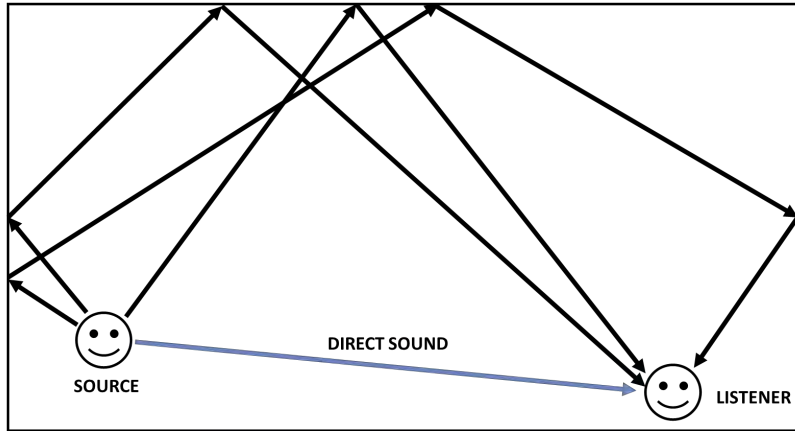
REALISTIC EFFECT OF DELAY ON SPEECH PERCEPTION

- The current study shows
 - Delay distorts the “molecular” basis of speech sounds
 - The effect of the delay on speech is noticeable
 - Speech sounds more natural (and clearer) with lower delay
 - May affect speech identification in sub-optimal situations
 - Non-native speakers, faster speech rate, diction, level etc
 - Listeners with poorer than normal frequency and temporal resolution and cognition
 - The listening environments are unfavorable
- If any or all of the above conditions are met, either listening effort would need to increase to maintain understanding, or understanding suffers

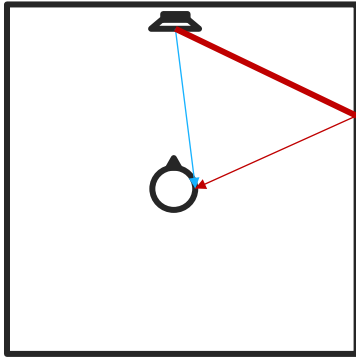
MANY WEARERS WITH ZERODELAY TECHNOLOGY
REPORTED BEING ABLE TO **LOCALIZE SOUNDS** BETTER,
SOUNDS ARE **MORE 3-D**, MORE **SPACIOUS** FEELING



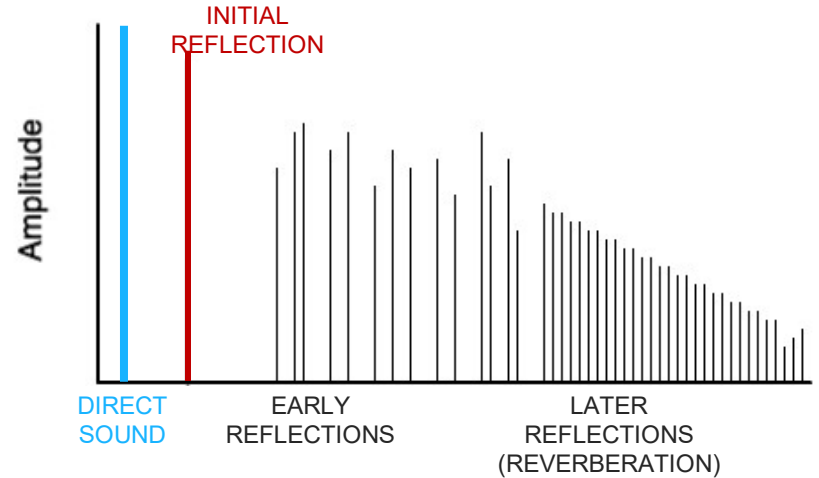
THE REFLECTION PATTERN OF A ROOM IS UNIQUE



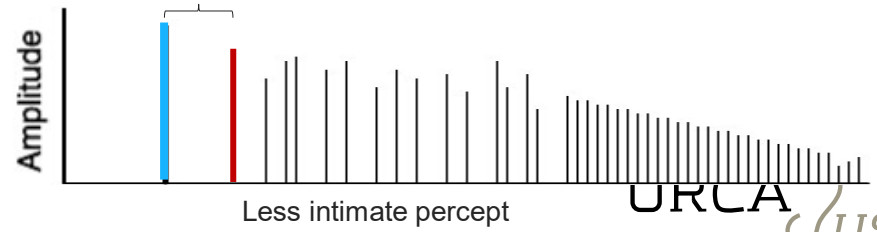
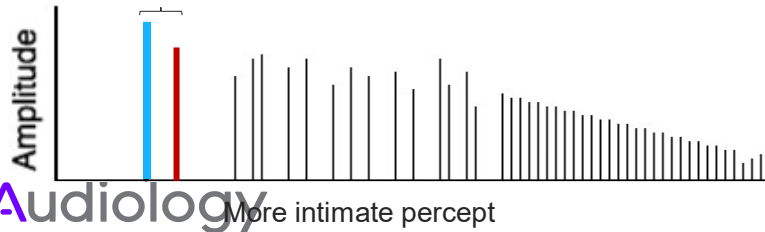
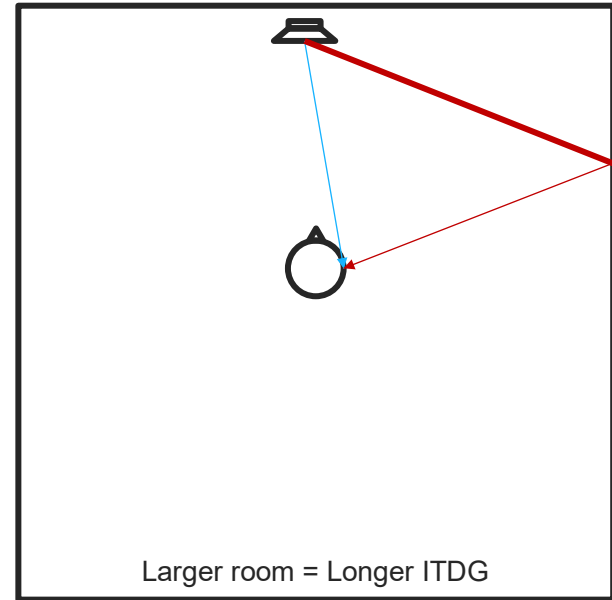
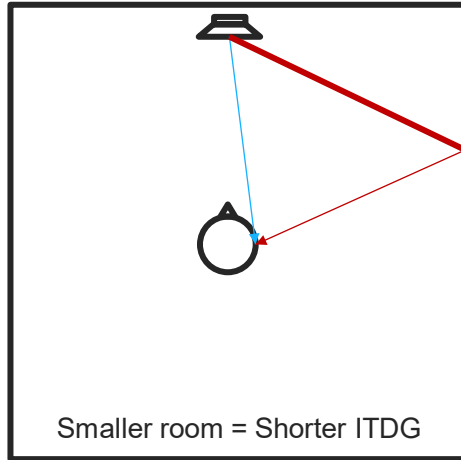
IMPORTANCE OF INITIAL REFLECTION



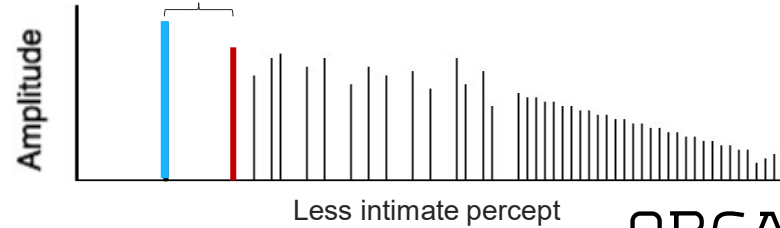
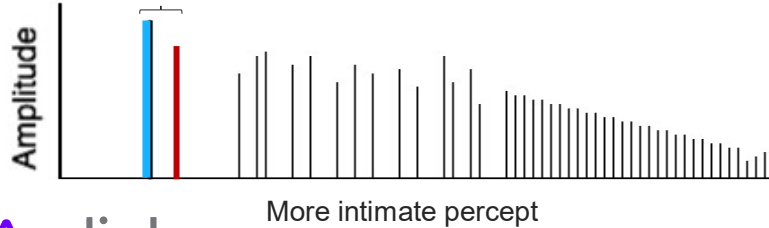
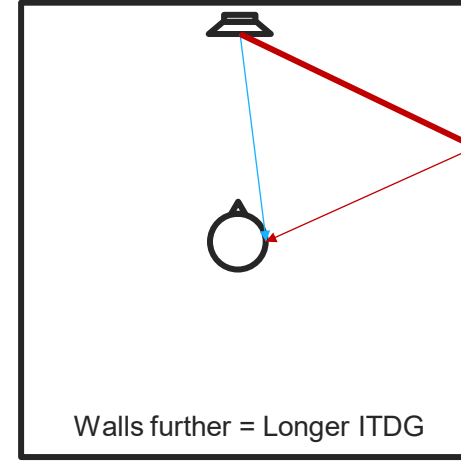
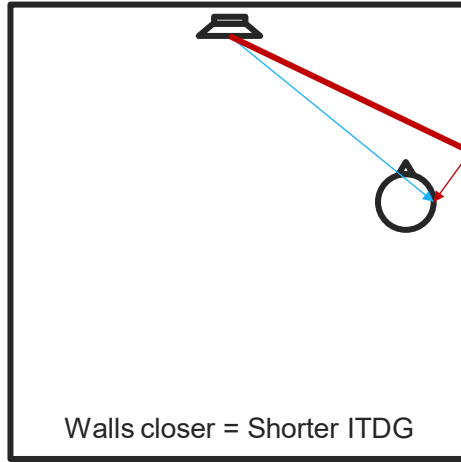
ITDG – initial time delay gap



ITDG IN DIFFERENT SIZE ROOMS



ITDG IN DIFFERENT LISTENING POSITIONS

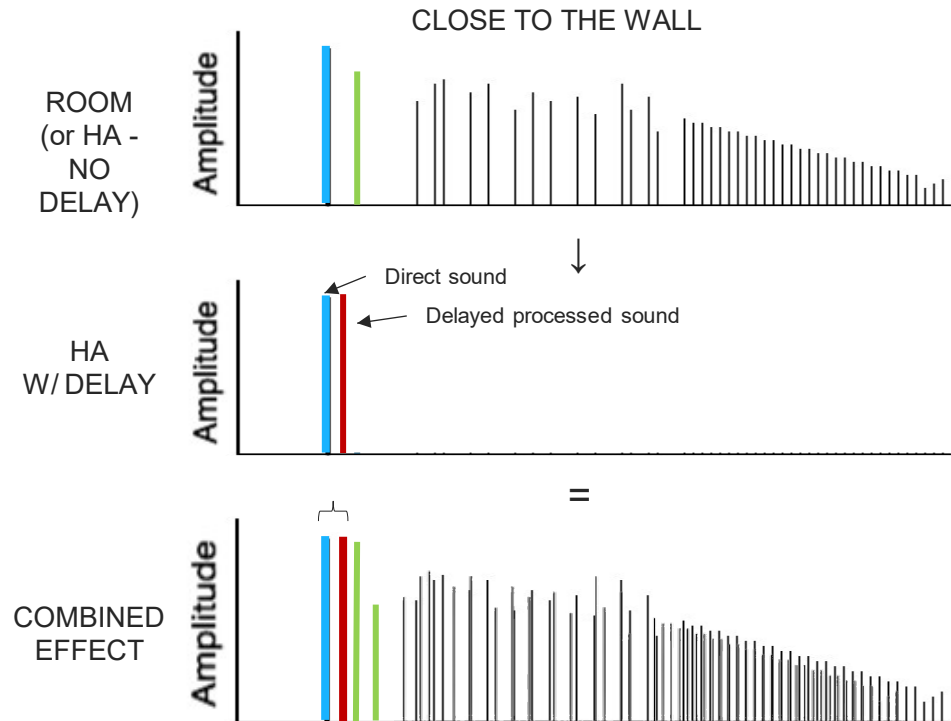


OUR PERCEPTION OF THE REFLECTION PATTERN INFORMS US ABOUT OUR HEARING SPACE

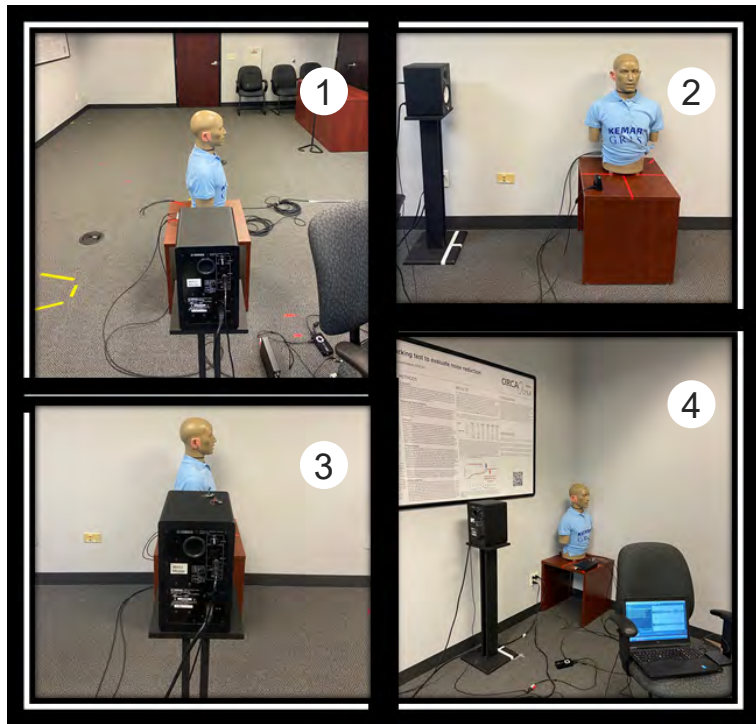
- Do I hear what I see?
- Do what I hear sound real?
- What do I know about the size/shape/materials of the listening space?
- Where am I sitting in the room? Where are the walls in relation to my position?
- How far and which direction is the sound source from me?
- Do I need to adjust my behavior in this space?
 - Move position
 - Feeling solemn, happy etc...

Could delayed HA processing distort the in-situ reflection patterns and render the auditory percept of space around the listener unnatural?

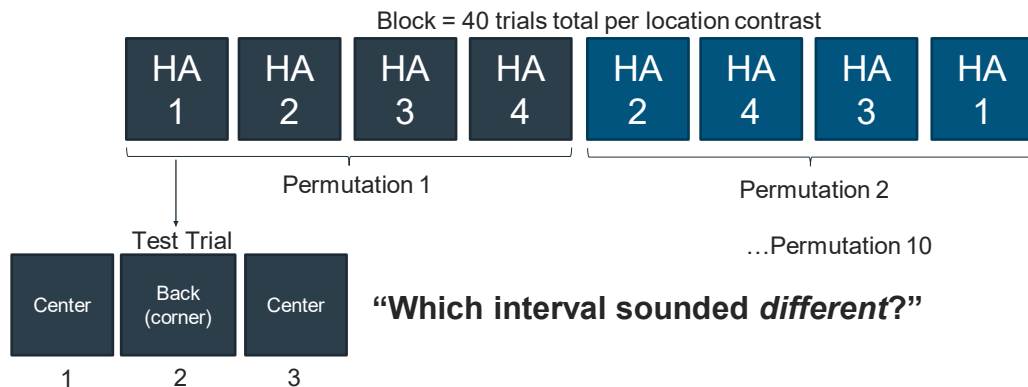
SPECULATION: ROOM REFLECTIONS + DELAYED HEARING AID



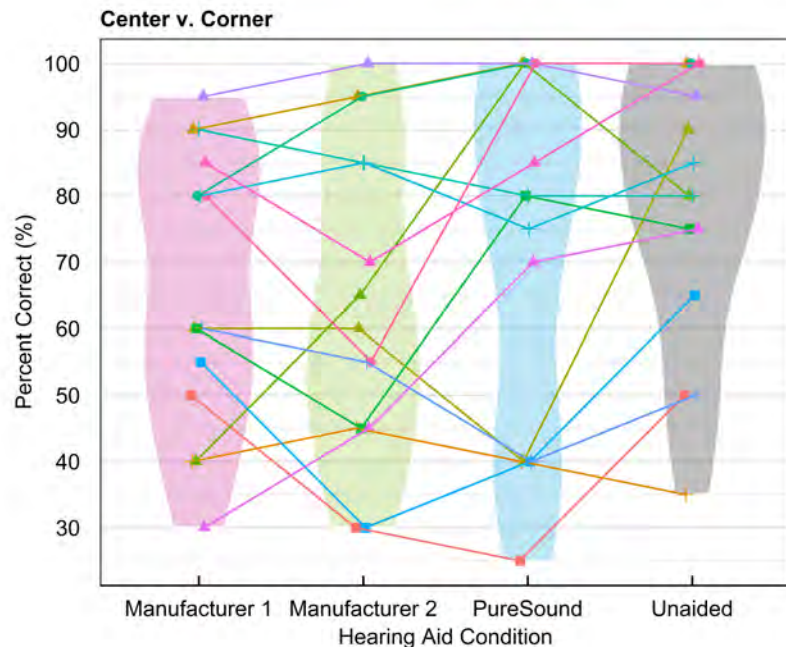
TESTING SPATIAL DISCRIMINATION: KEMAR RECORDING SETUP & PRESENTATION



- 1 = center (reference)
2 = back
4 = corner



INDIVIDUAL LISTENER PERFORMANCE



HI01 HI04 HI07 HI11 HI14
 HI02 HI05 HI08 HI12 HI15
 HI03 HI06 HI09 HI13

• N1 ▲ N2 ■ N3 + S1

IMPLICATIONS OF THE FINDINGS

- Spatial awareness of oneself and locations of objects in space may be altered with longer delays
- Longer delay
 - More difficulty to precisely identify location of objects/self in space
 - Loss of 3-D sensation and appreciation of surroundings
 - More reliant on visual information to compensate
 - More critical for those with visual impairment

Processed food

- Loses nutritional values
- Has lots of artificial ingredients
- Not so good for your health

Fresh food

- Retains all the minerals, vitamins etc
 - Does not have artificial ingredients
 - Better for your health

Thus, ZeroDelay or ultra-fast processing is like FRESH food (vs processed food) in hearing aid processing

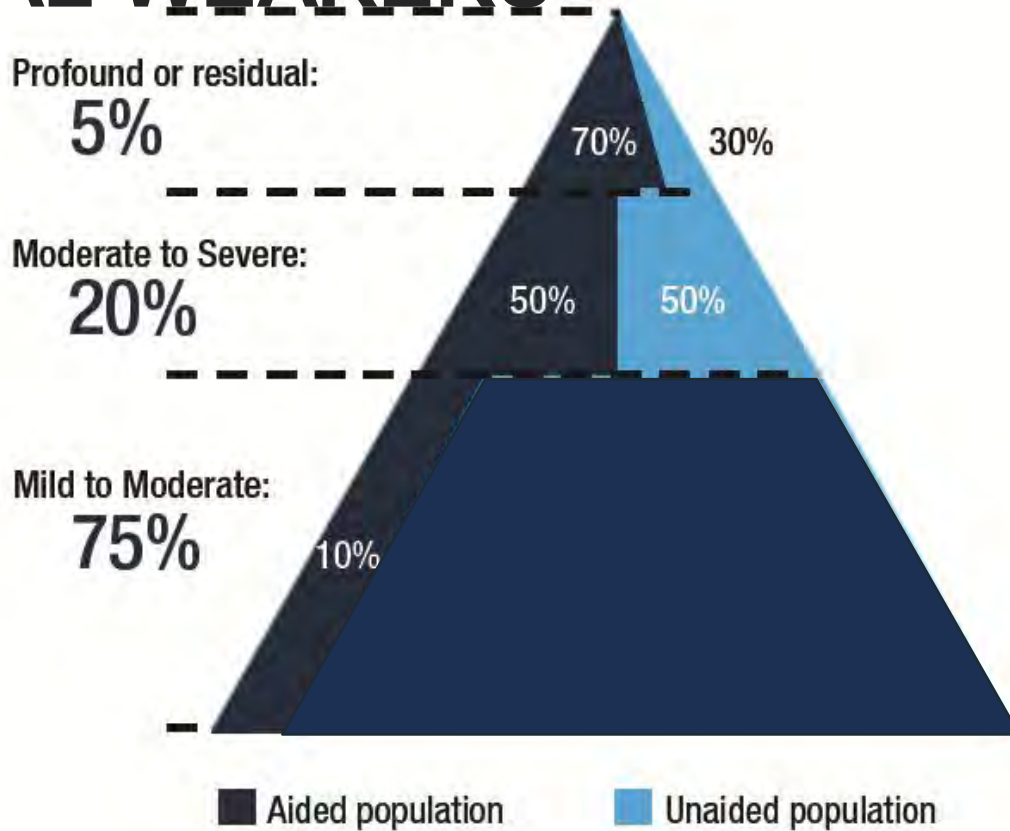
Longer delays

- Smears spect
- Alters temporal pattern
- More effortful to understand

Zero Delay

- s all the cues
- Does not introduce artifact
 - Less effortful

AN OPPORTUNITY TO REACH MORE POTENTIAL WEARERS



Thank you for listening!!!



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