

A photograph of a modern office building with a mix of brick and glass facades. The building is surrounded by greenery, including trees and a stone sign. The sign reads "2300 CABOT DRIVE" and "Francis Kuk, PhD Widex ORCA-USA". The text "INNOVATIONS IN SOUND AND COGNITION: PART 1 - SOUNDS AS NATURE INTENDS" is overlaid on the image in white, bold, sans-serif font.

# INNOVATIONS IN SOUND AND COGNITION: PART 1 - SOUNDS AS NATURE INTENDS

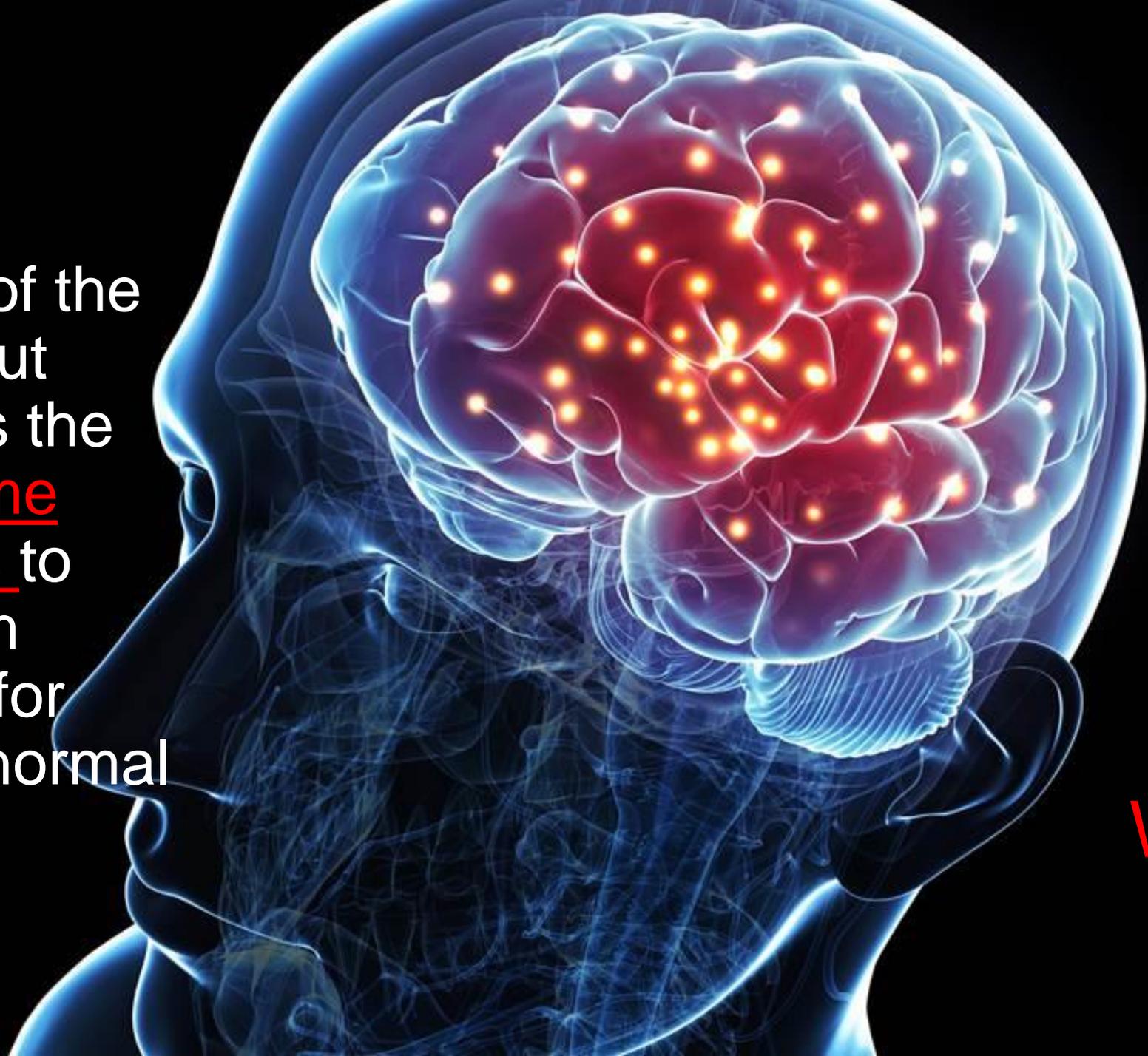
2300 CABOT DRIVE

*Francis Kuk, PhD  
Widex ORCA-USA*



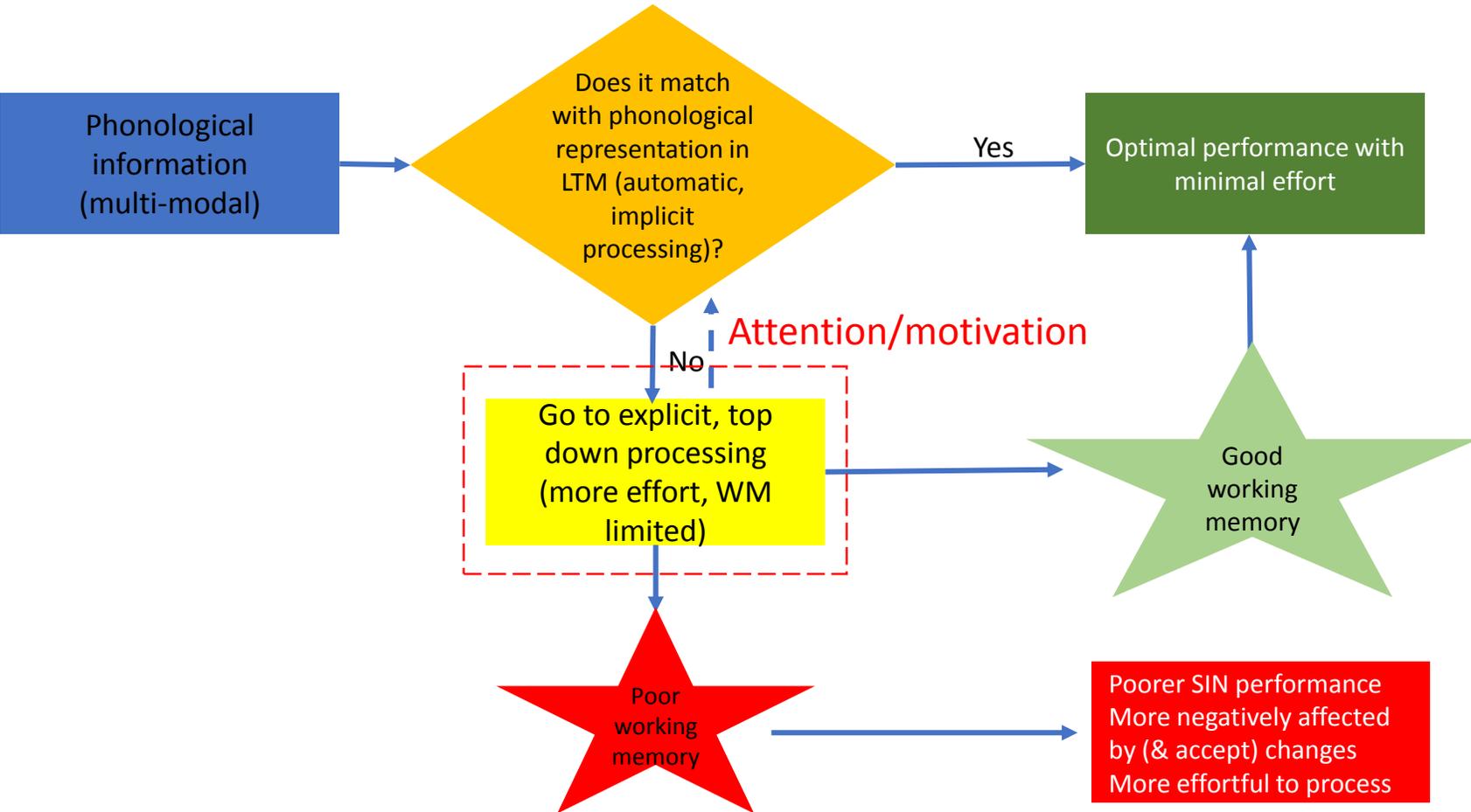
Hearing aids are kind of like food

Keeping the naturalness of the amplified input sounds gives the brain the same opportunities to process them optimally as for people with normal hearing



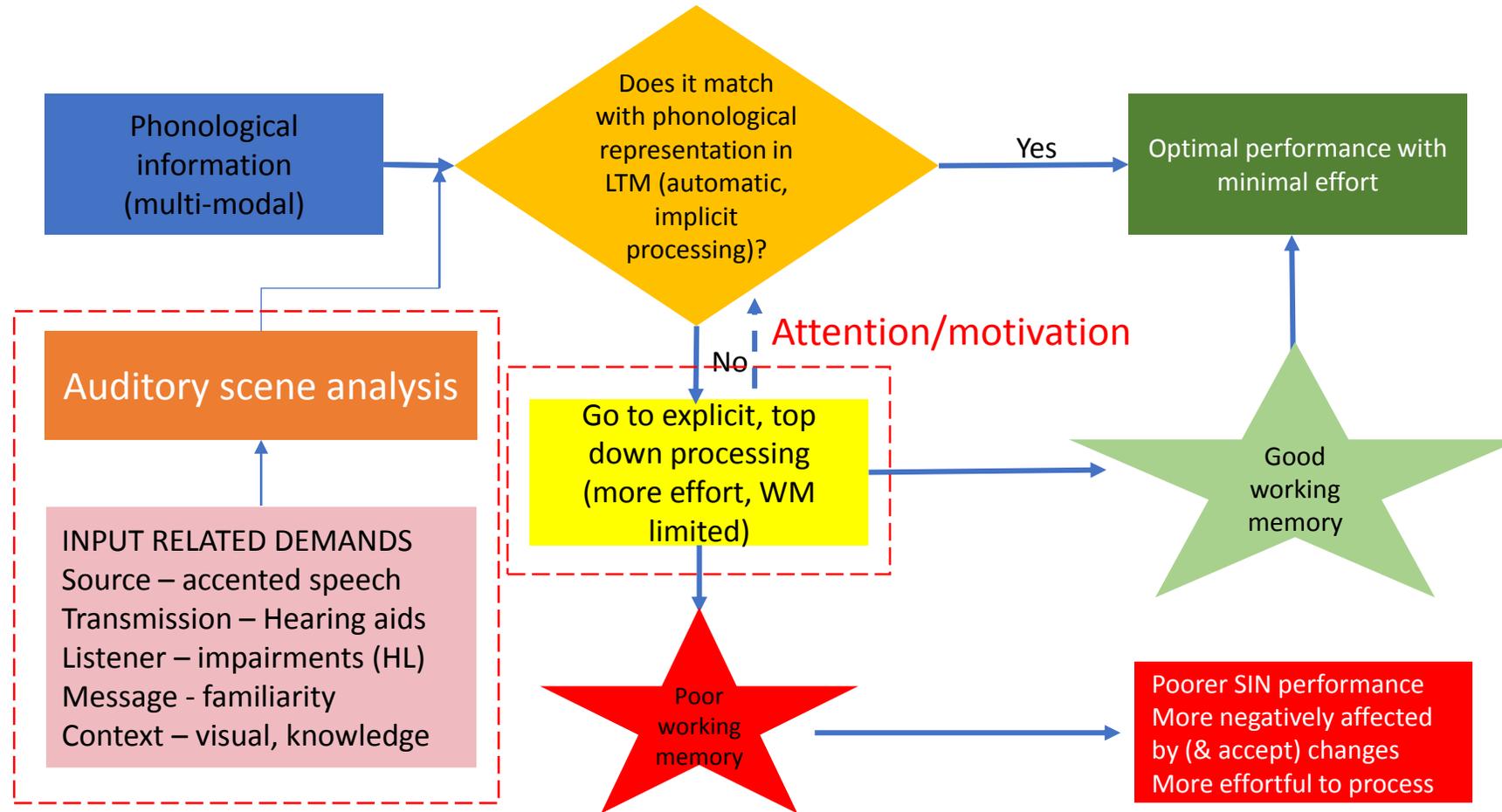
WHY?

# EASE OF LANGUAGE UNDERSTANDING MODEL



EASE OF LANGUAGE UNDERSTANDING MODEL  
RONNBERG (2008)

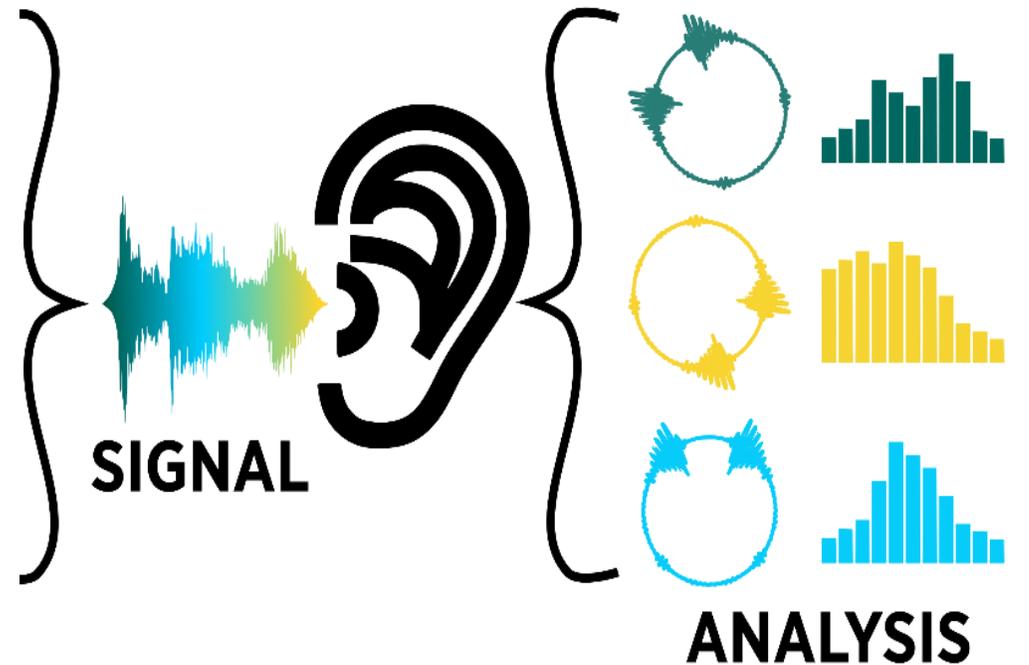
# GOODNESS OF MATCH DEPENDS ON RESULTS OF AUDITORY SCENE ANALYSIS



EASE OF LANGUAGE UNDERSTANDING MODEL  
RONNBERG (2008)

# WHAT IS AUDITORY SCENE ANALYSIS ?

How the brain separates one sound from a mixture of sounds in order to focus on the intended target.



# EXAMPLES OF PRIMITIVE CUES THAT WE USE

- Examples
  - Frequency (F0)
  - Pitch
  - Harmonicity
  - ITD, ILD
  - Onset asynchrony
  - Loudness
- Sounds that share similar characteristics on these cues are grouped together as coming from the same source
- The more these cues are preserved, the easier it is to identify and follow the intended speaker in a noisy place (e.g., party)

# ACCURACIES OF AUDITORY SCENE ANALYSIS DEPENDS ON **INPUT-RELATED DEMANDS**

Source – COVID masked speech

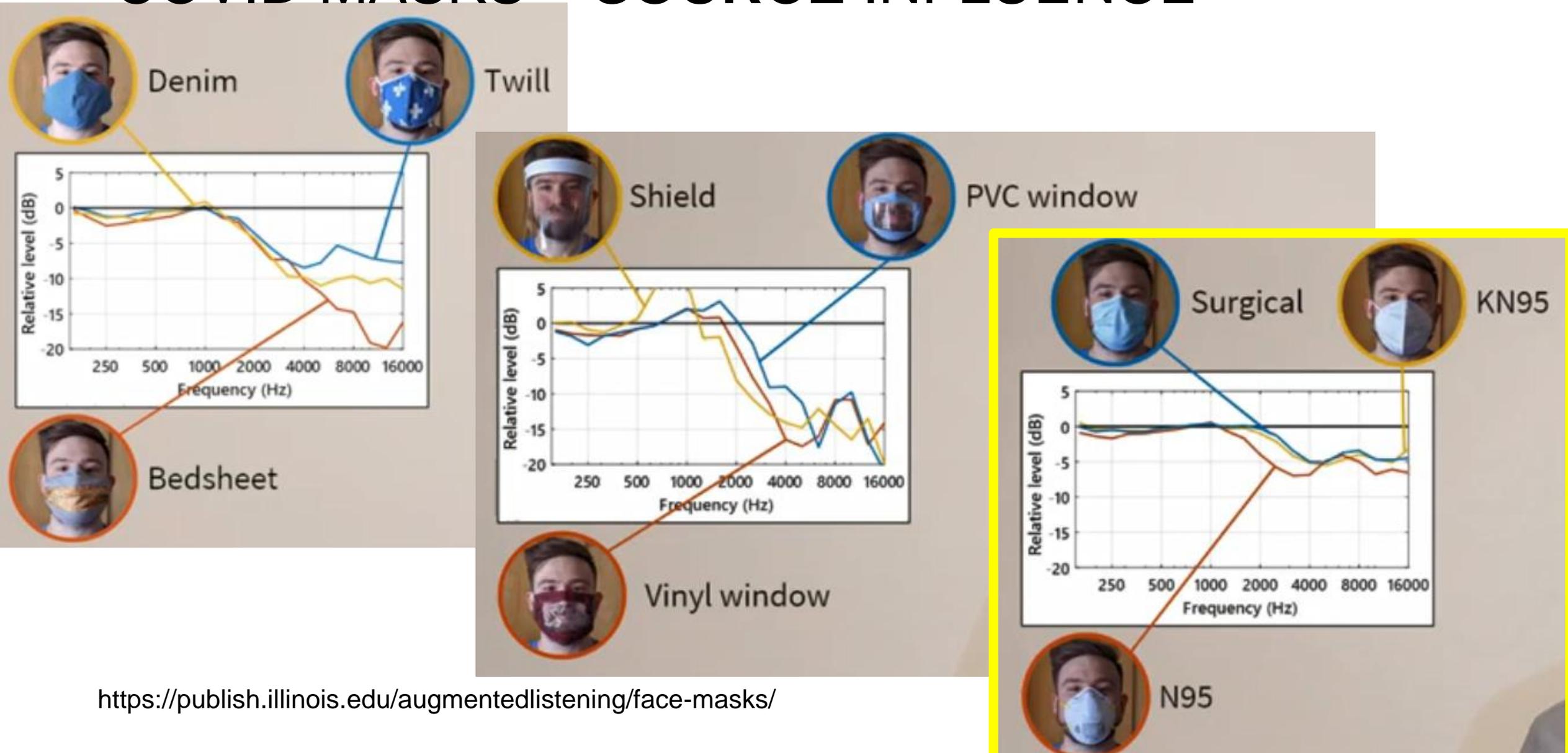
Transmission – Hearing aids

Listener – impairments (HL)

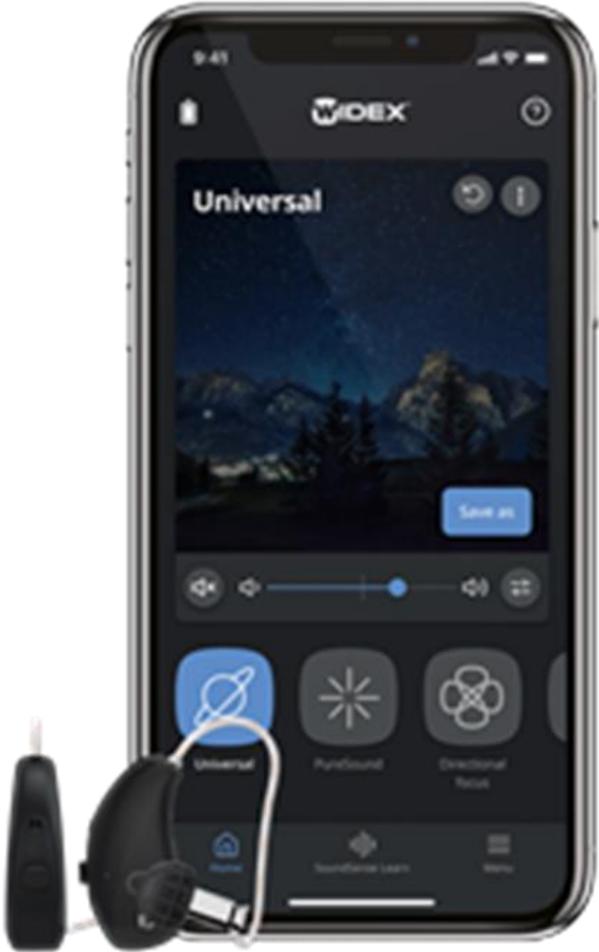
Message - familiarity

Context – visual, knowledge

# COVID MASKS – SOURCE INFLUENCE



# PATIENT CENTERED: CREATING A “MASK” PROGRAM



# ACCURACIES OF AUDITORY SCENE ANALYSIS DEPENDS ON **INPUT-RELATED DEMANDS**

Source – COVID masked speech

Transmission – Hearing aids

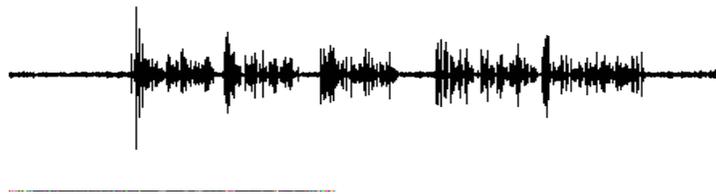
Listener – impairments (HL)

Message - familiarity

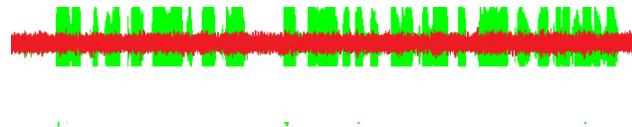
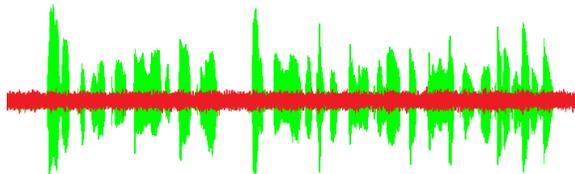
Context – visual, knowledge

# HOW HEARING AIDS AFFECT THE INPUT RELATED DEMANDS

- Limited bandwidth reduces the audibility of sounds
- Fast compression alters (reduces) the envelope



- Distortion at high input levels reduces the SNR of the input and smears the temporal envelope



- These changes make it more difficult for the listener to decode the input
  - Failure to understand
  - Expend greater effort to understand – leading to fatigue
  - Frequent failure leads to withdrawal from communication situations, social isolation, cognitive deprivation etc

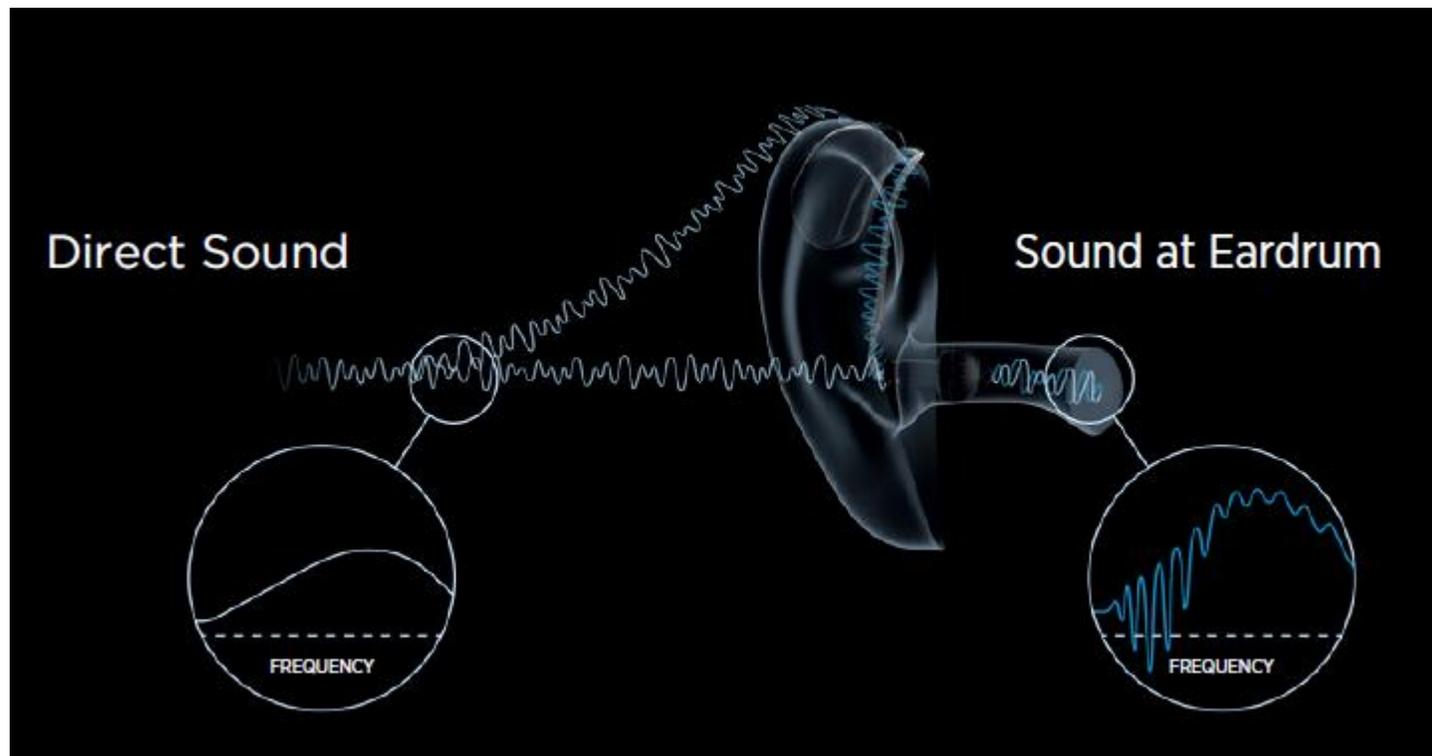


# WIDEX'S LONG **HISTORY** OF PRESERVING THE NATURALNESS OF SOUNDS

---

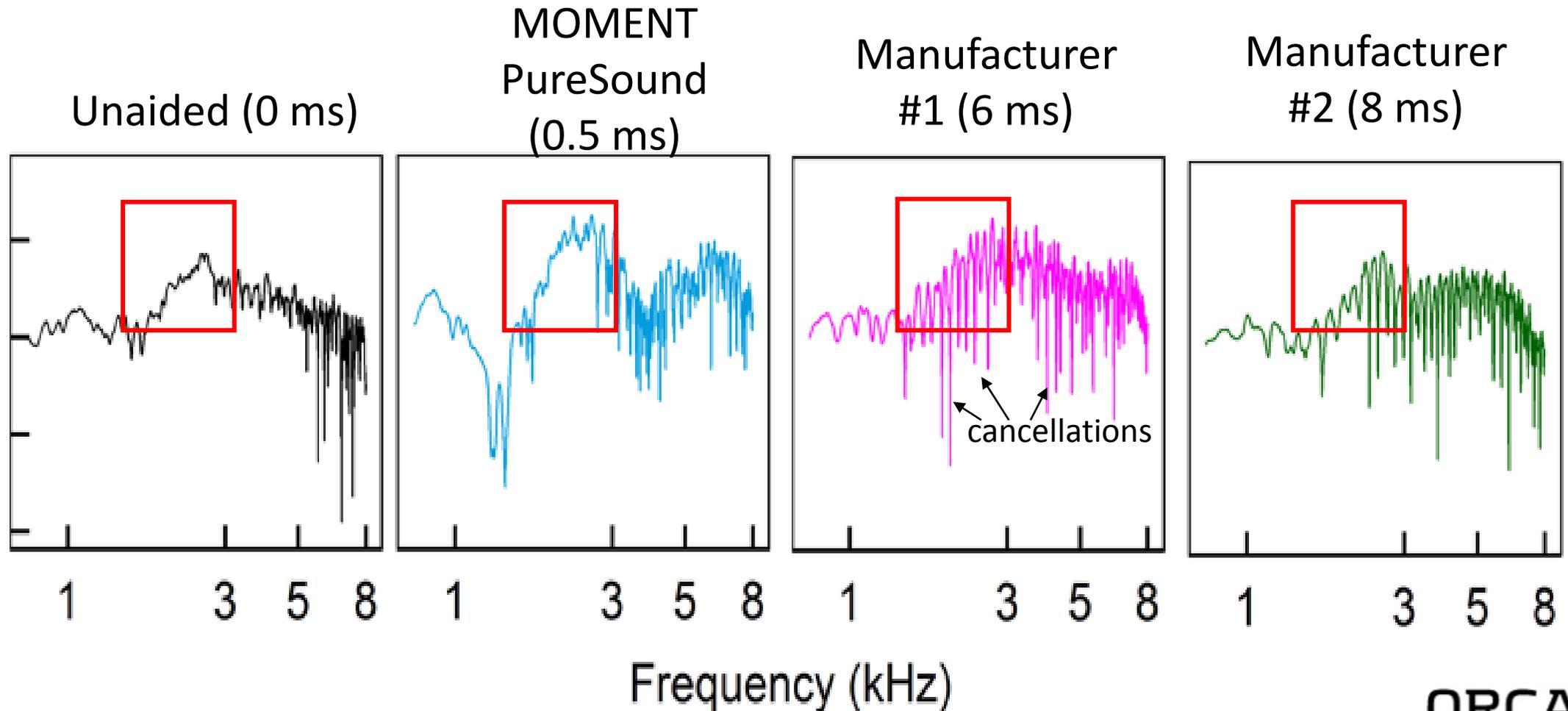
- Slow acting (and later dual compression) – to maintain the temporal dynamic/envelope
- Extended dynamic range compression (EDRC) – to ensure audibility of soft sounds
- Extended input dynamic range (TruSound) – to ensure loud input sounds are not distorted
- Broad bandwidth to 10 KHz – to ensure audibility of a full range of frequencies
- LATEST ZeroDelay Technology is another example of keeping the ***naturalness of input sounds***

# WHEN DOES PROCESSING DELAY DISTORT?

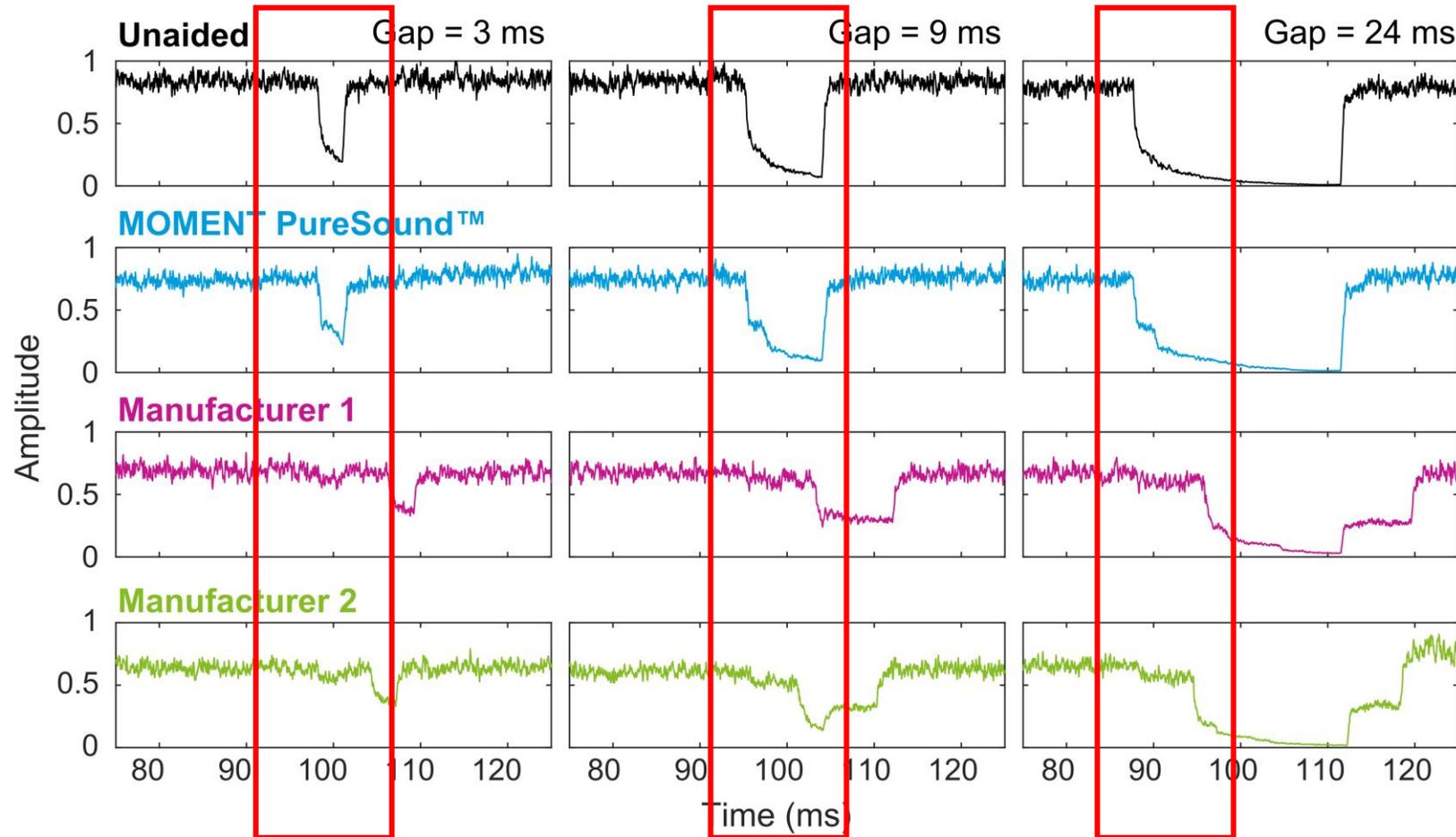


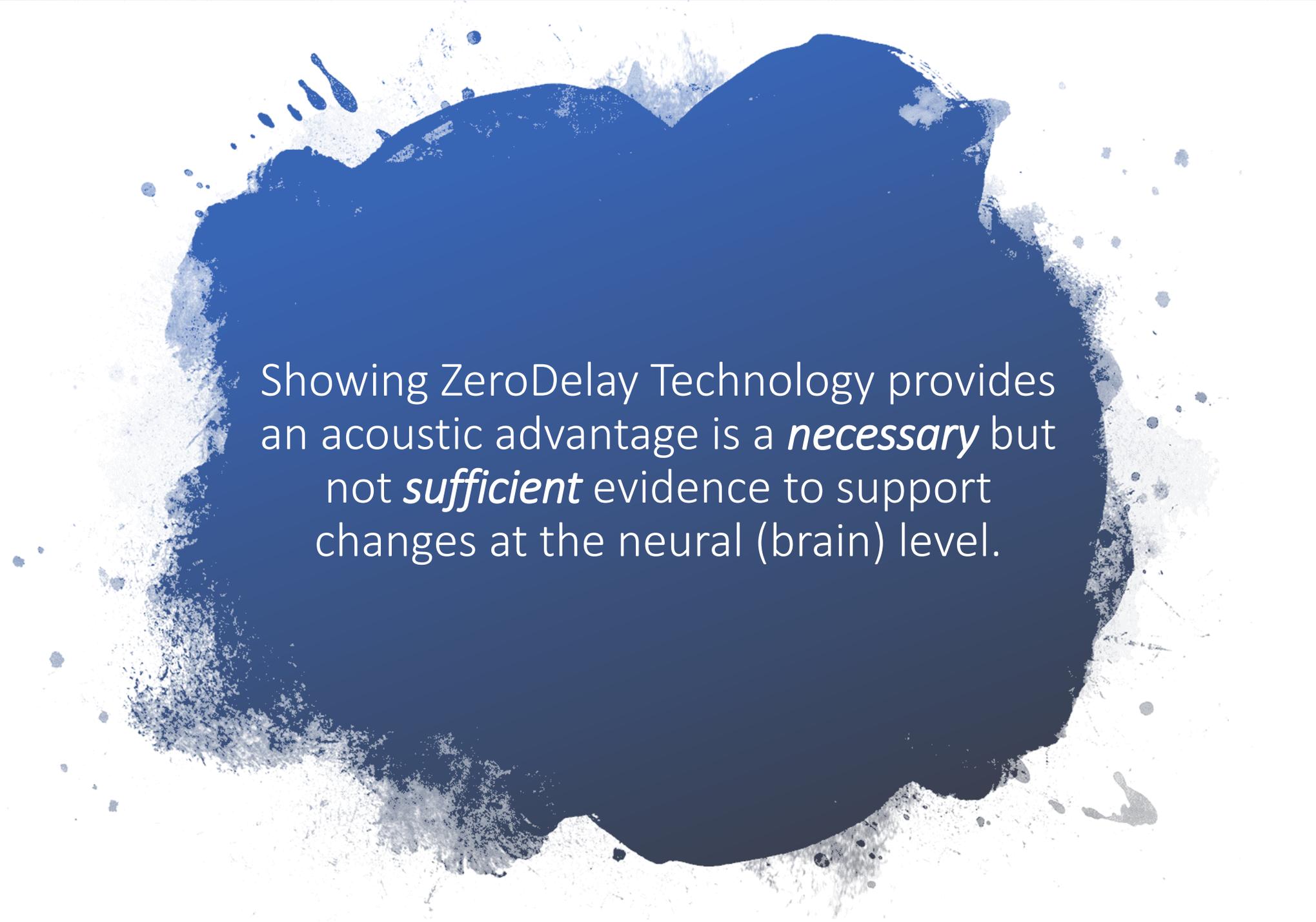
This occurs in **ALL** instant-fit eartips – double dome, tulip, and open, and vented custom earmolds.

# SPECTRAL DISTORTION FROM PROCESSING DELAY



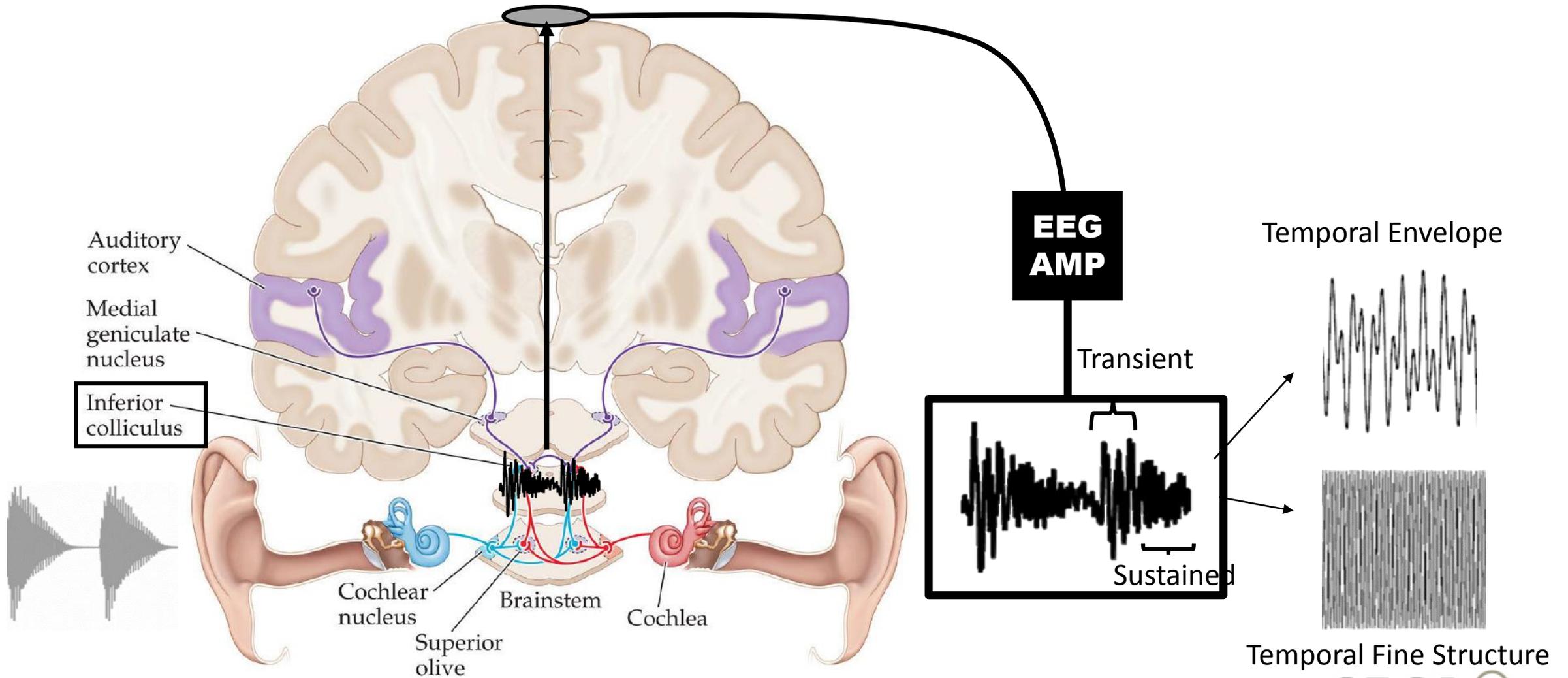
# TEMPORAL DISTORTION FROM PROCESSING DELAY



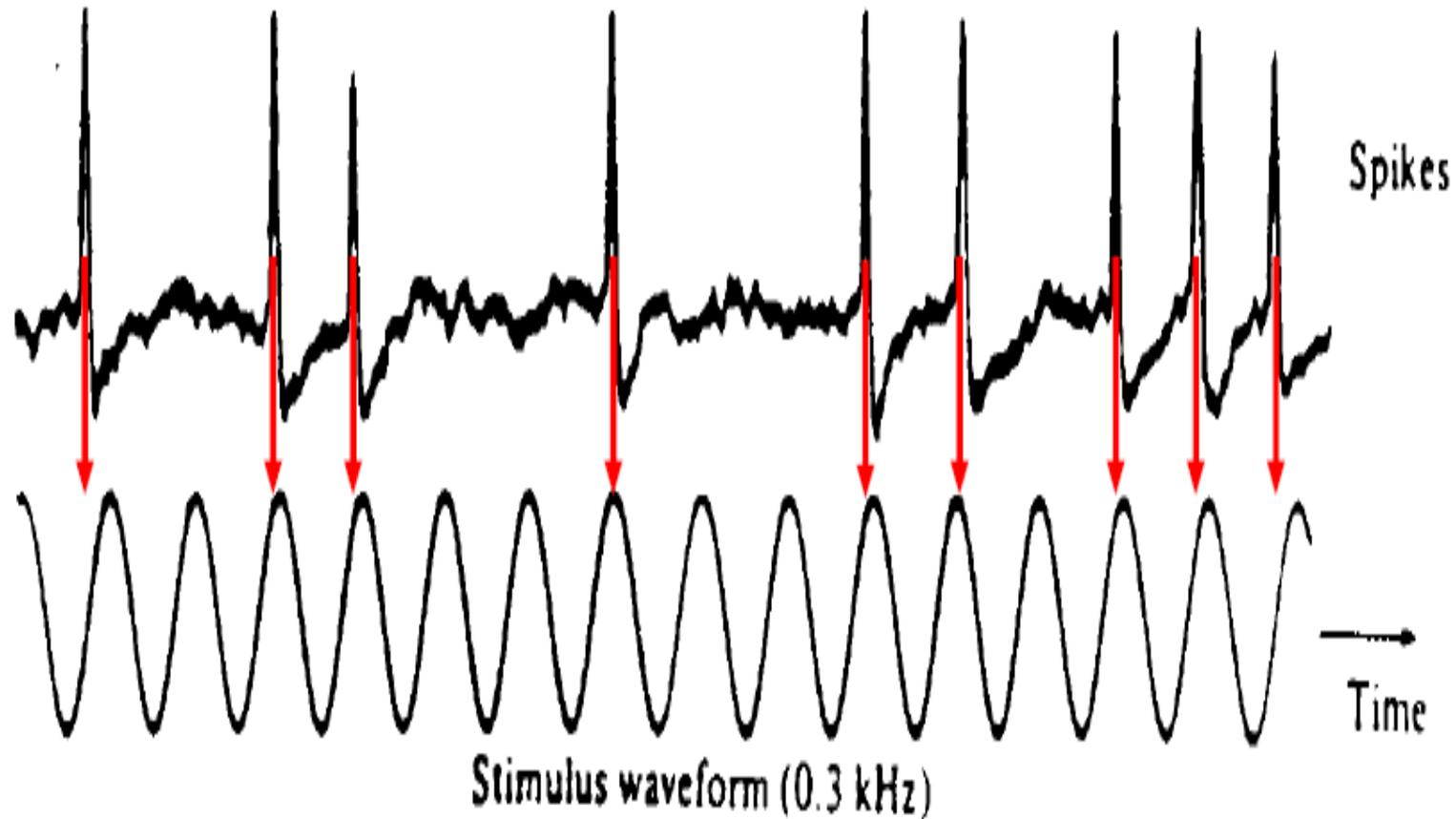


Showing ZeroDelay Technology provides an acoustic advantage is a *necessary* but not *sufficient* evidence to support changes at the neural (brain) level.

# THE FREQUENCY FOLLOWING RESPONSE (FFR)



# PHASE-LOCKING – HOW THE BRAIN CODES ENVELOPE INFORMATION



# WHAT INFORMATION CAN WE GET FROM CODING OF TEMPORAL ENVELOPE?

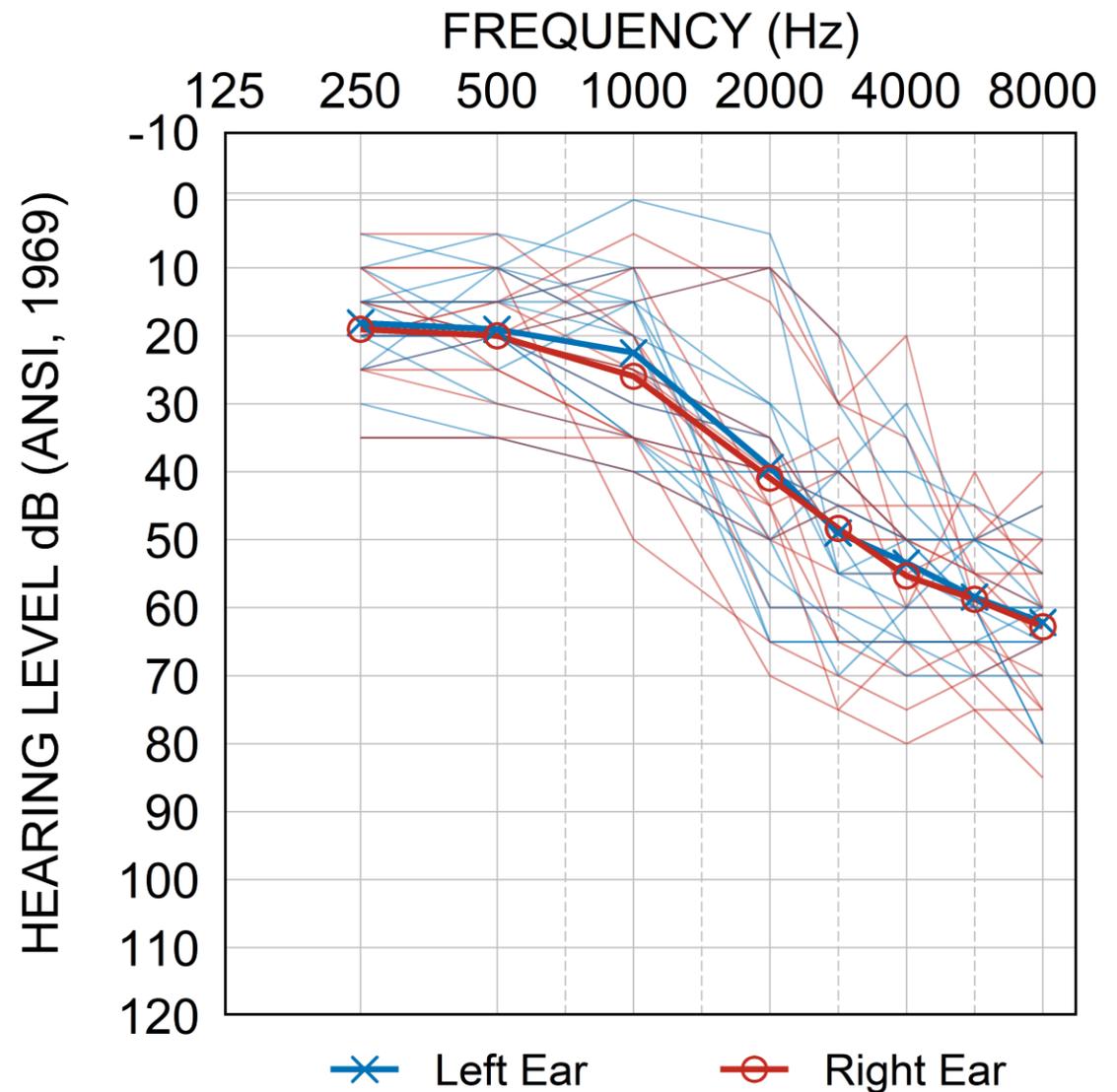
- EFR measures the phase-locking ability of the auditory system to the fundamental frequency (F0) of speech sounds at the brainstem level
  - EFR magnitude represents neural input modified by central influences. It reflects the goodness (sharpness) of the neural input to the brain
  - It correlates with 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
- Potential means to improve EFR – auditory training.

# WE ASKED THESE RESEARCH QUESTIONS

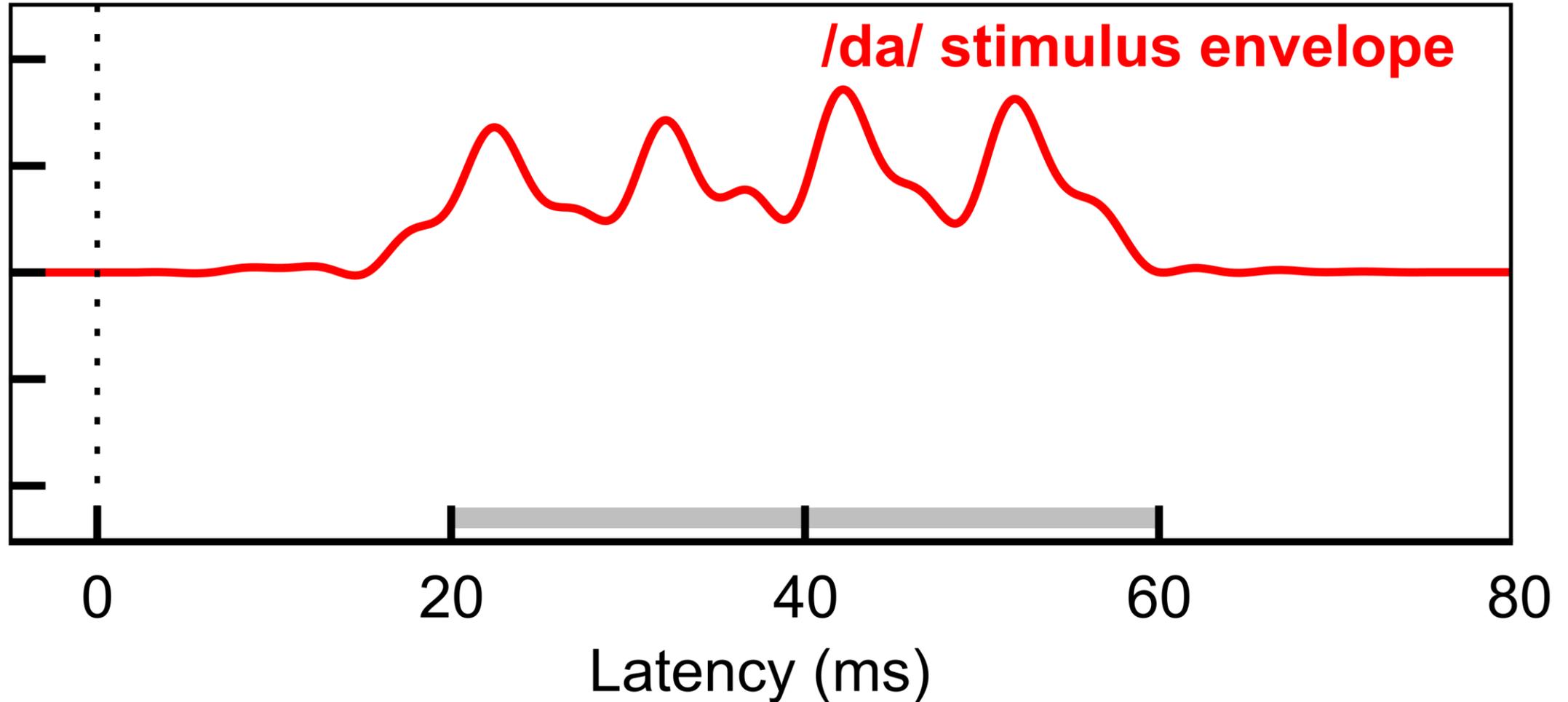
- Does the acoustic advantage offered by ZeroDelay Technology translate into *better neural coding* of the input?
- How does the neural input achieved with ZeroDelay Technology *compare with competitors' premium products* that have a longer delay?
- Would ZeroDelay Technology *need* a directional microphone to achieve *comparable speech intelligibility* in noise as other premium products with directional microphones?

## DETAILS OF STUDY: ENVELOPE FOLLOWING RESPONSE (EFR)

- 16 experienced hearing aid wearers with mild-to-moderate loss
- 3 electrodes with Cz as active
- Synthesized /da/ at 70 dB SPL presented over 8000 trials
- Listened to PureSound program and two other premium hearing aids in counterbalanced order

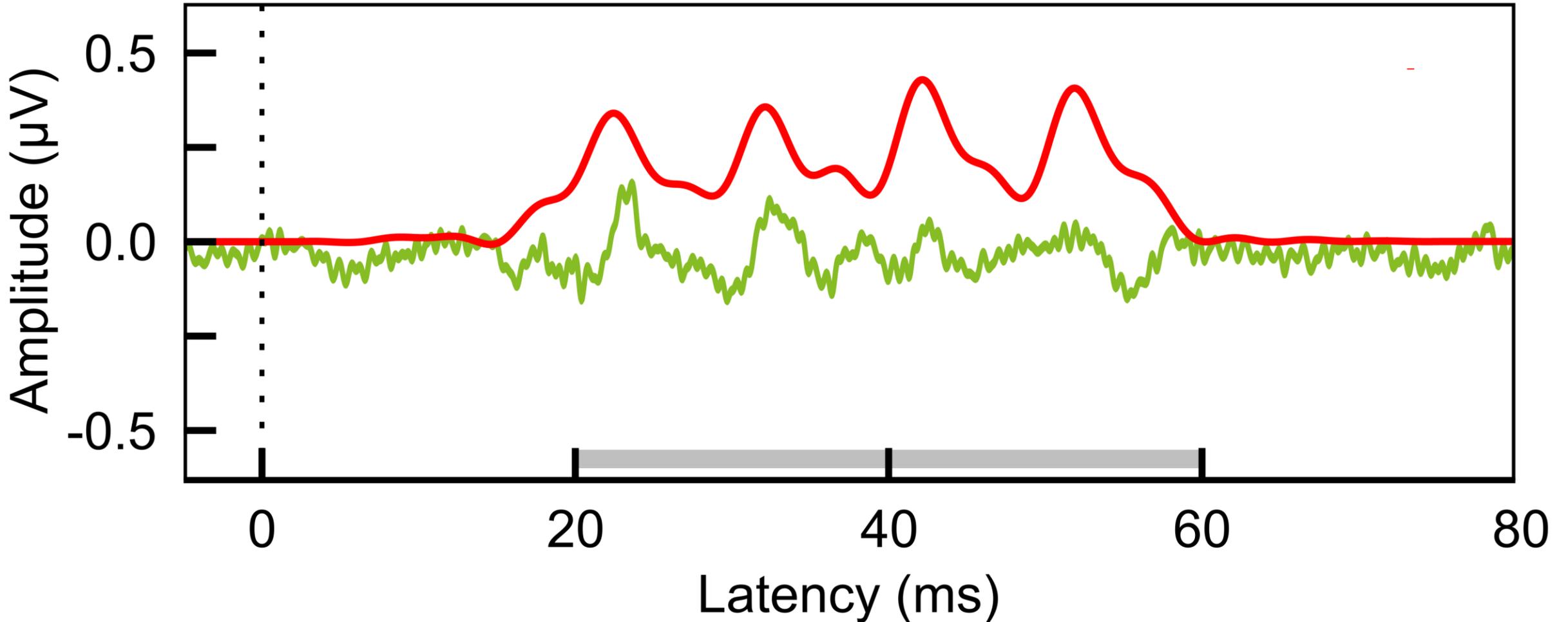


# INPUT ENVELOPE AND EFR BETWEEN PURESOUND AND TWO PREMIUM HEARING AIDS



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

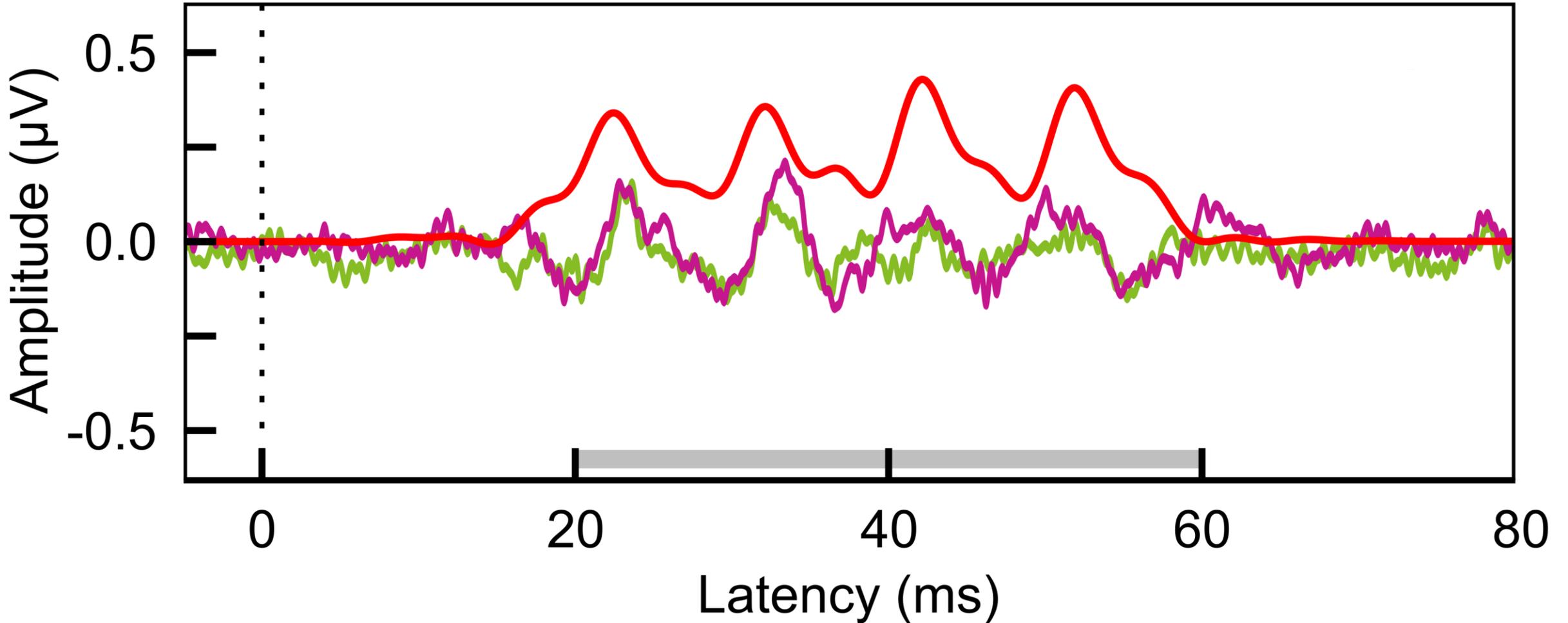
Manufacturer 1



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

Manufacturer 1

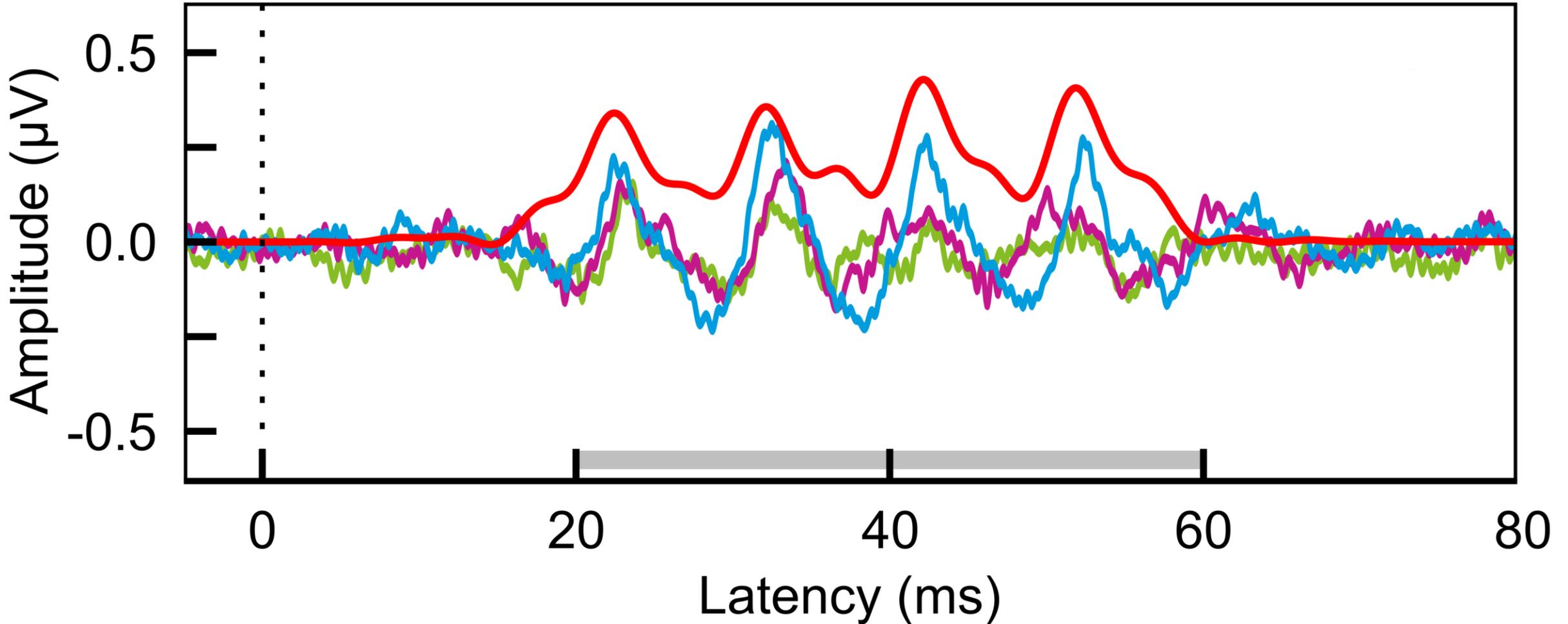
Manufacturer 2



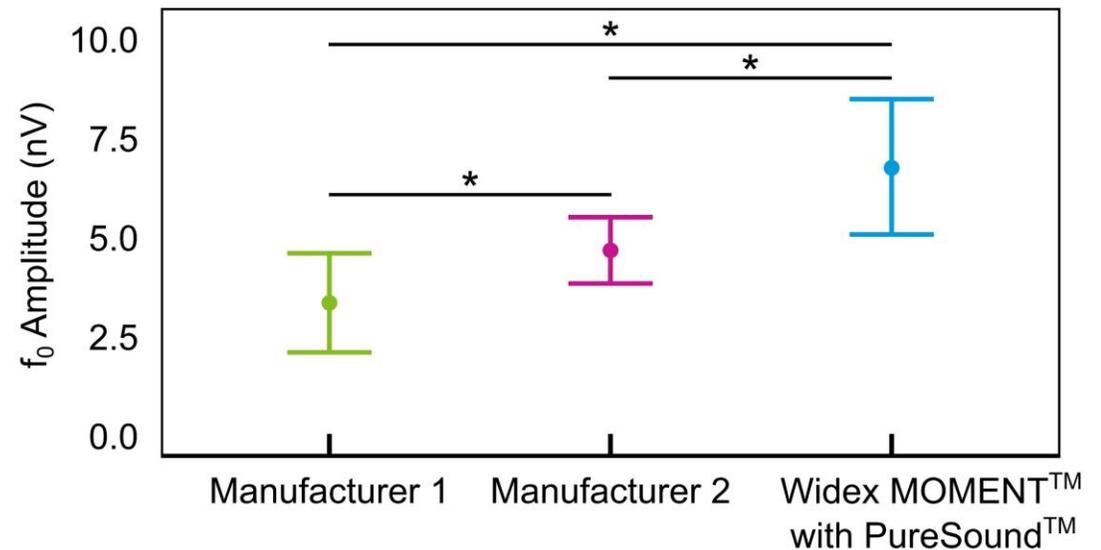
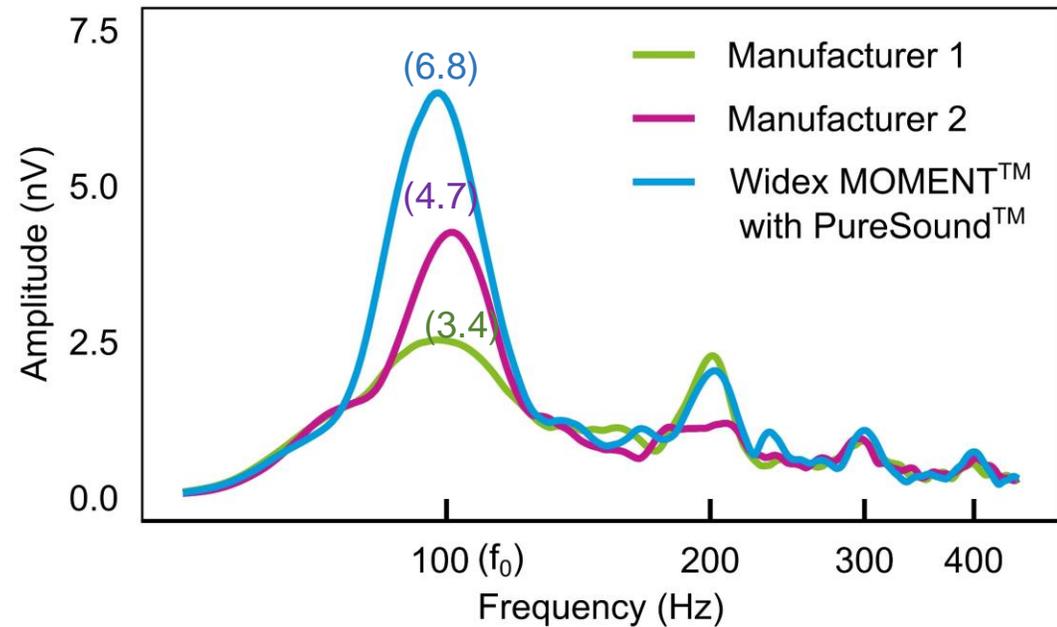
# INPUT ENVELOPE AND EFR BETWEEN PURESOUND AND TWO PREMIUM HEARING AIDS

Manufacturer 1

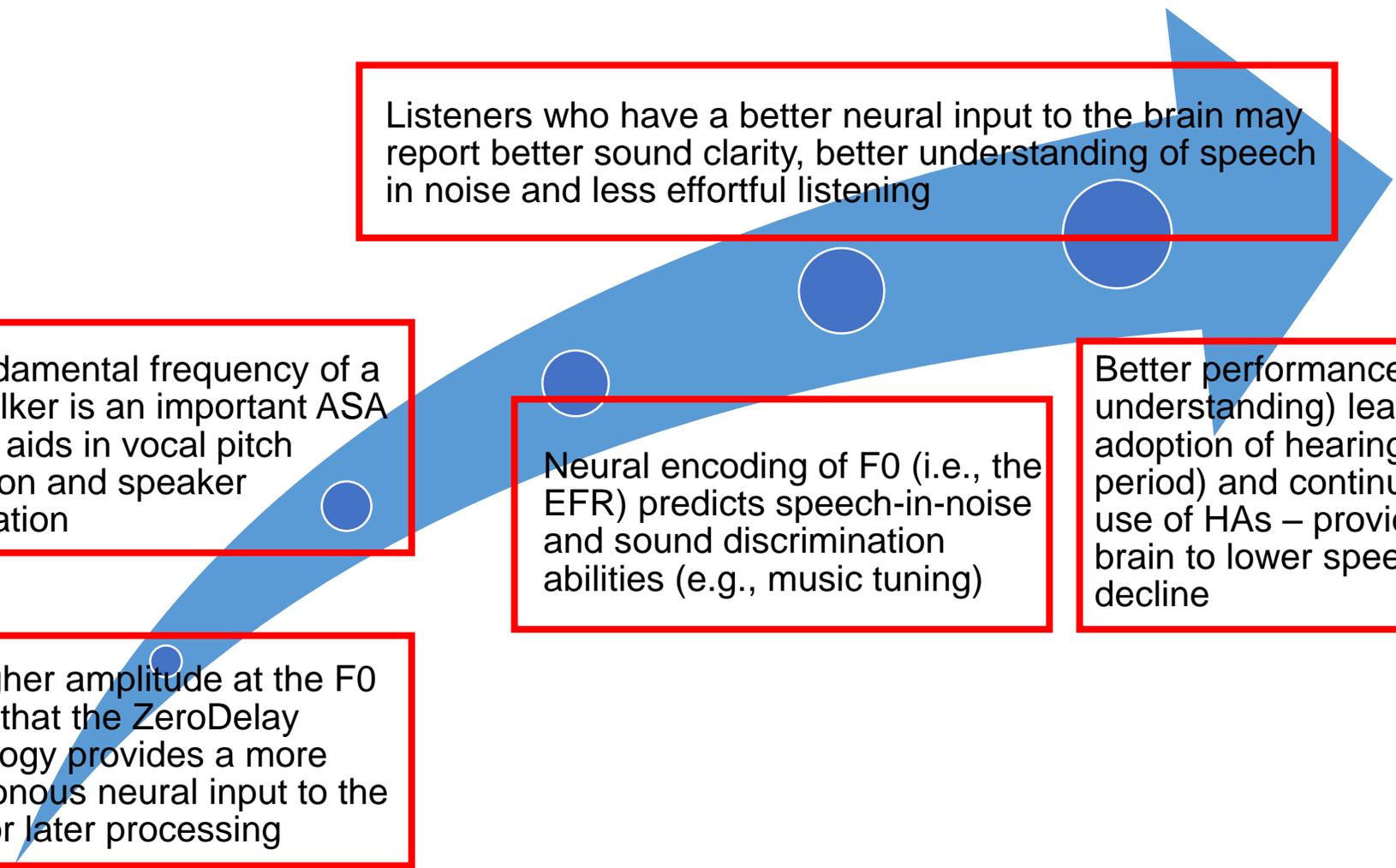
Manufacturer 2 Widex MOMENT™ with PureSound™



The amplitude of the EFR suggests that the envelope of the /da/ is coded more strongly (better synchrony) in the PureSound than other HAs



# WHAT DOES A MORE SYNCHRONIZED (OR STRONGER) F0 MEAN?



Listeners who have a better neural input to the brain may report better sound clarity, better understanding of speech in noise and less effortful listening

The fundamental frequency of a target talker is an important ASA cue that aids in vocal pitch perception and speaker identification

Neural encoding of F0 (i.e., the EFR) predicts speech-in-noise and sound discrimination abilities (e.g., music tuning)

Better performance (quality and understanding) leads to quicker adoption of hearing aids (shorter trial period) and continual and consistent use of HAs – providing steady input to brain to lower speed/risk of cognitive decline

The higher amplitude at the F0 means that the ZeroDelay technology provides a more synchronous neural input to the brain for later processing

# WHAT IF THE SYNCHRONY IS WEAKER?

Poorer F0 means more difficulty with speech in noise and poorer sound quality

Increased effort to understand/communicate

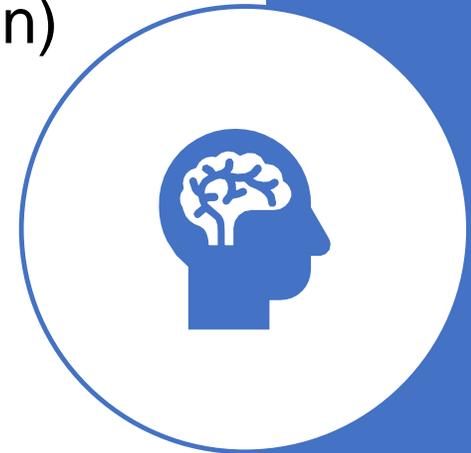
Increased fatigue & negative feelings

Decreased willingness to accept hearing aid; longer adaptation period  
Decreased motivation to communicate

Social withdrawal which may increase speed of cognitive decline

# WHO MAY **BENEFIT THE MOST?**

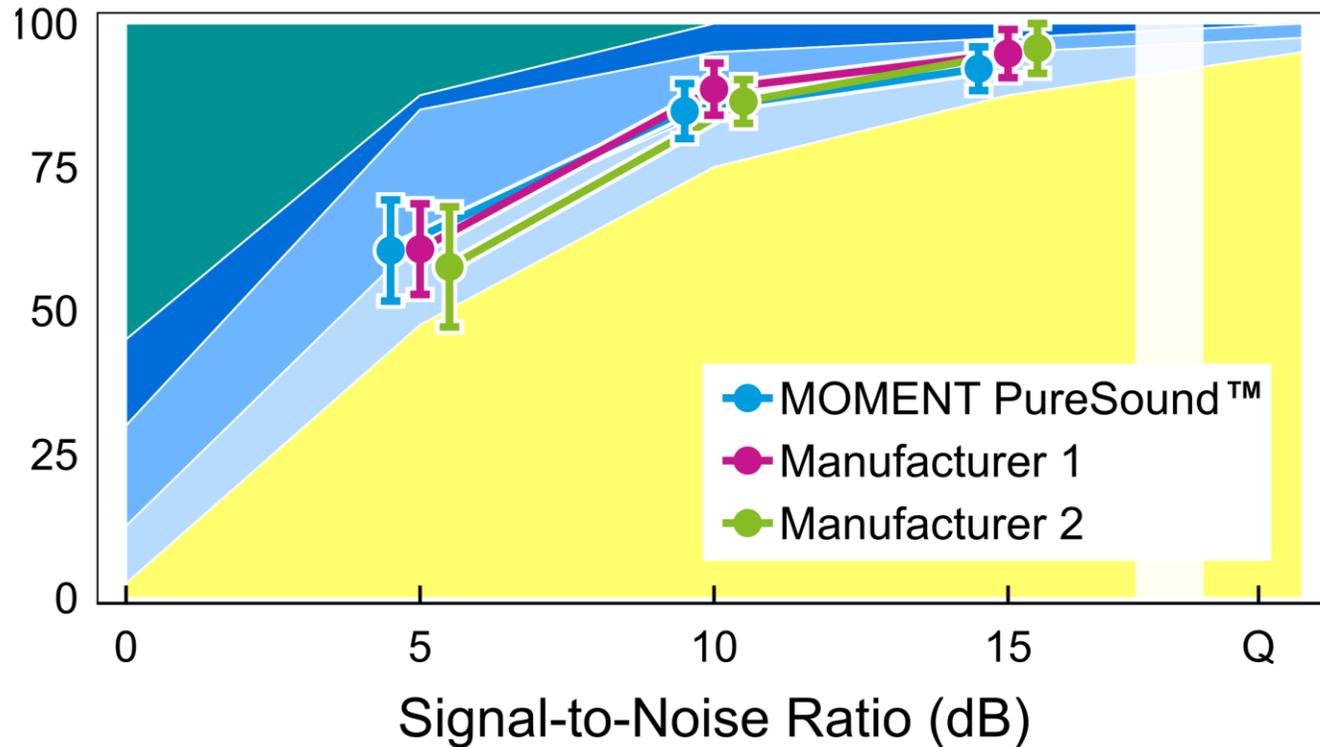
- **EVERYONE!!!**
- People who have *poor* EFR (temporal envelope resolution) **need and appreciate** the improved naturalness to give the brain an easier sound for processing
  - Elderly
  - Non-musicians
  - People who have poor speech in noise
- People who have *good* EFR (temporal resolution) can **appreciate** the improved naturalness of the input
  - Younger individuals
  - Milder hearing loss
  - Musicians





Is ZeroDelay  
Technology's new  
approach to ensure  
naturalness sufficient to  
ensure speech-in-noise  
performance in  
realistic noisy  
conditions?

# THE PURESOUND PROGRAM IS AS EFFECTIVE AS OTHER PREMIUM HEARING AIDS IN NOISE



- 21 listeners
- Test conditions
  - Quick RRT
  - Speech front (75 dB SPL), noise back
  - Continuous speech shaped noise
  - Realistic SNRs 5, 10 & 15
  - PureSound and 2 other premium HAs

## 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 Technology is like FRESH food (vs processed food) in hearing aid processing**

## Longer delays

- Smears envelope cue
- Alters temporal pattern
- More effortful to understand

## Zero Delay

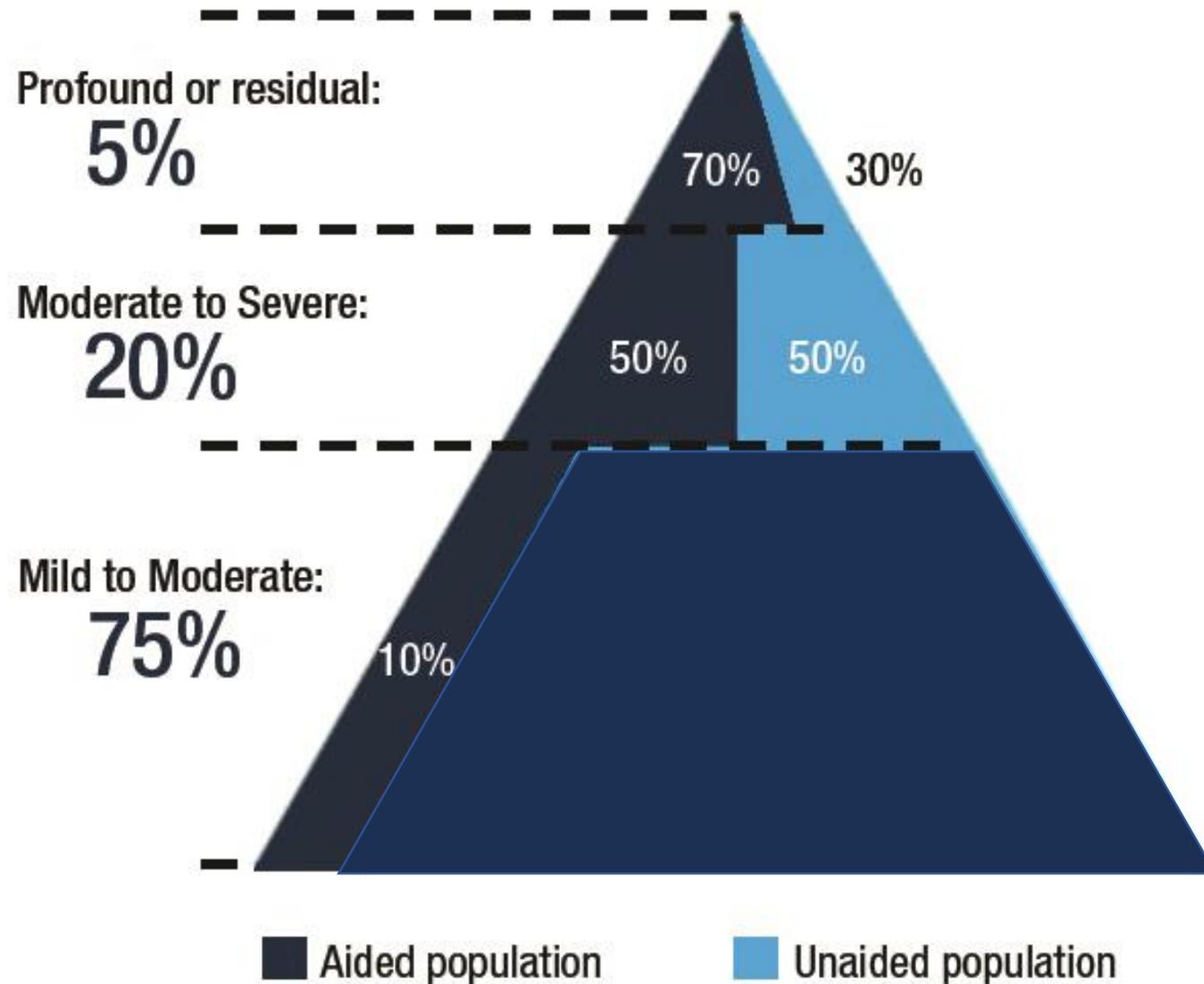
- Retains all the envelope cues
- Does not introduce artifact
- Less effortful

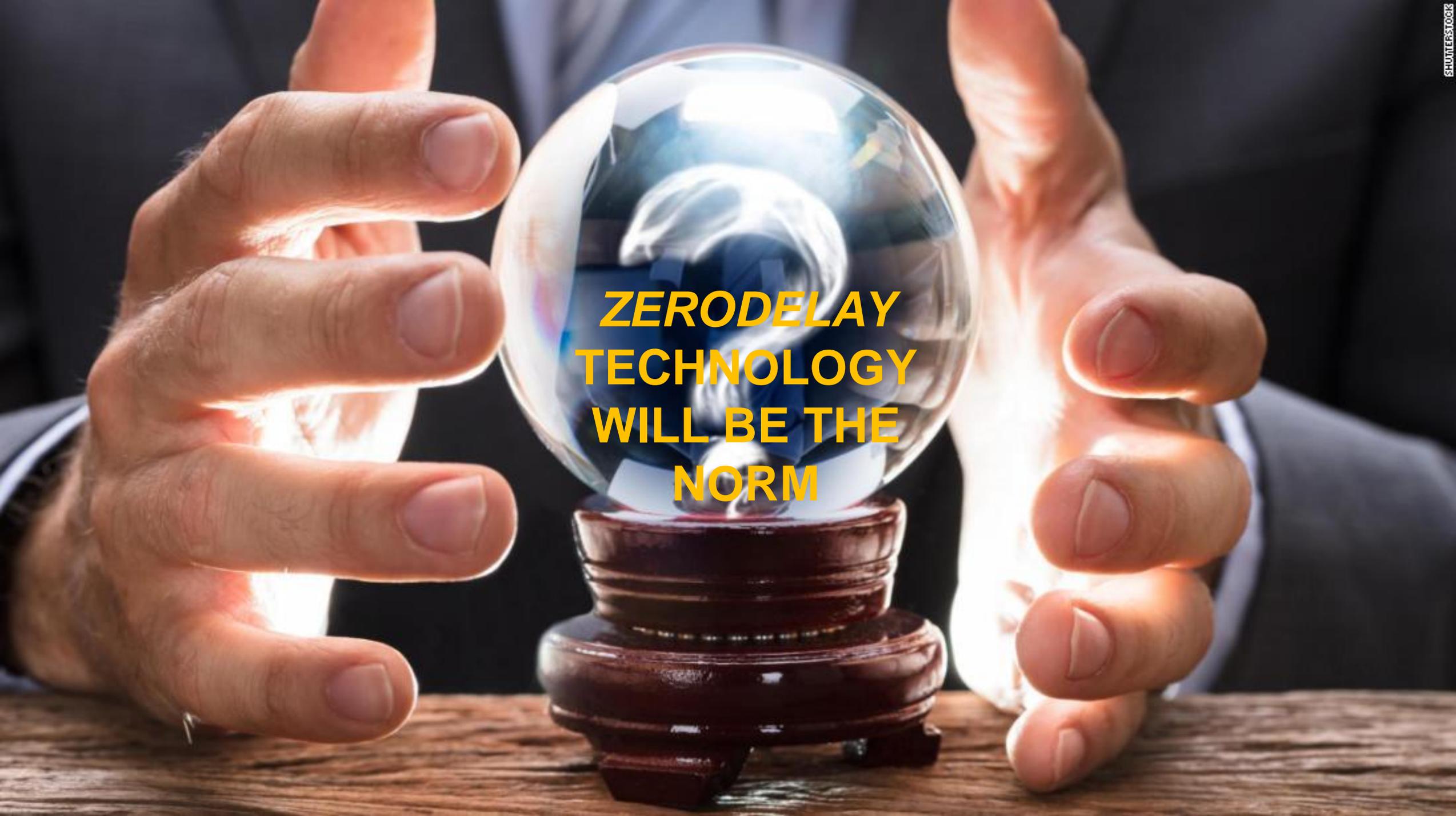
# BENEFITS OF ZERODELAY TECHNOLOGY

Giving the brain a healthier sound to “**digest and assimilate**”

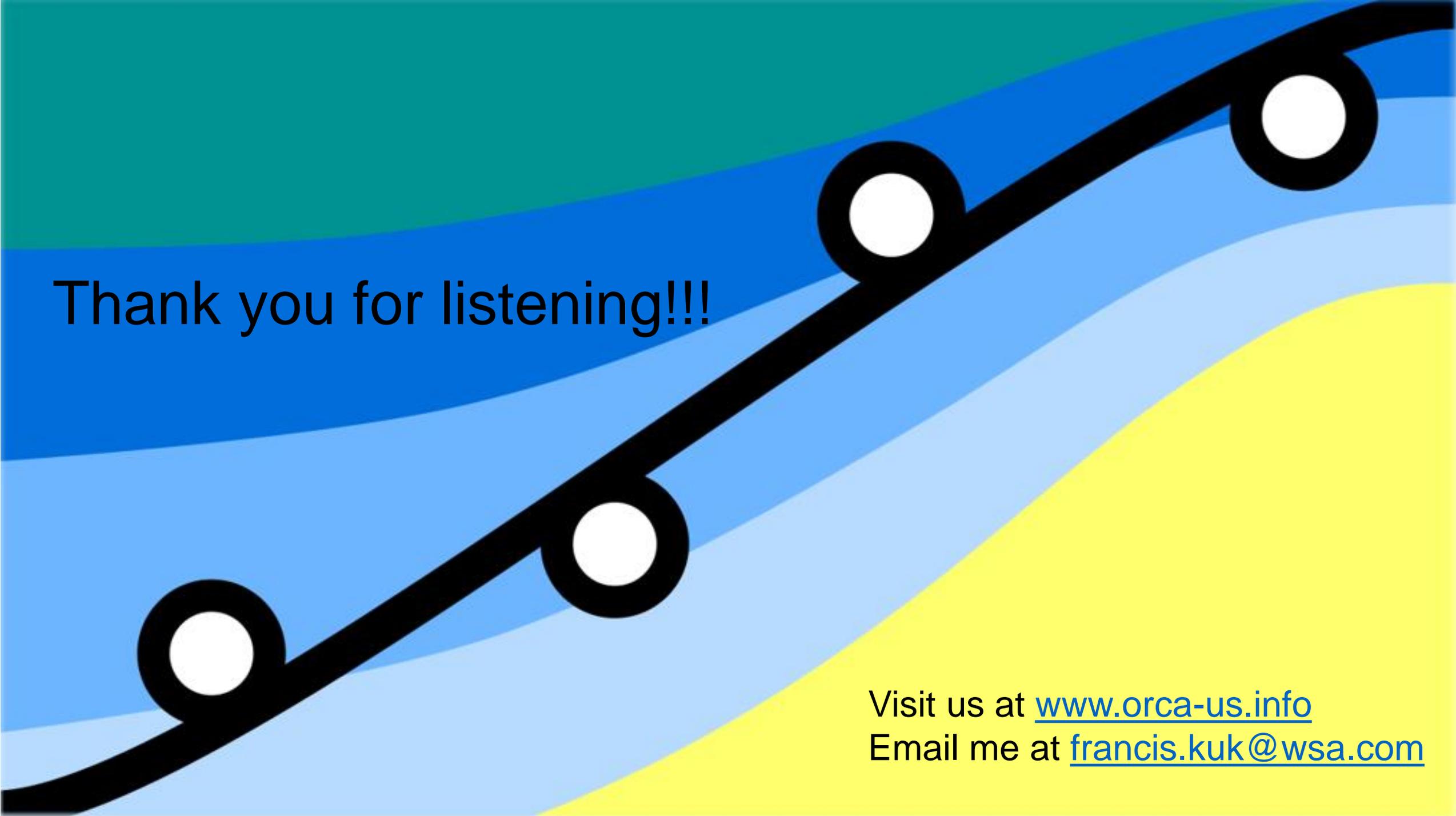
- **Preserves the naturalness** of the input signals in any vented fitting (from mixing of direct leaked sounds and processed sounds) at a neural level
- A more natural neural input, especially of the temporal envelope could **facilitate auditory scene analysis**, and makes speech understanding in noise more successful and less effortful
- This may **encourage greater willingness to communicate**, increasing social connectedness and may decrease the speed of potential cognitive decline

# AN OPPORTUNITY TO REACH MORE POTENTIAL WEARERS



A close-up photograph of a person's hands in a dark suit jacket, holding a glowing crystal ball. The crystal ball is mounted on a dark wooden base and is illuminated from within, creating a bright, ethereal glow. Inside the crystal ball, the text "ZERODELAY TECHNOLOGY WILL BE THE NORM" is written in a bold, yellow, sans-serif font. The background is dark and out of focus, emphasizing the hands and the crystal ball. The overall mood is one of futuristic vision and technological advancement.

**ZERODELAY  
TECHNOLOGY  
WILL BE THE  
NORM**



Thank you for listening!!!

Visit us at [www.orca-us.info](http://www.orca-us.info)  
Email me at [francis.kuk@wsa.com](mailto:francis.kuk@wsa.com)