Hearing Rehabilitation

”Why can’t I hear in background noise, and what can we do about it?”

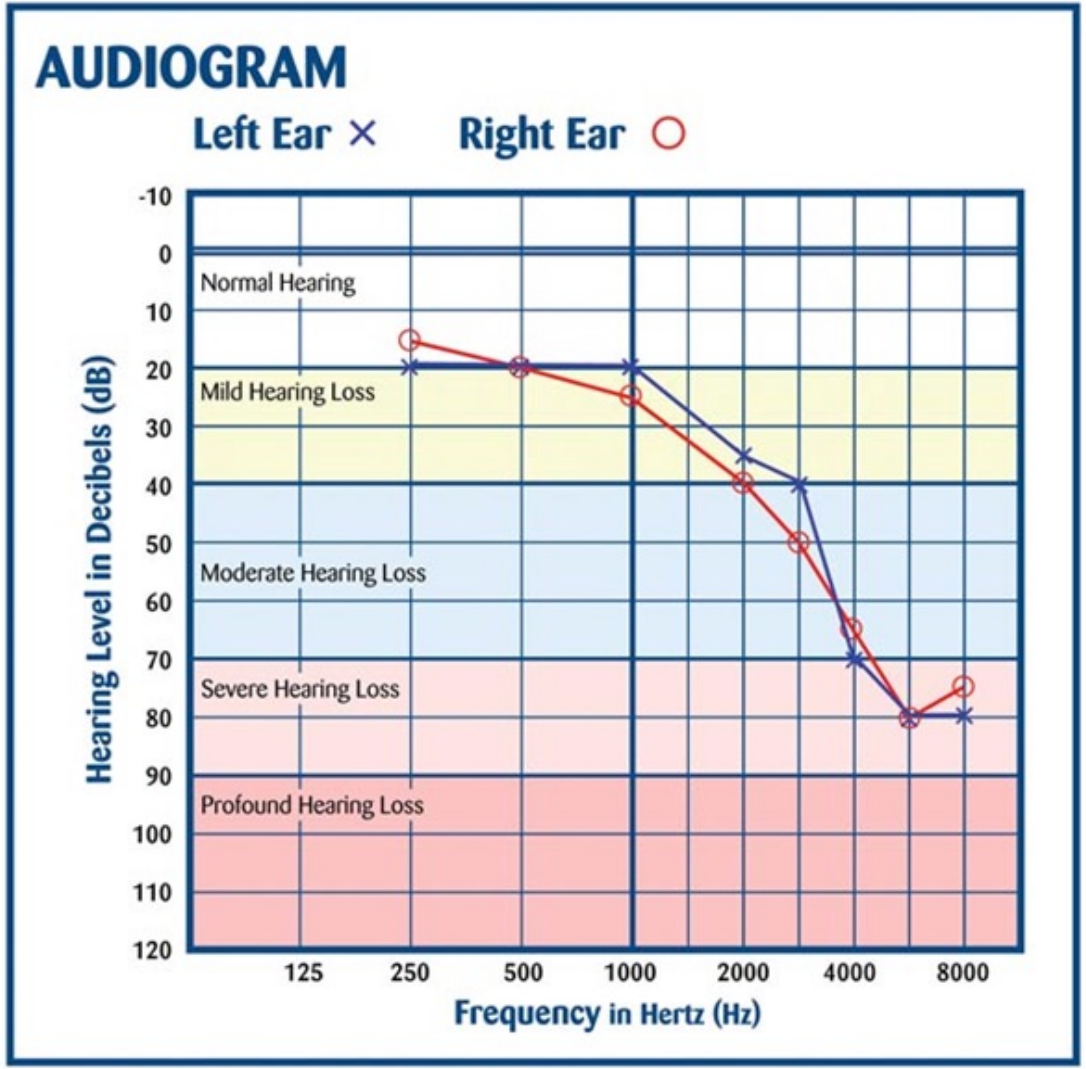
Matthew Fitzgerald, Ph.D.
Stanford University

Stanford MEDICINE | Otolaryngology Head & Neck Surgery

Brief overview

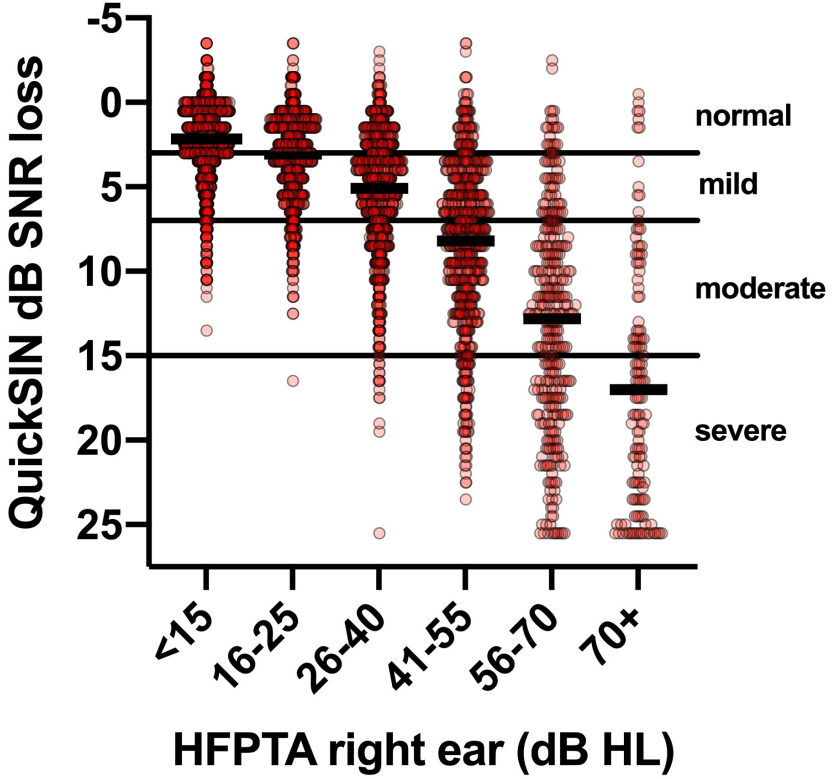
- Why do we have difficulty understanding speech in the presence of background noise?
- How can we measure these abilities clinically?
- What can we do about this problem?

Duh… you have hearing loss, right?

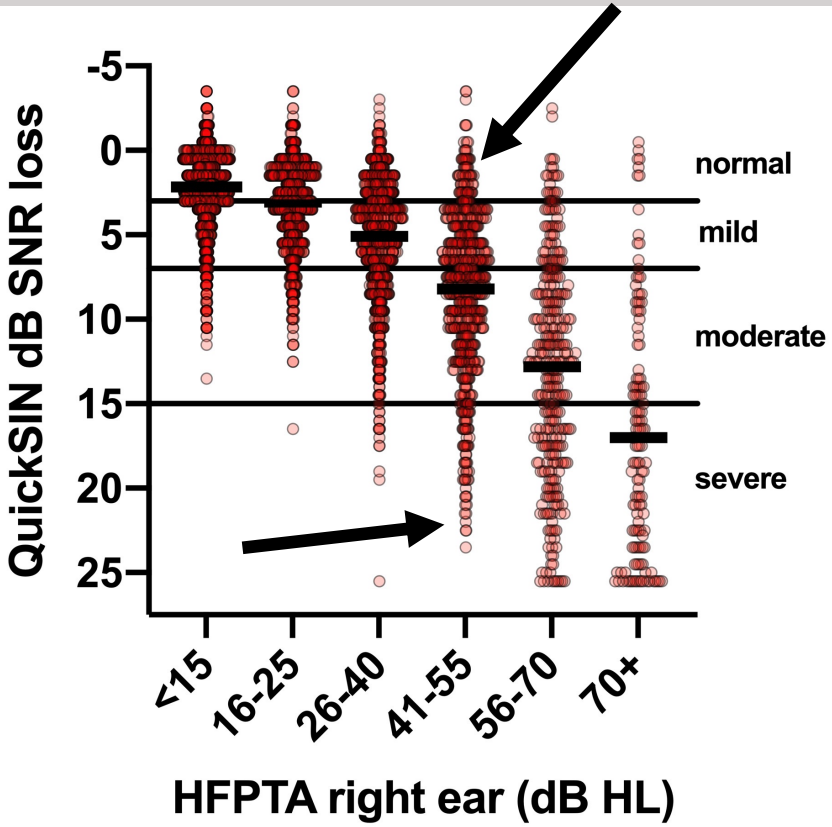

AUDIOGRAM
Left Ear ×
Right Ear ○
Hearing Level in Decibels (dB)
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
Normal Hearing
Mild Hearing Loss
Moderate Hearing Loss
Severe Hearing Loss
Profound Hearing Loss
125
250
500
1000
2000
4000
8000
Frequency in Hertz (Hz)

So hearing loss is why I can't hear in background noise?

Speech in noise abilities deteriorate with hearing loss



Note variability in SIN performance for patients with similar hearing levels!



So if it's not just hearing loss, what else is going on?

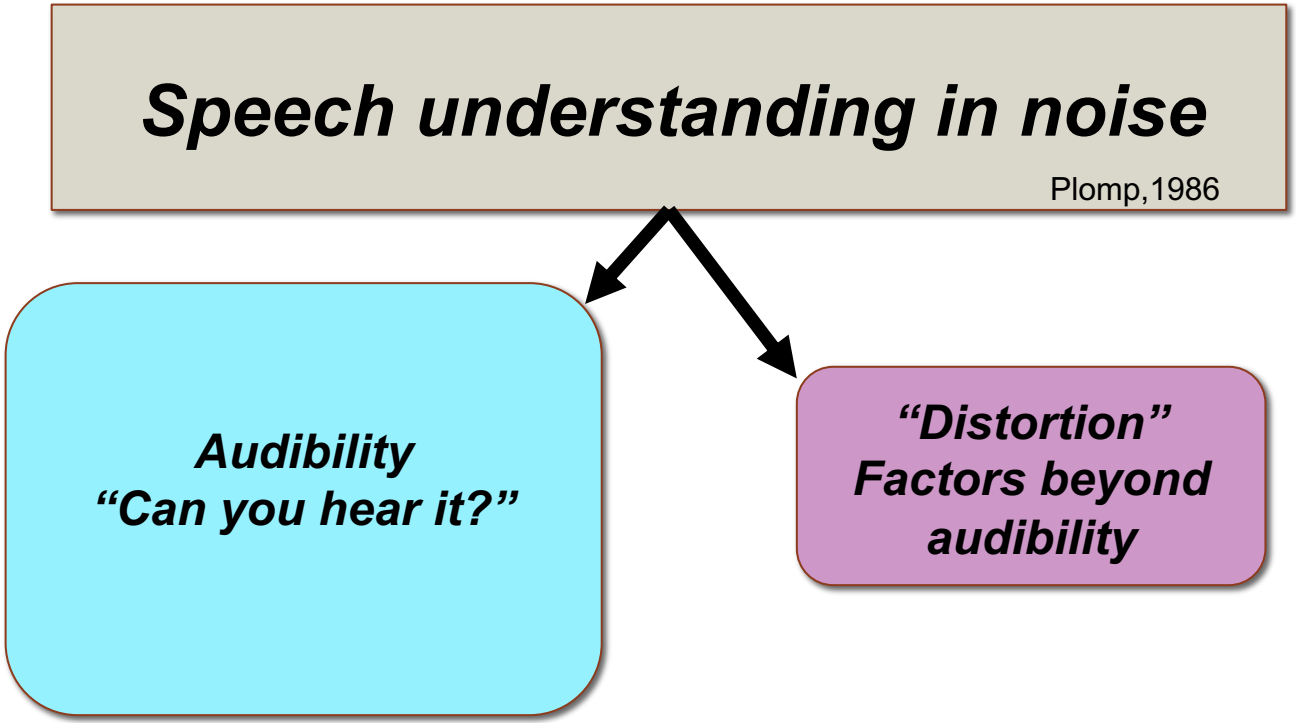
Speech understanding in noise

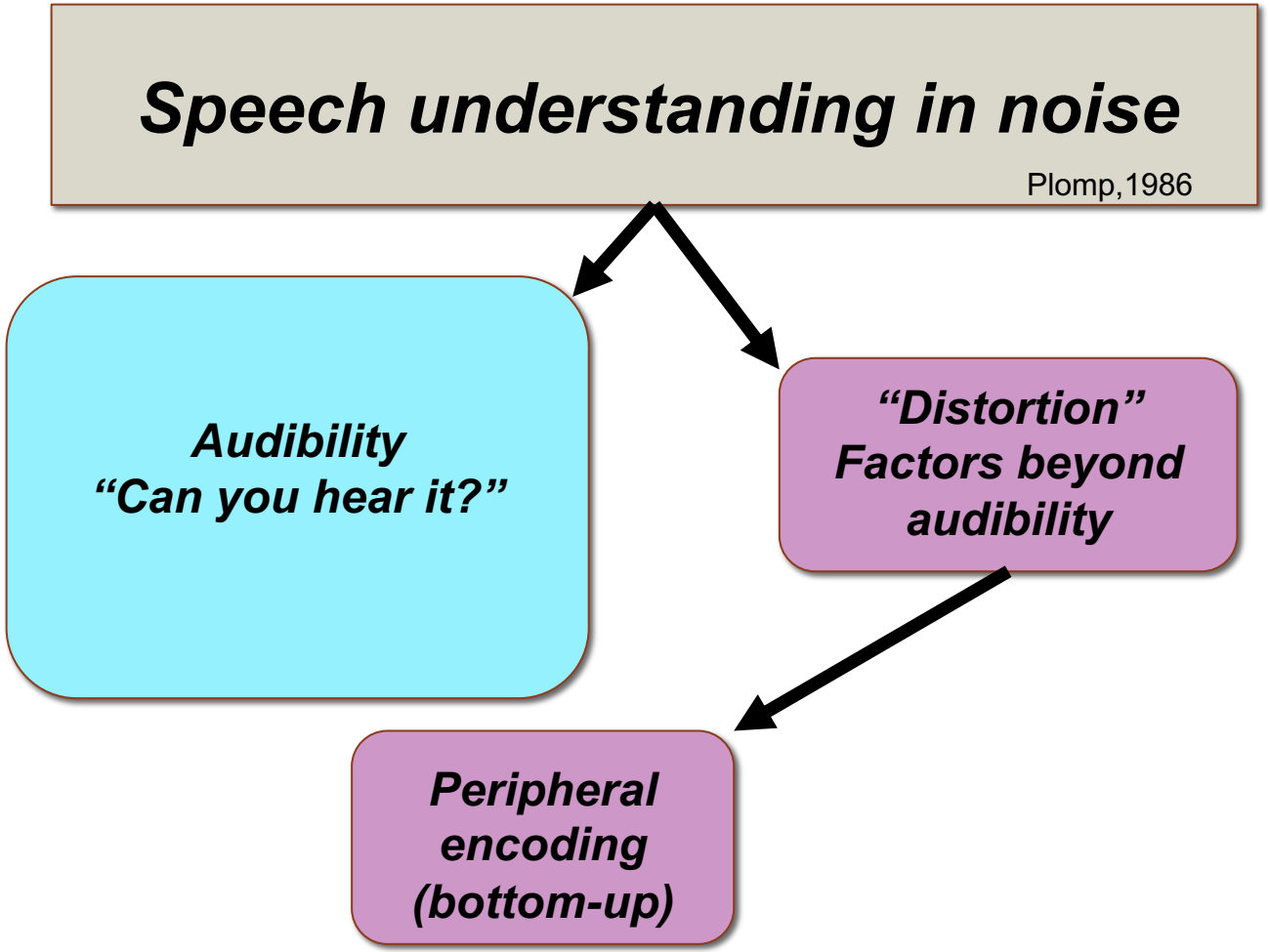
Plomp, 1986

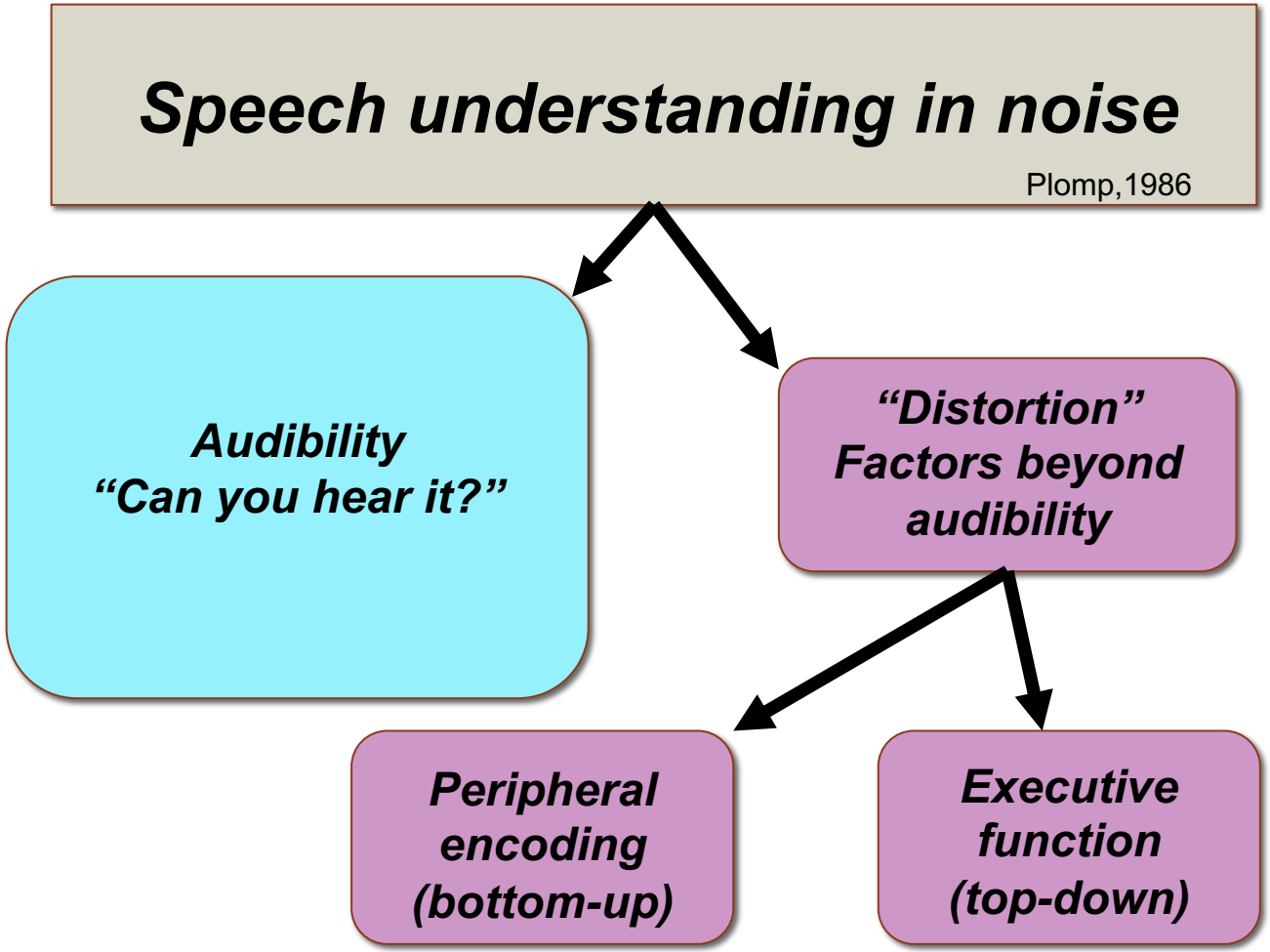
Speech understanding in noise

Plomp, 1986

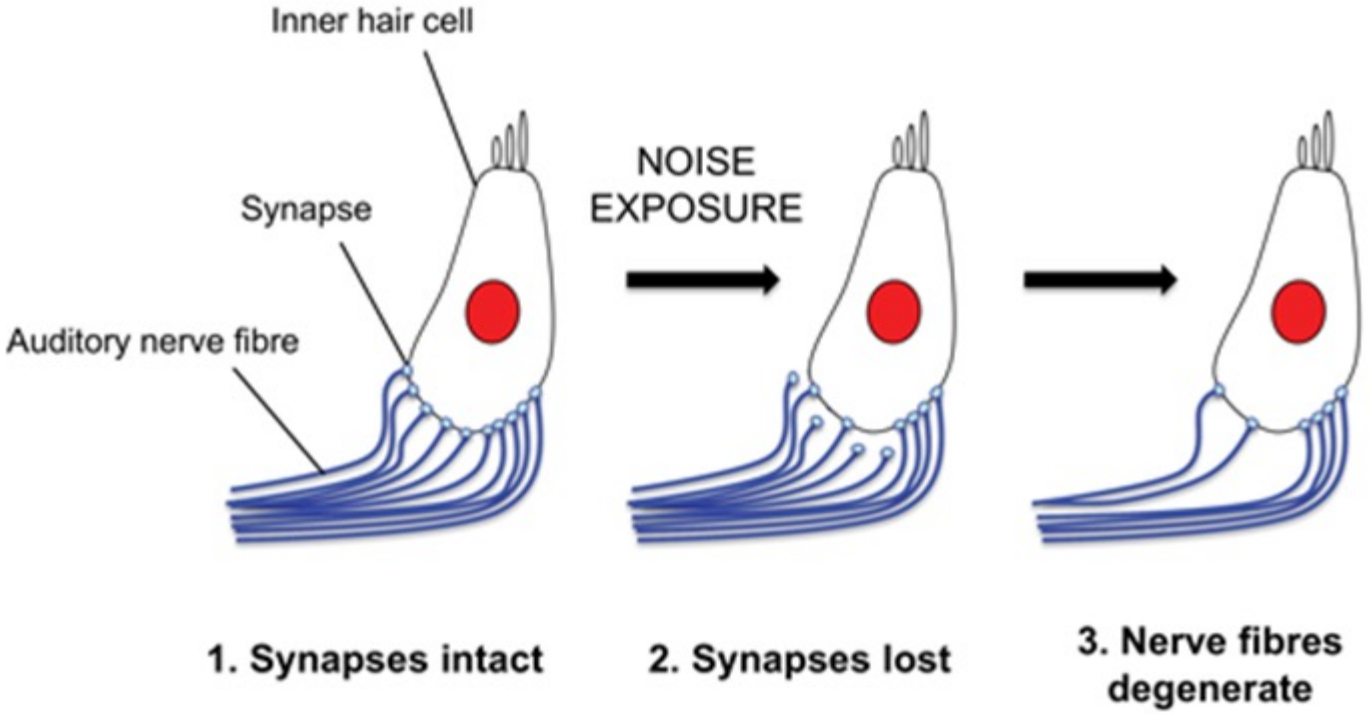
Audibility
"Can you hear it?"


Speech understanding in noise
Plomp,1986
Audibility
"Can you hear it?"
"Distortion"
Factors beyond
audibility


Speech understanding in noise
Plomp,1986
Audibility
"Can you hear it?"
"Distortion"
Factors beyond
audibility
Peripheral
encoding
(bottom-up)


Speech understanding in noise
Plomp,1986
Audibility
"Can you hear it?"
"Distortion"
Factors beyond
audibility
Peripheral
encoding
(bottom-up)
Executive
function
(top-down)

The first thing you lose are the nerves that send sound up to your brain



We think this is one reason why people have trouble understanding speech in noise…

What else happens when you lose your hearing?

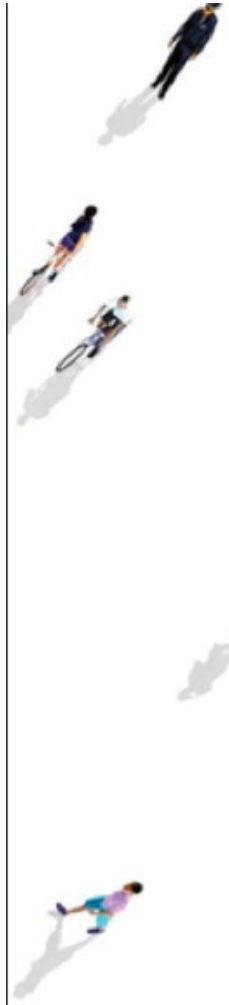
- **You don’t just lose your ability to hear soft sounds**
- **You also lose your ability to tell small differences in pitch between sounds**
- **This doesn’t matter in quiet, but it does matter in background noise…**

What about the effects of age?

As a general rule, speech in noise abilities get worse as we age

Age doesn't guarantee worse abilities in noise, it just makes it more likely.

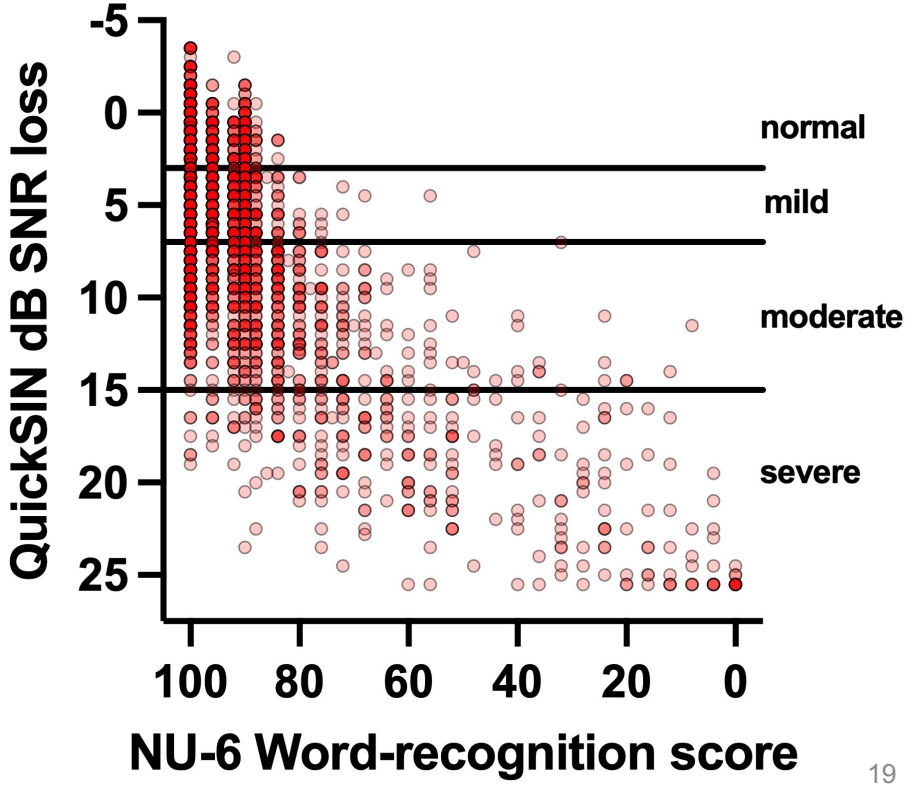
So what happens when you measure speech in noise clinically?



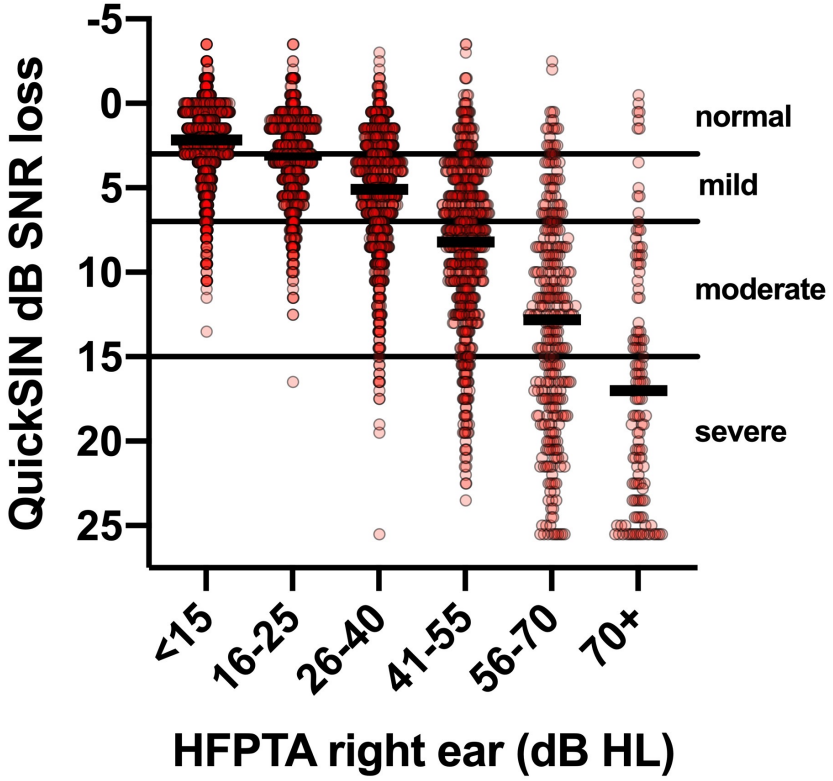
They Say
"I Can't Hear in Noise,"
We Say
"Say the Word Base"

BY GEORGE LINDLEY

Speech in noise identifies deficits missed by testing only in quiet



Note individuals with normal hearing who have trouble with speech in noise



Brief overview

- Beyond hearing loss, why do individuals have difficulty understanding speech in the presence of background noise?
- How can we measure these abilities?
- What can we do about this problem?

Hearing aids and cochlear implants are amazing, but there are limitations

- **HA and CI can fix the "can you hear it" problem**
- **Hearing aids cannot fix the transmission problem caused by age + subtle auditory damage**
- **Cochlear Implants can't represent the entire speech signal (and the effects of age either!)**

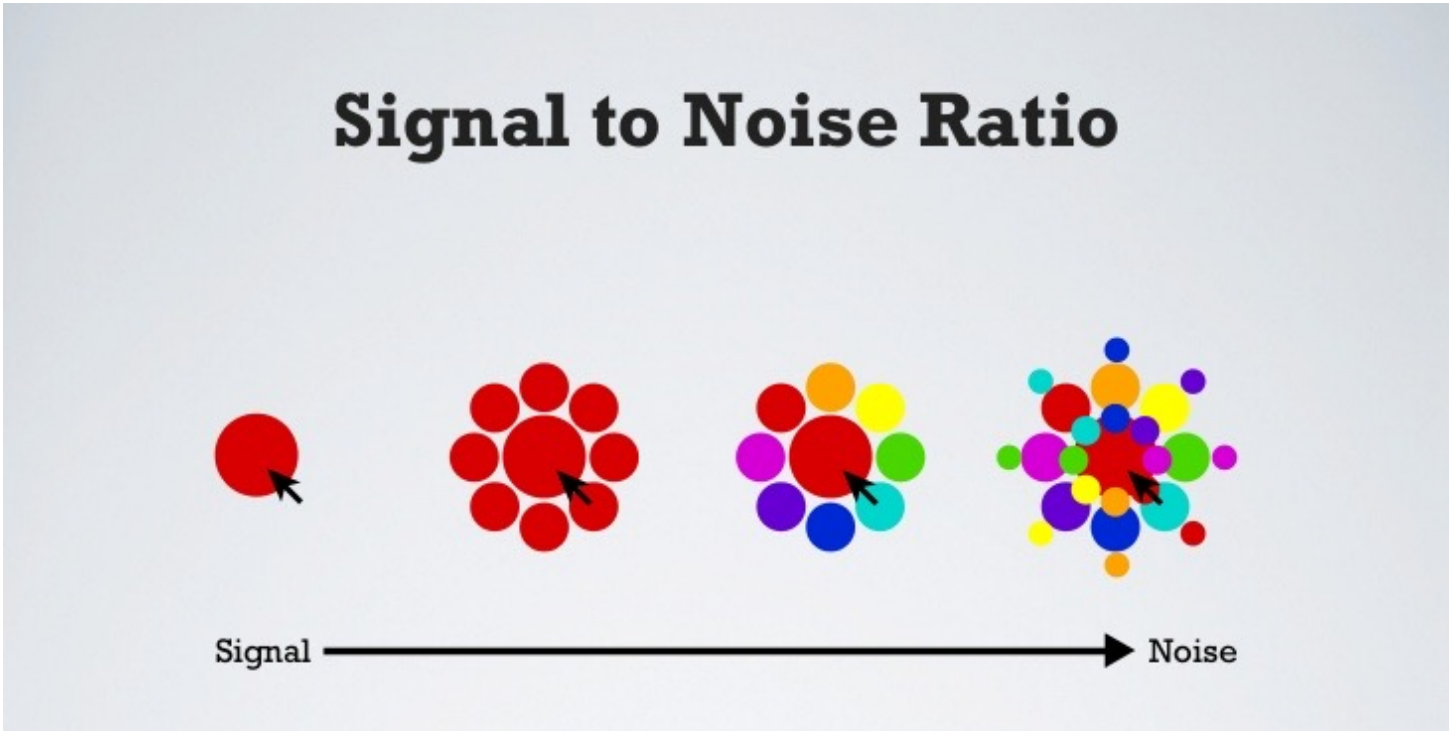
Matt Fitzgerald's first rule of hearing aids:

Matt Fitzgerald's first rule of hearing aids:

Audibility is king…

Just remember that being able to hear the sound does not guarantee perfect speech understanding in noise

People with hearing loss really have a signal to noise problem



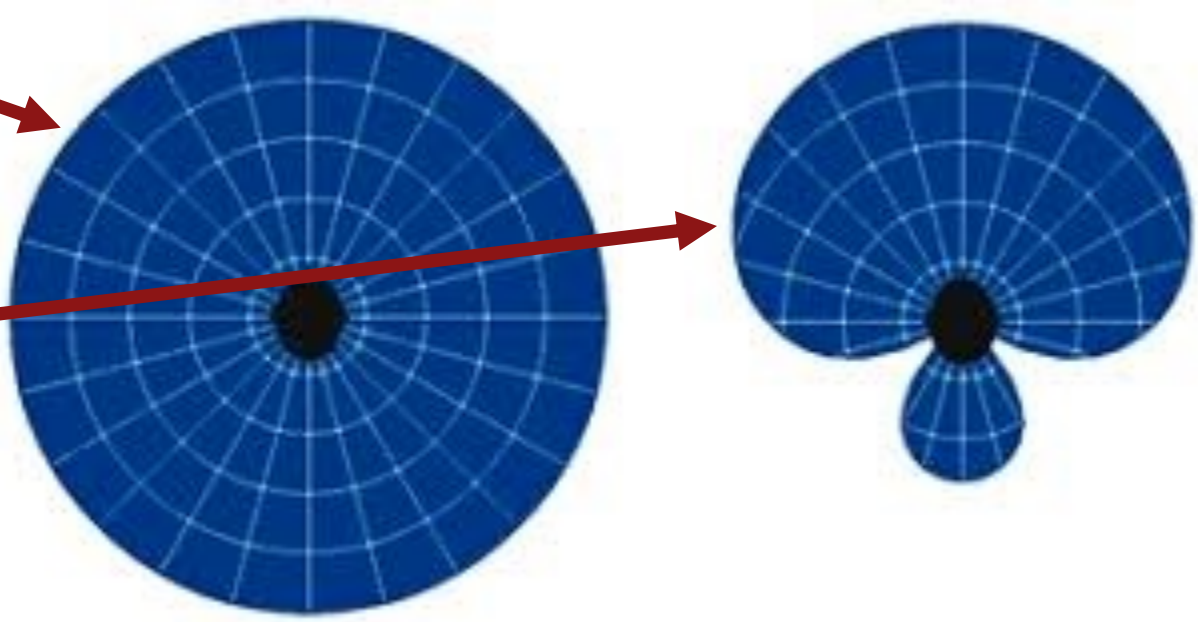
So how do we improve the SNR for patients?

- **Technology within the hearing aid or cochlear implant**
  - **Spectral enhancement**
  - **Noise reduction**
- **Directional microphones**
- **Wireless remote microphones / FM systems…**
- **Artificial intelligence????**

Directional microphones can also improve signal to noise ratio

Omnidirectional

Directional



FM systems or wireless remote microphones yield significant improvements in SNR

Goal is to directly transmit the signal from the speaker to the device recipient

Widely used in schools and children, intermittent use in adults

Comparison of environmental microphone vs FM system

Artificial Intelligence

Uses machine learning to better predict what is speech and what is noise

May eventually be able to learn your voice, or your spouse's voice to tune your HA or CI just for you!

I am working on this now….

What about tinnitus?

A few thoughts on tinnitus

- ***Primary cause of tinnitus is hearing loss***
- **Tinnitus is influenced other variables**
  - **Stress / anxiety**
  - **”Somatic” tinnitus**
    - **(changes with tension / movement in jaw, neck, shoulders)**
- **Tinnitus doesn’t cause anything – other things cause tinnitus**
- **First step if you have hearing loss is hearing aids**
  - **Counseling and sound therapy**
  - **Cognitive behavioral therapy / mindfulness therapy.**

A few things to think about…

- **Hearing loss has a big effect on your ability to understand speech in noise – but it's not the only thing…**
- **When you lose your hearing though, there are other changes which affect speech understanding**
- **We can make sounds audible, but to improve the SNR requires additional signal processing**
- **Tinnitus is almost always a result of hearing loss, and can be affected by other things**

Stanford Ear Institute

Stanford MEDICINE | Otolaryngology Head & Neck Surgery