Flying to the Moon on Radio Waves: Optimizing Outcomes with RF Technologies

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The Hearts for Hearing Team

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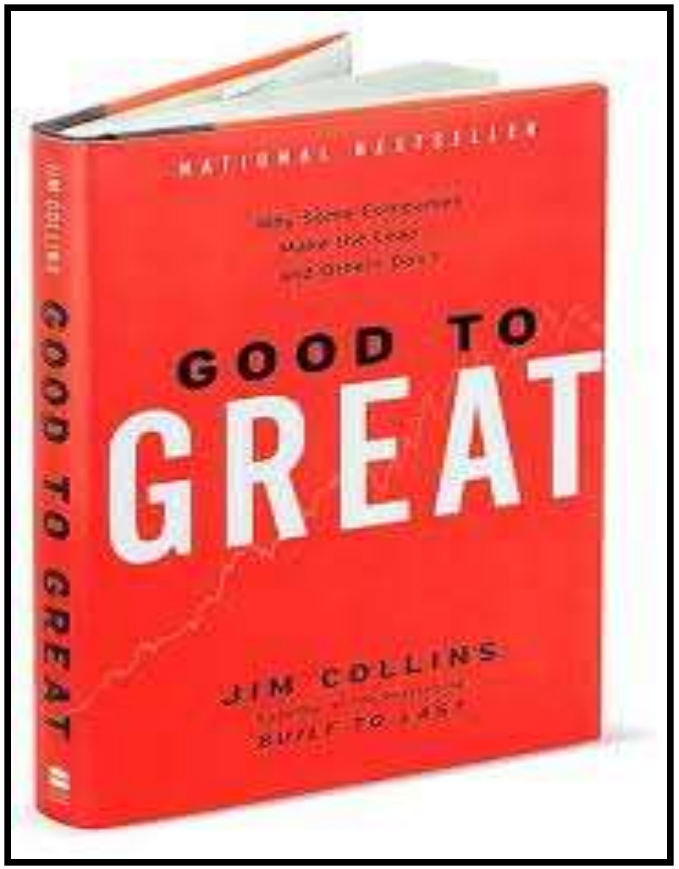
From Good to Great!



All too often, good is the enemy of great. – Jim Collins

Oklahoma!

- 50th recent visit to the dentist
- 48th in physical activity
- 50th in % of people who eat at least one vegetable per day
- #1 in fast food restaurants per capita
- 49th in heart health

Road Map

- Adaptive Digital Broadband Wireless Technology
  - Introduction
  - Study with CI Users
  - How about Hearing Aid Users?
- Classroom Audio Distribution Systems
- Audio Streaming

A Noisy World!

The SNR in these environments is typically -5 to +5 dB

- 37 dB A (with A.C. = 52 dBA)

- Classroom:
  - 66 dBA
- School Assembly:
  - 76 dBA
- School Cafeteria:
  - 82 dBA
- OKC Thunder Basket
  - 100 dBA

Children with hearing loss need a +15 dB SNR!

The Evolution of Technology

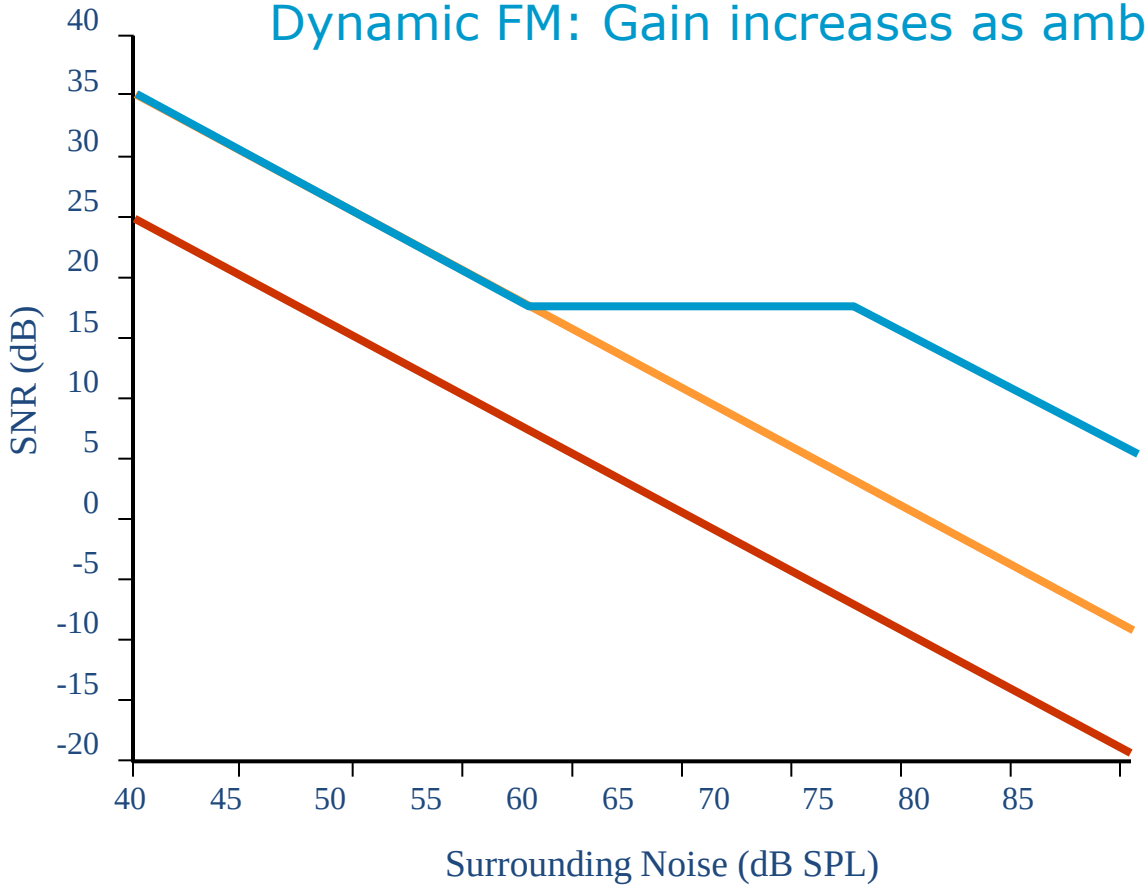
- 1996 First miniaturized ear-level FM receiver
- 2000 Universal ear-level FM receiver
- 2003 Frequency-flexible FM system
- 2008 Dynamic FM - the first adaptive FM system

What about Dynamic FM?

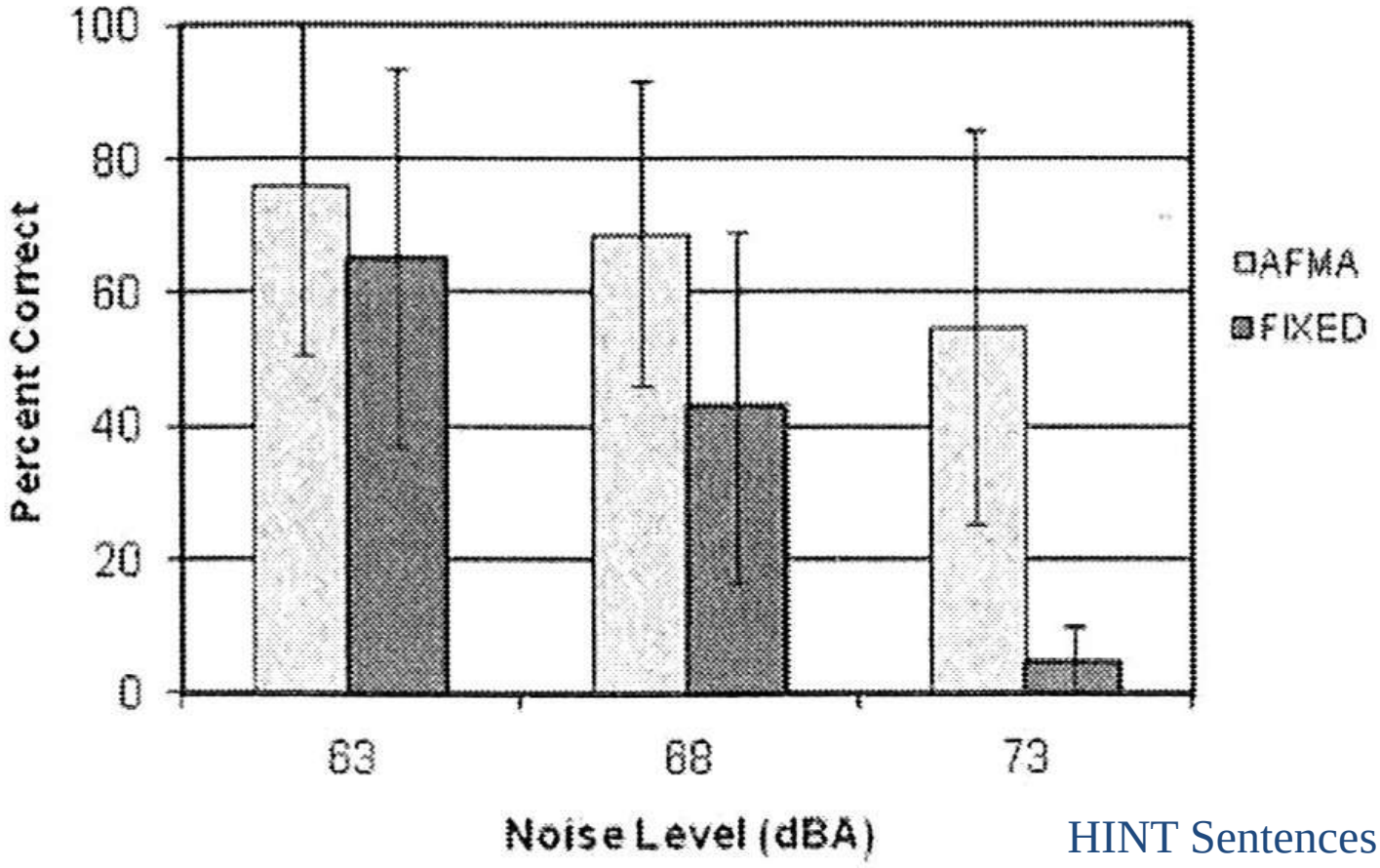
No FM

Traditional FM: Gain is fixed

Dynamic FM: Gain increases as ambient noise increases



Thibodeau -- Dynamic FM

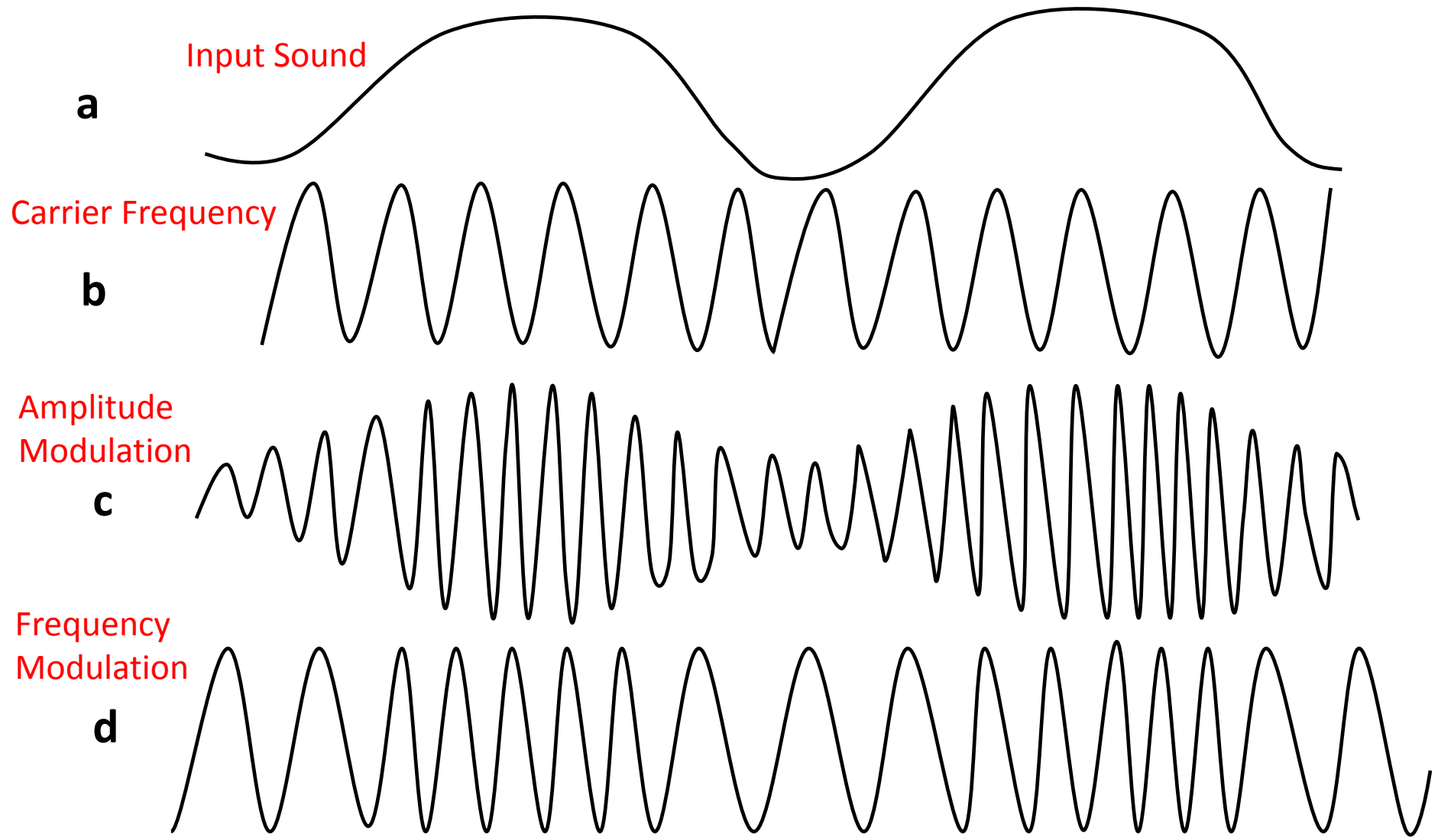


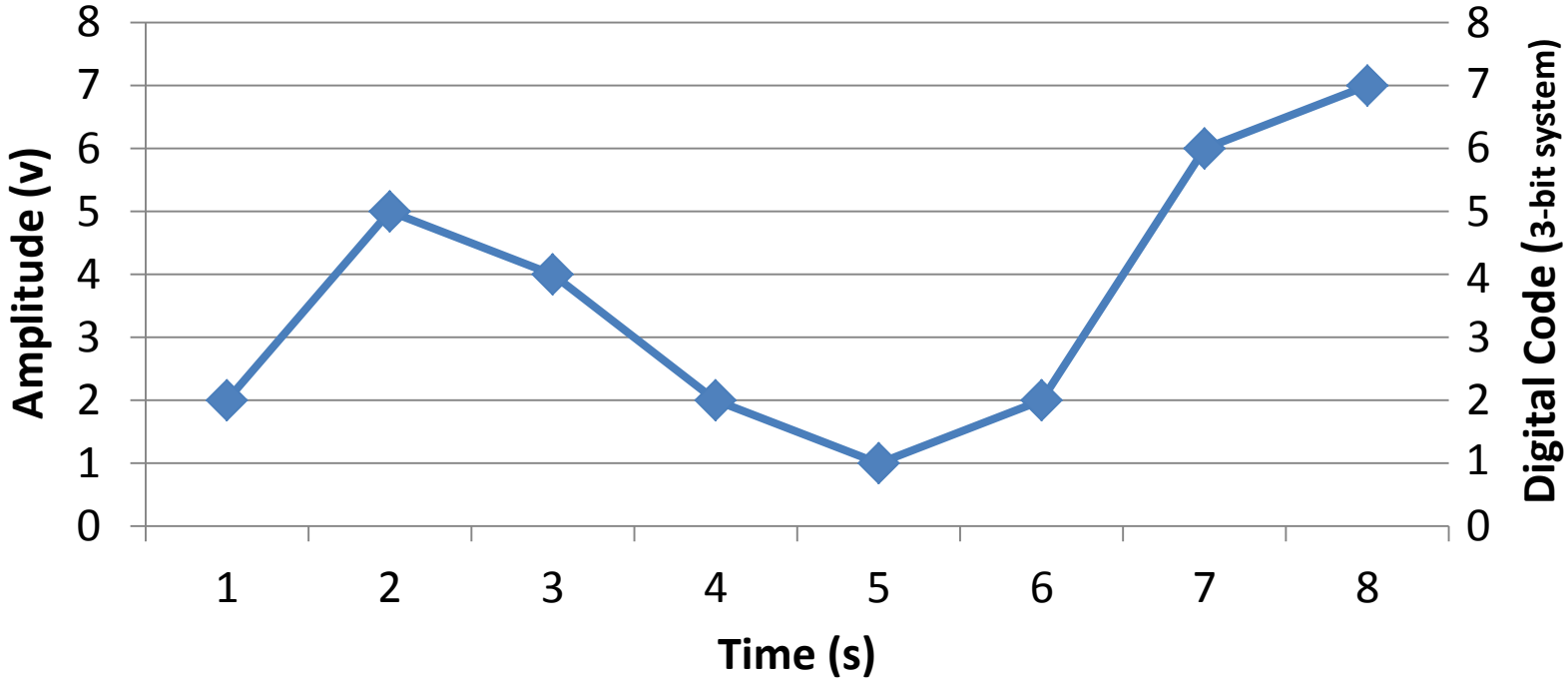
HINT Sentences

Thibodeau (2010), American Journal of Audiology

- What is a digital RF system?

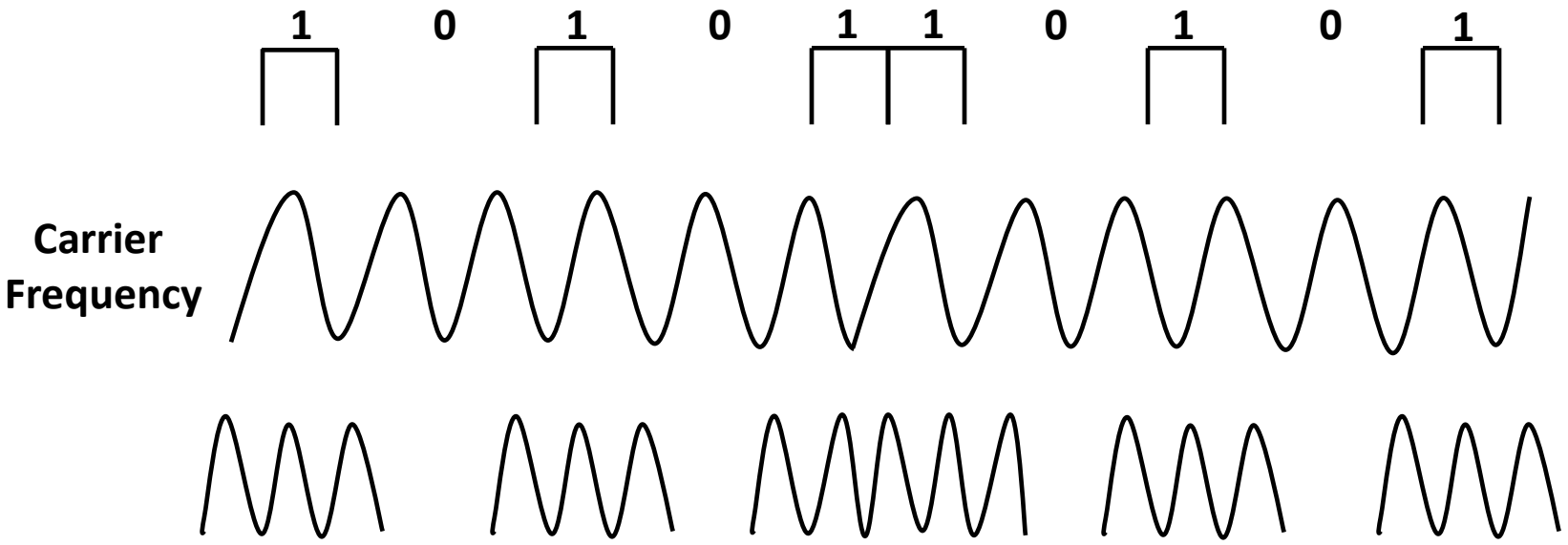
Frequency Modulation Radio Transmission



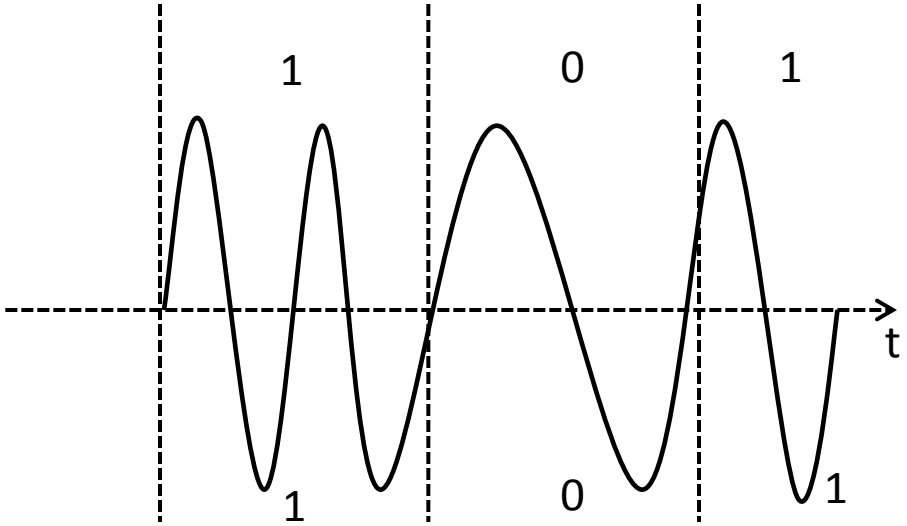


Time	Digital Code	Fours	Twos	Ones
1	2	0	1	0
2	5	1	0	1
3	4	1	0	0
4	2	0	1	0
5	1	0	0	1
6	2	0	1	0
7	6	1	1	0
8	7	1	1	1

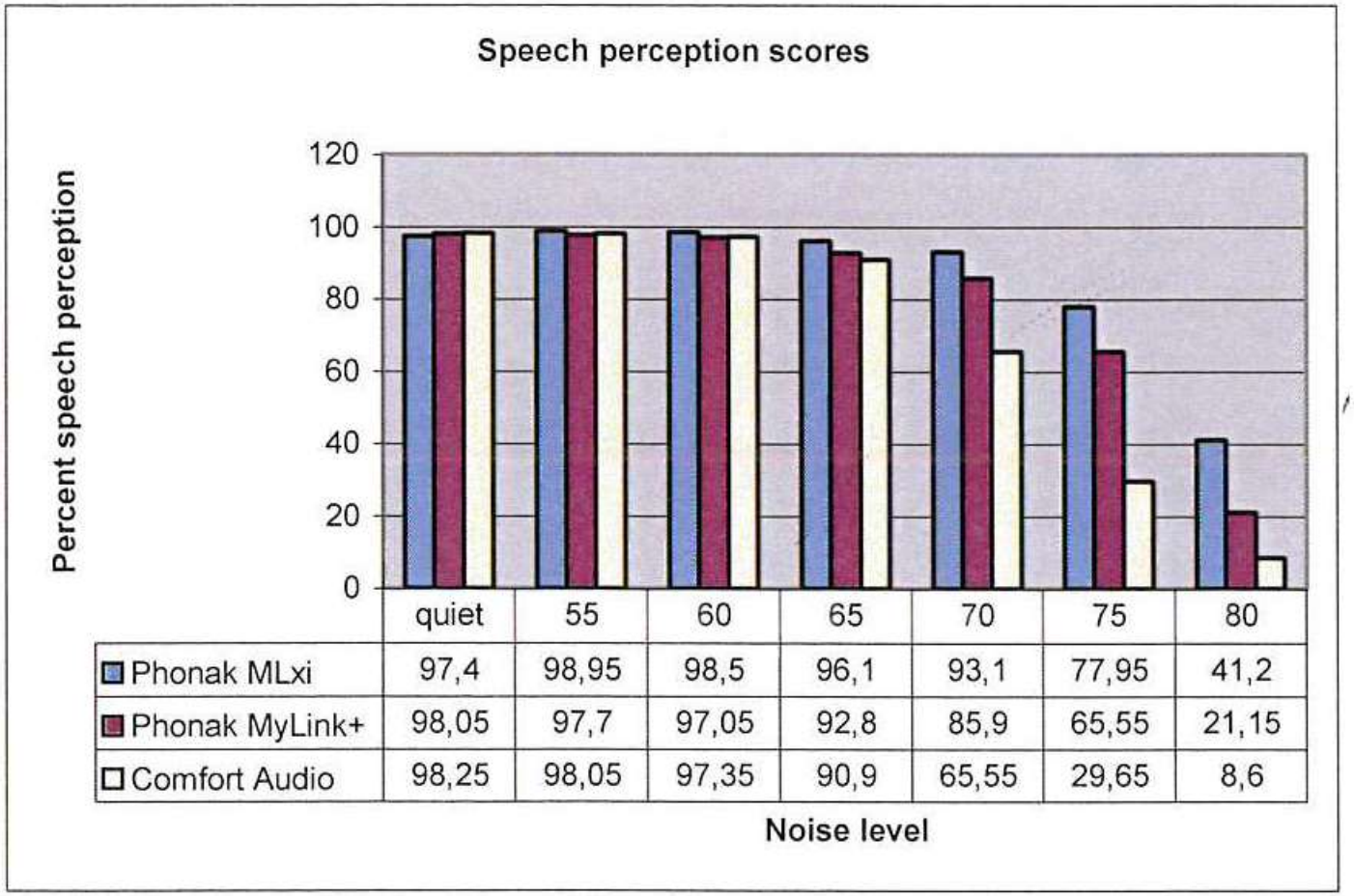
Digital Radio Frequency Transmission
Amplitude Shift Keying



Digital Radio Frequency Transmission
Gaussian Frequency Shift Keying



Dynamic FM & Digital RF



	quiet	55	60	65	70	75	80
Phonak MLxi	97,4	98,95	98,5	96,1	93,1	77,95	41,2
Phonak MyLink+	98,05	97,7	97,05	92,8	85,9	65,55	21,15
Comfort Audio	98,25	98,05	97,35	90,9	65,55	29,65	8,6

Aslund et al., 2011

N = 20

- Does an adaptive digital wireless system offer benefit for CI users?

Roger Digital Wireless Characteristics

- Audio signals are sampled, digitized and packaged in very short (160 µs) digital bursts of codes (packets) and broadcast several times, each at different channels between 2.4000 and 2.4835 GHz
  - The 2.4 GHz ISM (Industry, Science and Medical) band is globally license free
- Frequency hopping between channels, in combination with repeated broadcast, avoids interference issues
- The frequency hopping is adaptive, both receivers and transmitters are searching continuously to find free channels and to avoid occupied channels
- End-to-end audio delay is well below 25 ms – 7500 Hz BW
- Digital control of adaptive (Dynamic) gain changes

Roger Technology

Does it work for cochlear implant users?

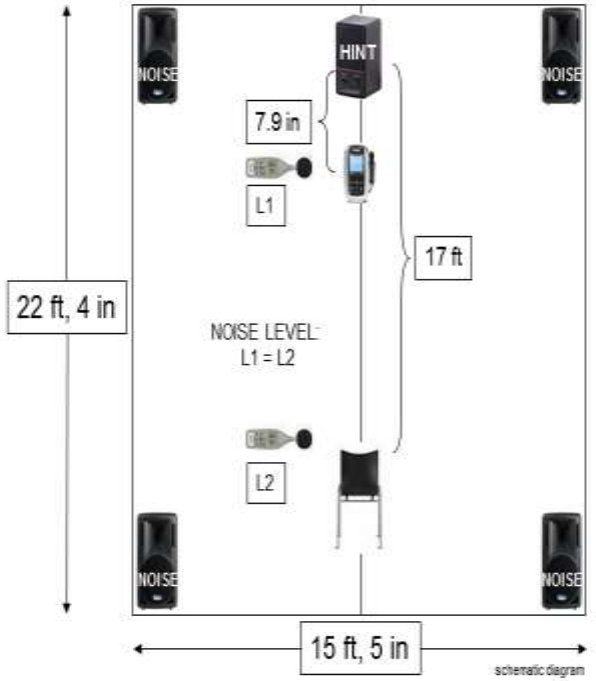
What about hearing aid users?

Study Objectives

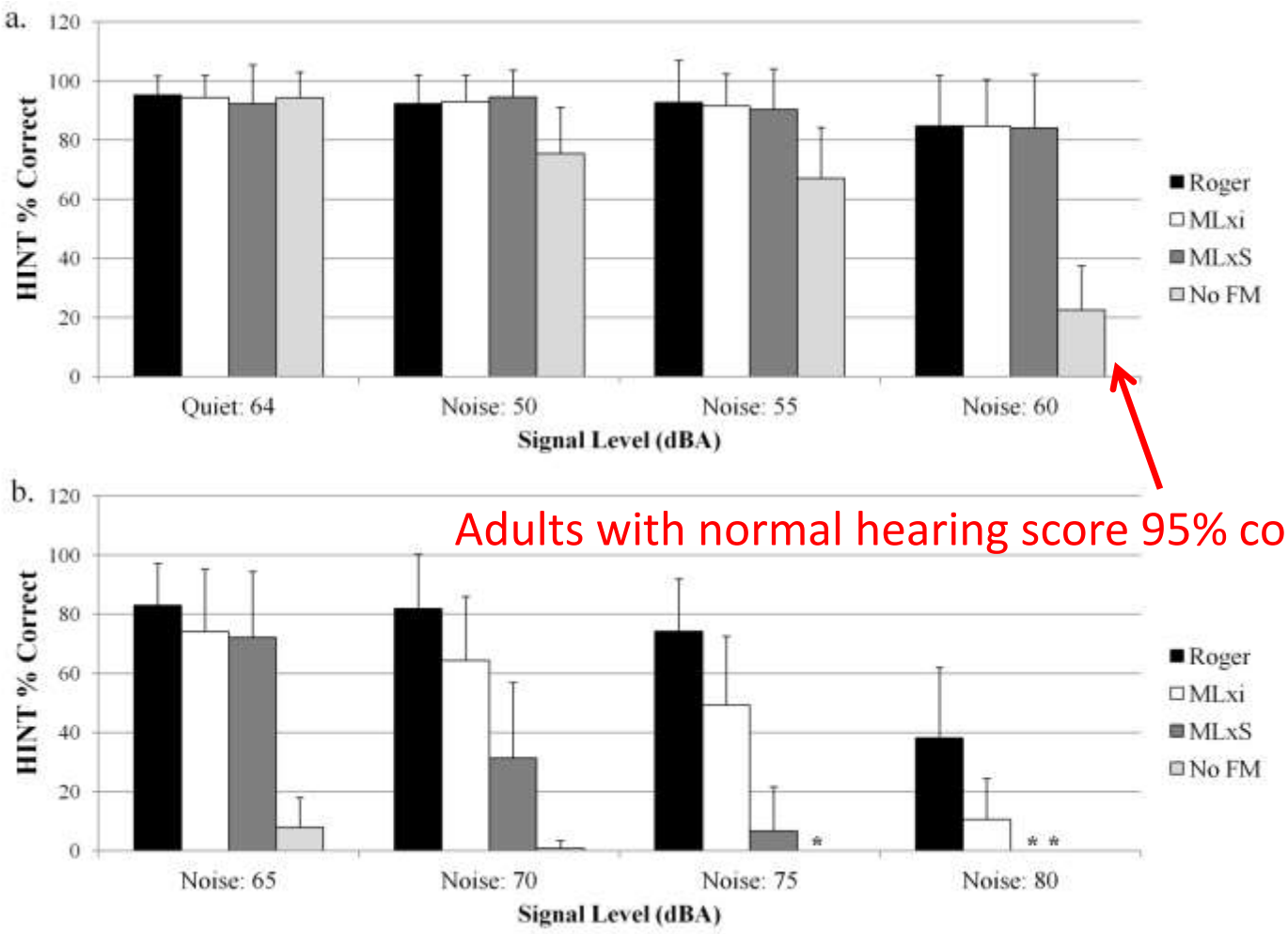
- Evaluate speech recognition in quiet and in noise with speech (HINT) at 85 dBA at transmitter and classroom noise at 50, 55, 60, 65, 70, 75, 80 dBA

- Evaluated 3 RF remote microphone systems:
  - Fixed-gain FM – MLxS
  - Adaptive FM – MLxi
  - Digital RF – Roger

- Ensure consistency of signal and a lack of interference.



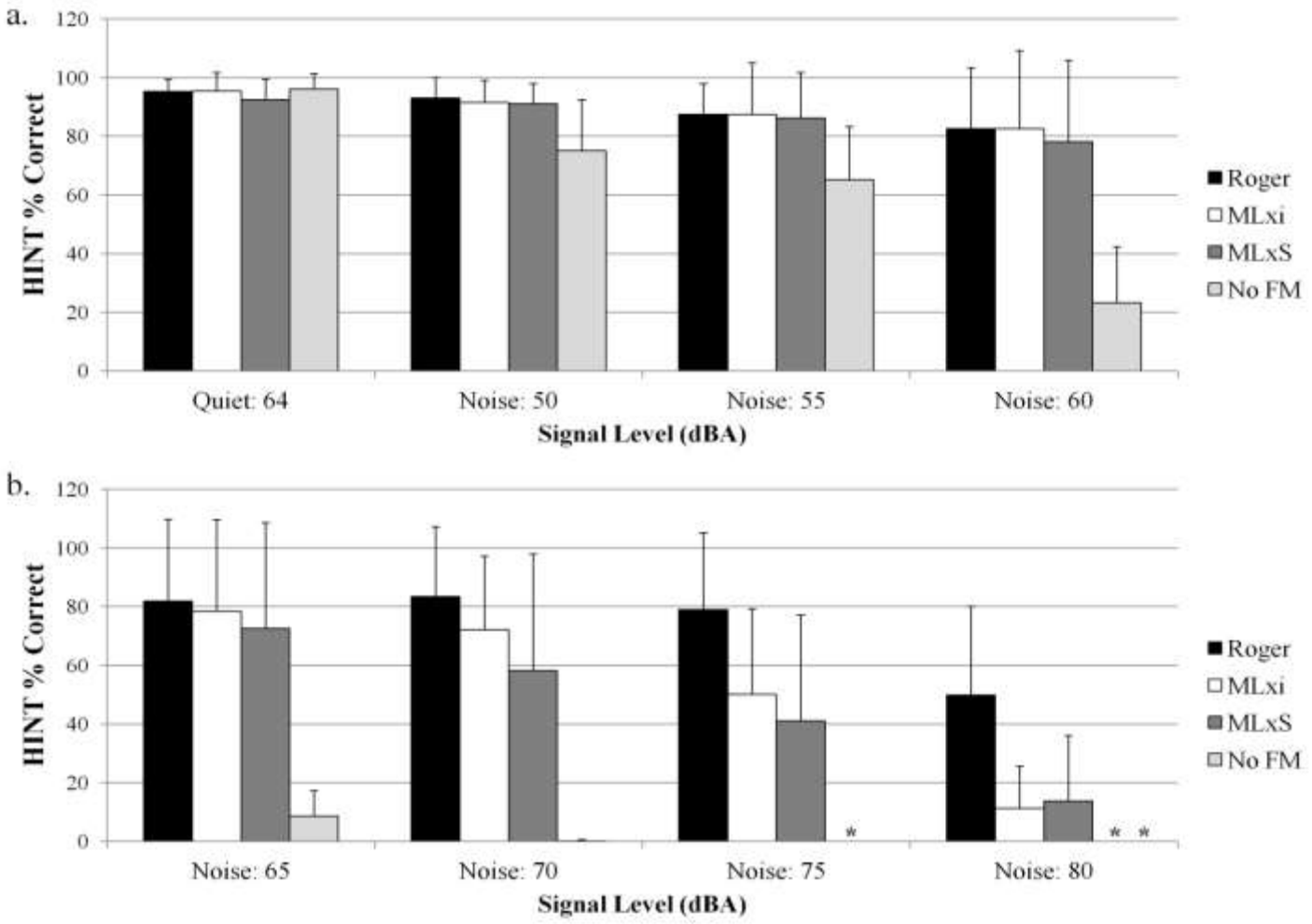
Results
Advanced Bionics Recipients (n = 16)



Adults with normal hearing score 95% correct here!

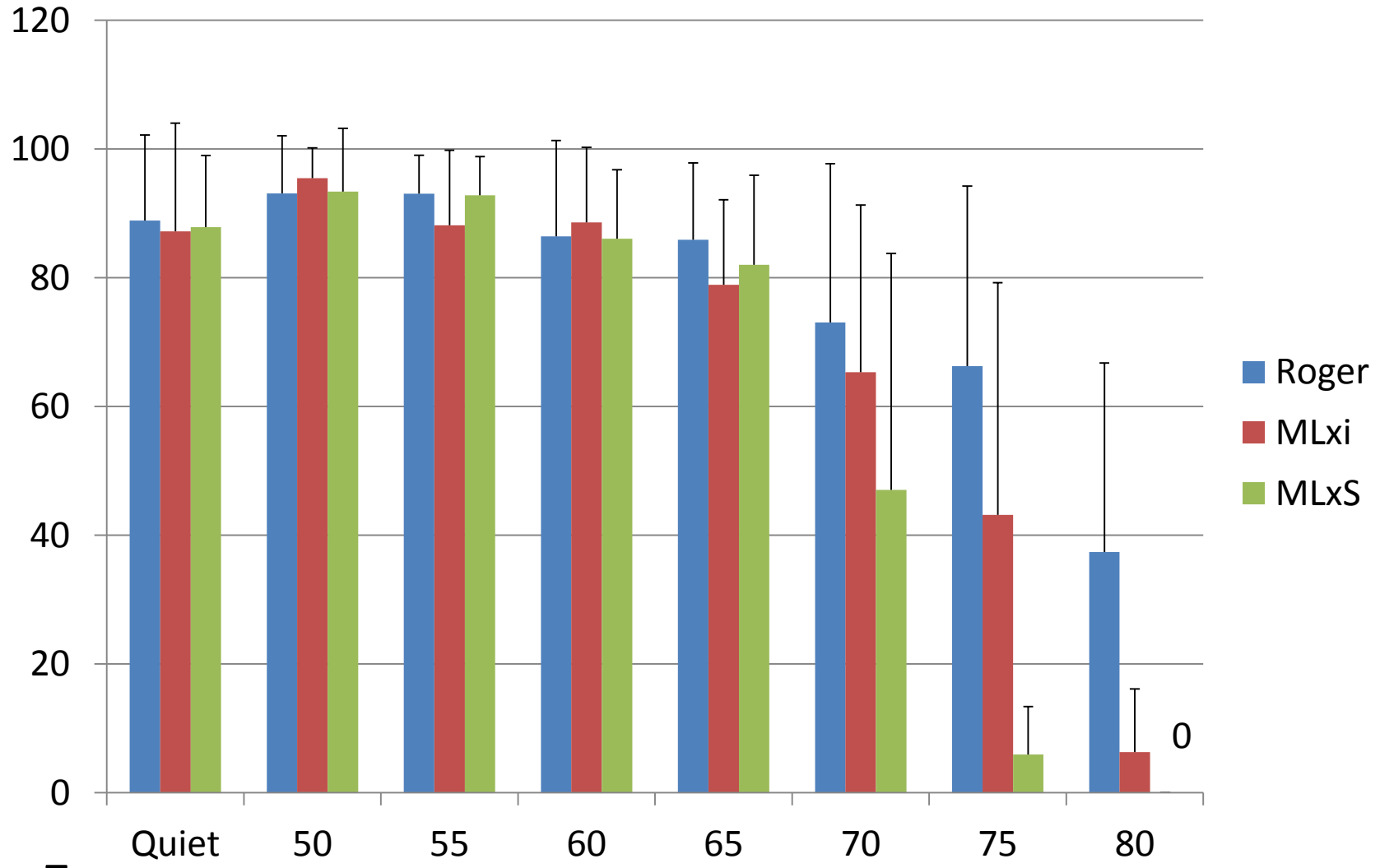
Wolfe et al., in press, JAAA

Results
Cochlear Recipients (n = 21)



Wolfe et al., in press, JAAA

MED-EL and Roger



N = 7

Wolfe et al., (2013), Hearing Journal

What about hearing aids?

Speech Recognition Benefits of Digital Adaptive Broadband Wireless Transmission Technology

Linda M. Thibodeau

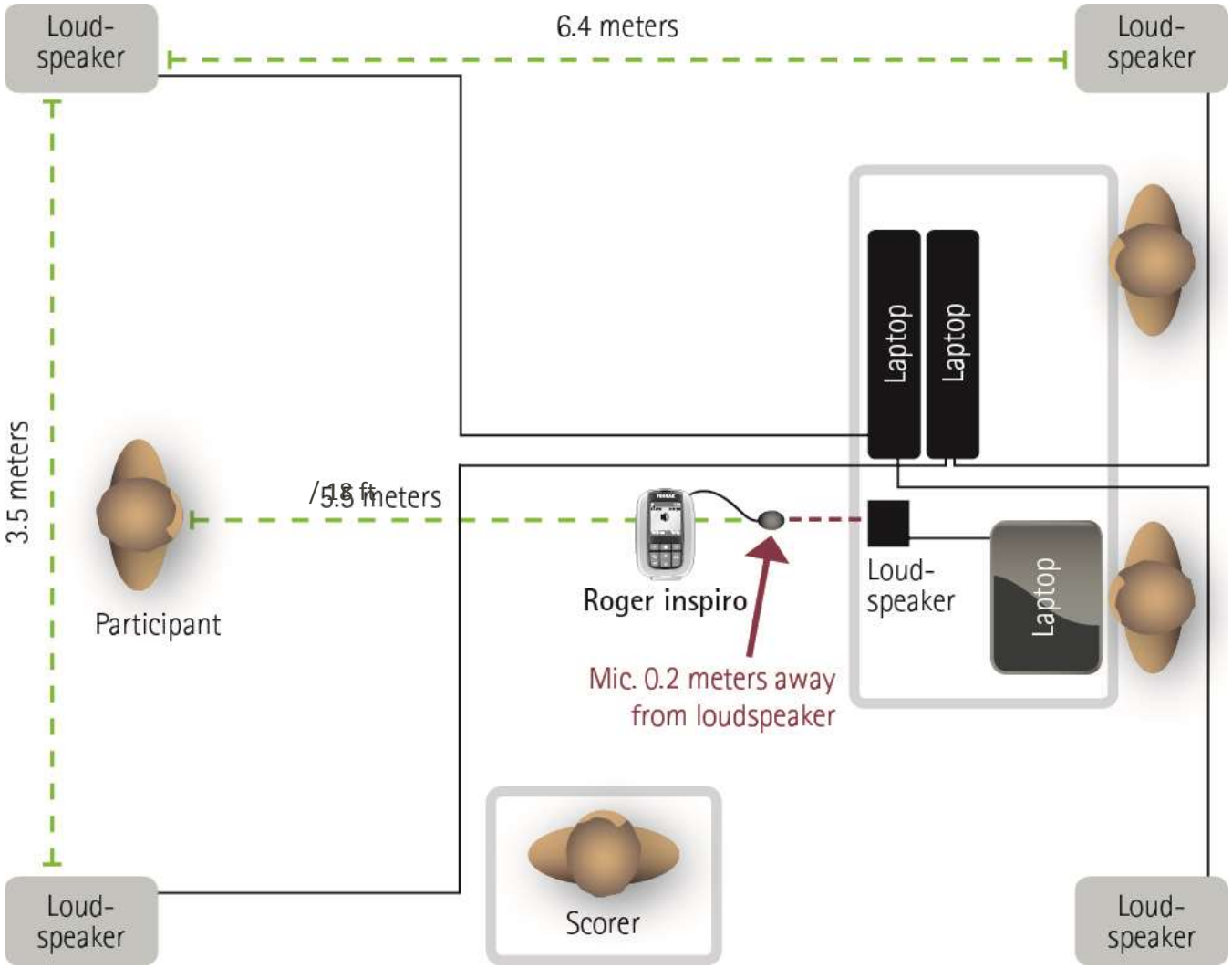
AAA, 2013

Annaheim, CA

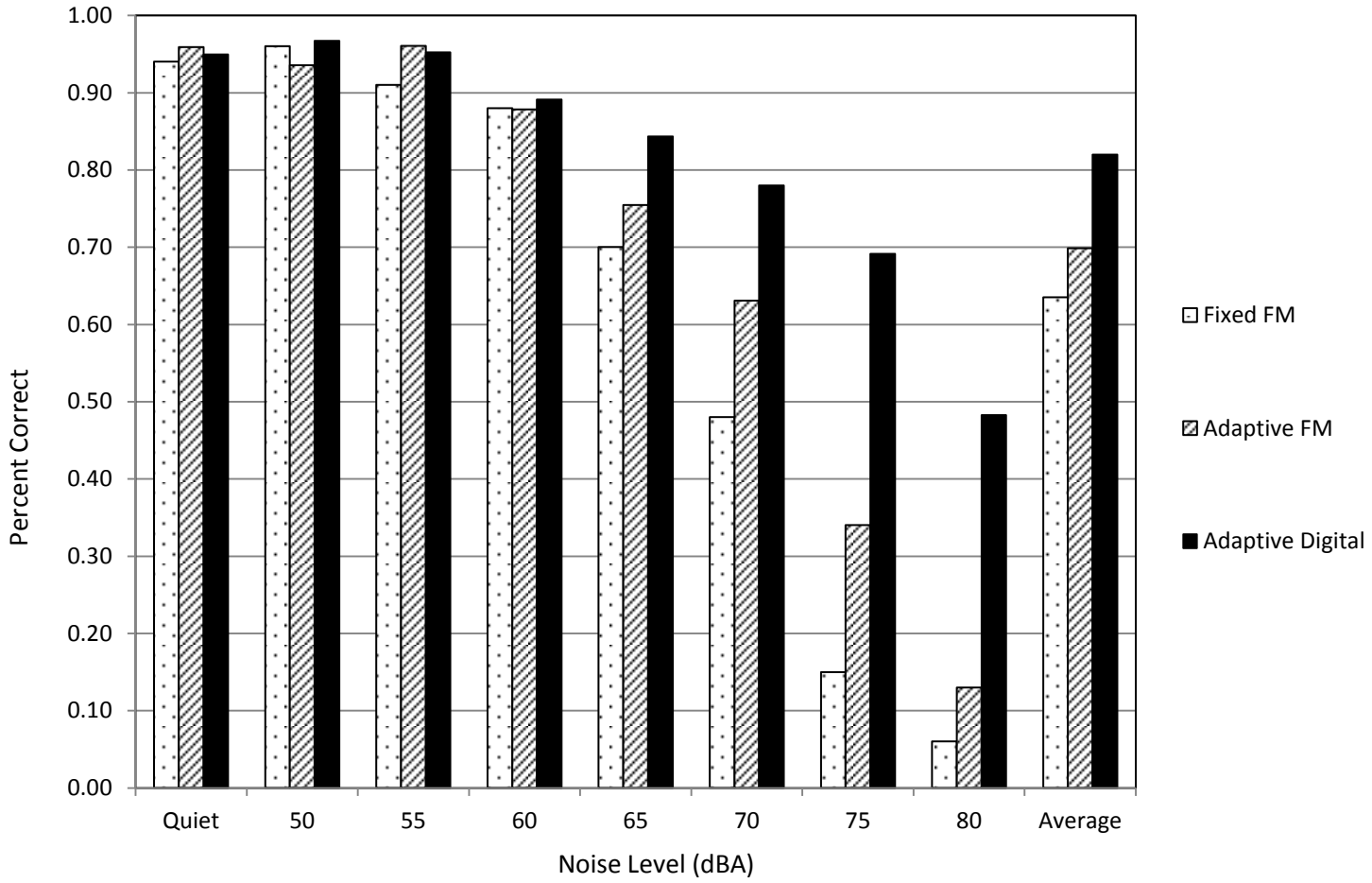
Research outline

- Dr. Linda Thibodeau
- University of Texas at Dallas
- Speech in noise testing
- 11 listeners using their own BTE's
- Ages 15 to 78
- Traditional FM vs Dynamic FM vs Roger
- Randomized, blinded
- Different noise levels

The test set-up



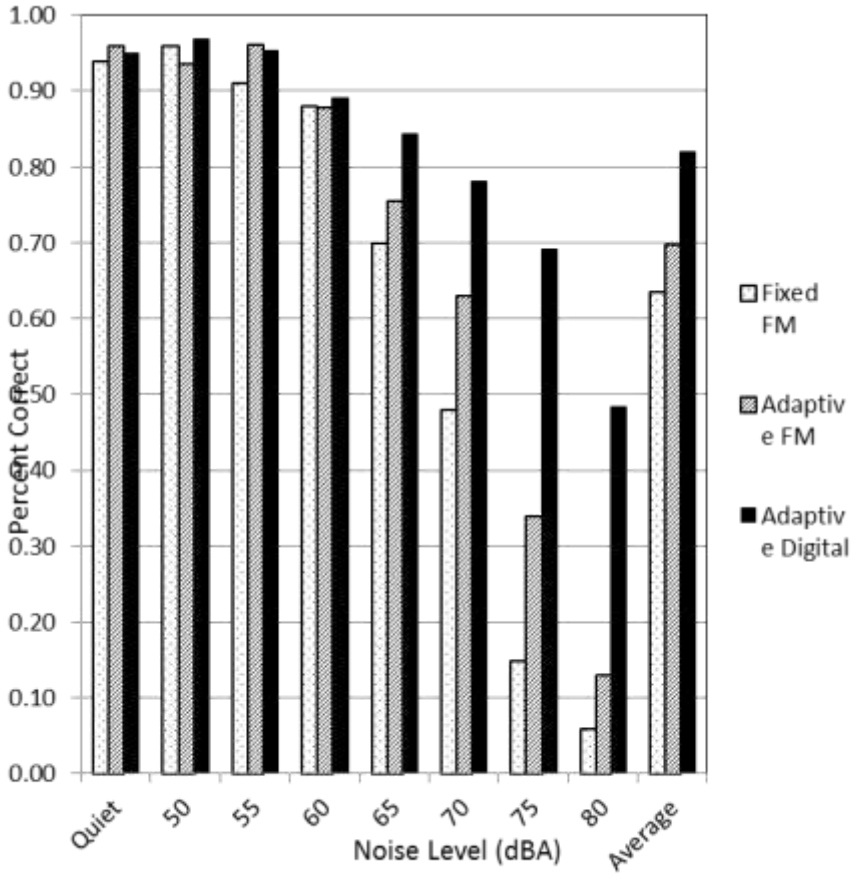
HINT Results (N=10)



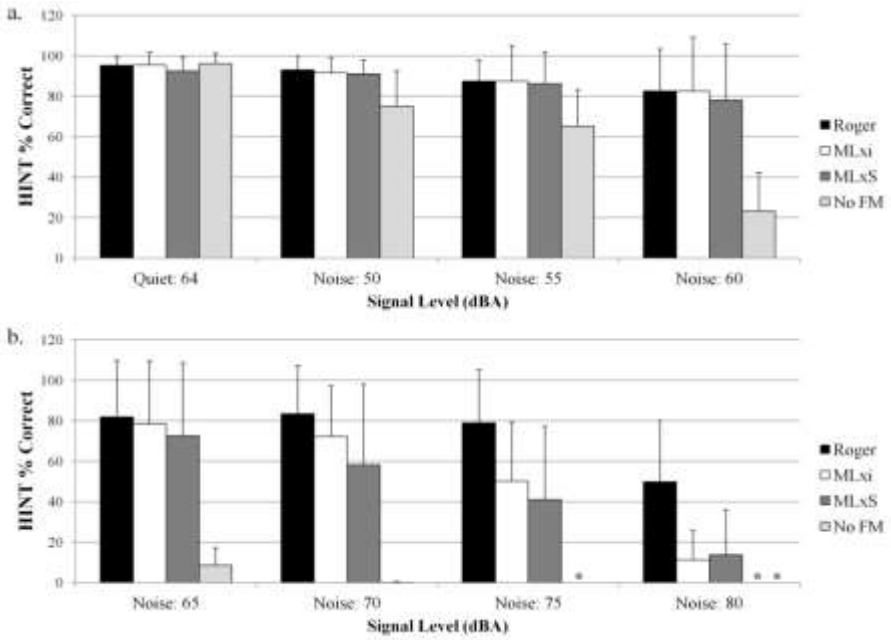
Thibodeau, 2013

Hearing Aid & CI Users

Hearing Aids



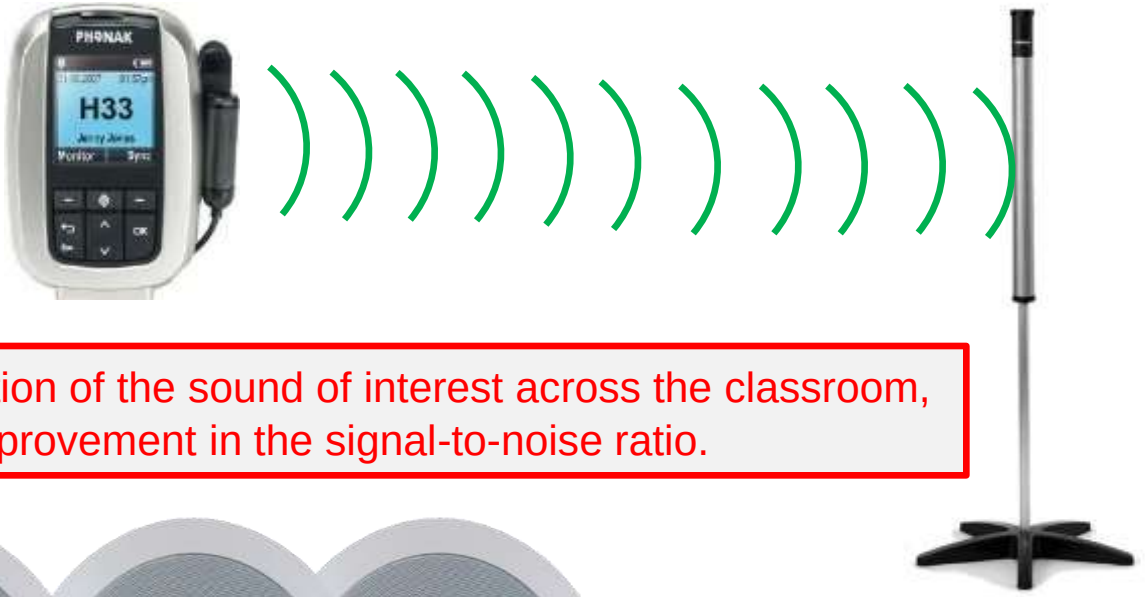
Cochlear Implants



Hearing Technology Research with Children

- What about digital RF in a classroom audio distribution system?

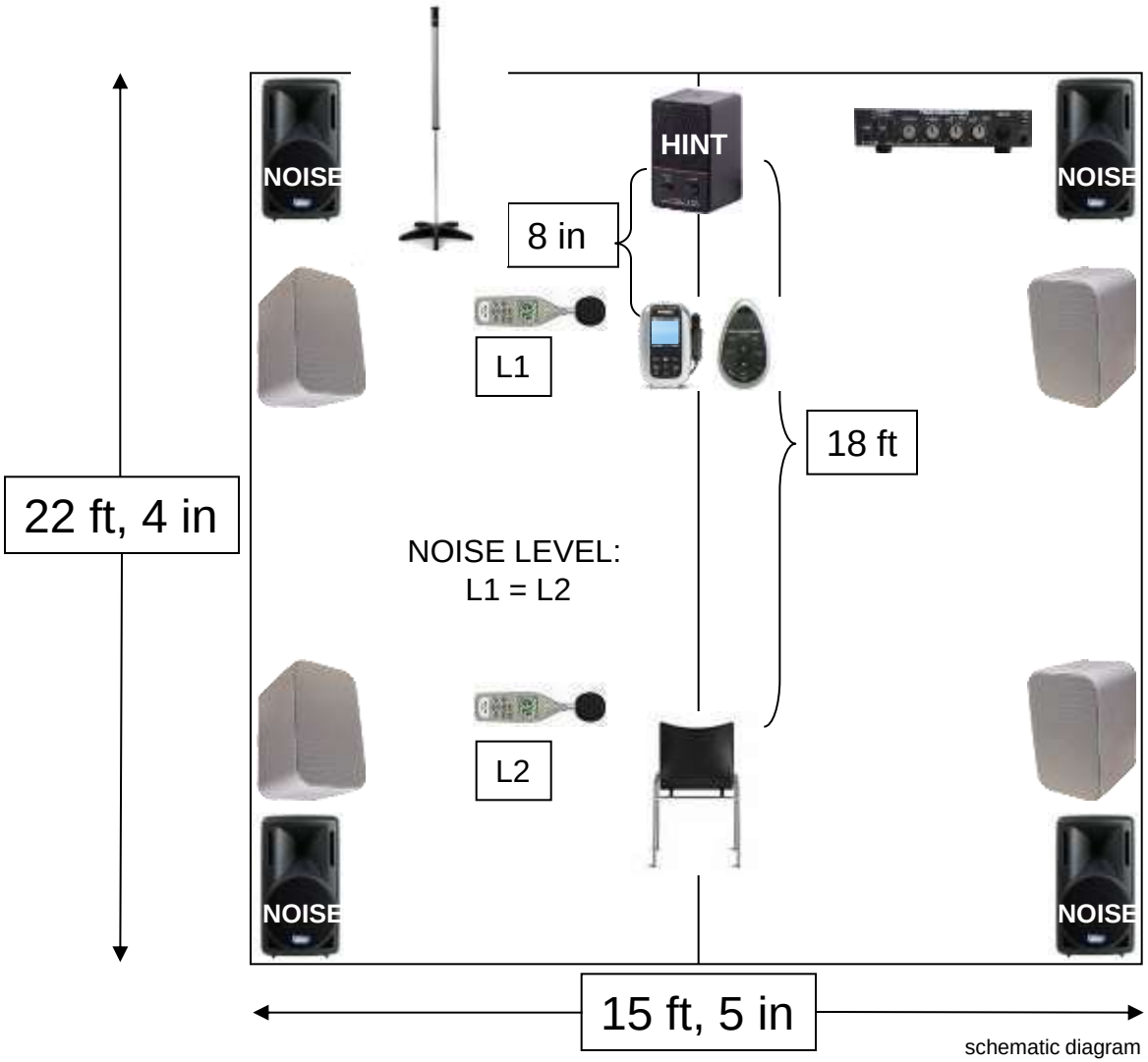
Classroom Audio Distribution Systems



Goals: Create a uniform distribution of the sound of interest across the classroom, and provide a modest improvement in the signal-to-noise ratio.

May utilize:
FM
Infrared
Digital RF

Classroom Setup



schematic diagram

Test Conditions

- No FM

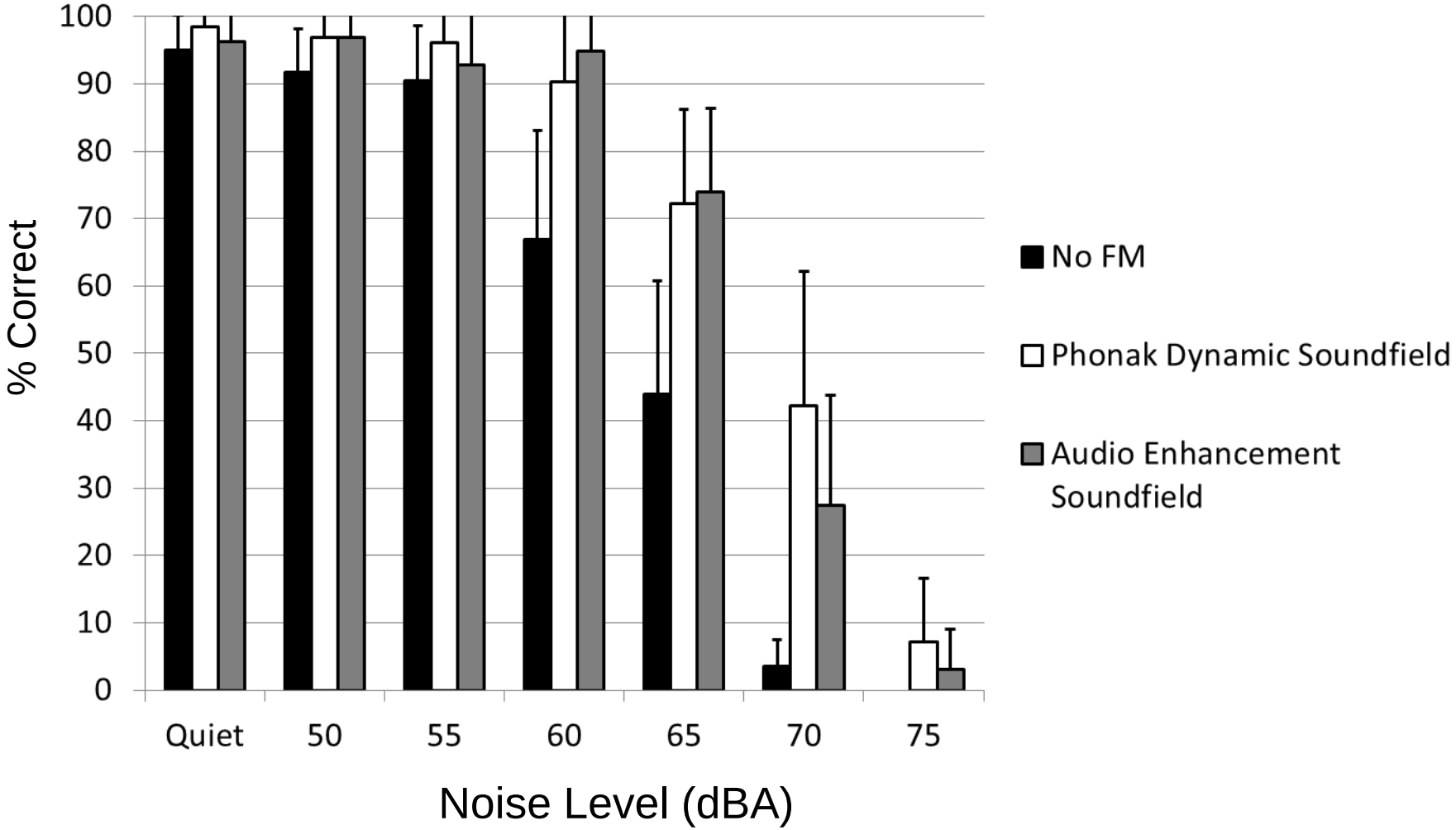
- Phonak DM5000 alone
- Audio Enhancement Elite II alone

- Phonak DM5000 + Personal FM
  - Inspiro to DM5000 and Personal FM

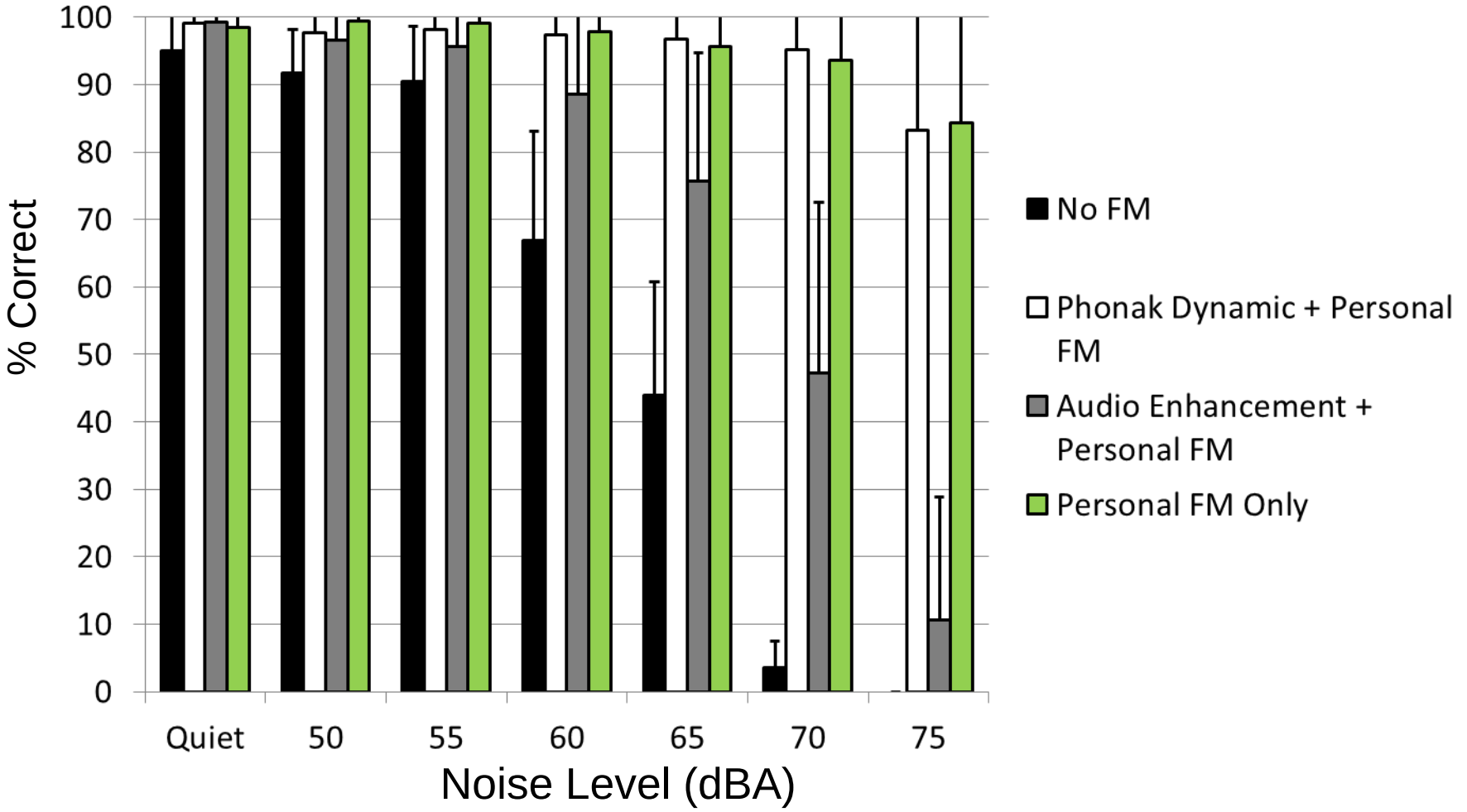
- Audio Enhancement Elite II + Personal FM
  - Inspiro connected to audio output port of Elite II

- Personal FM alone
  - Inspiro to personal FM

Children with Hearing Loss
CADS Performance



Children with Hearing Loss
CADS + FM vs. Personal FM



Clinical Implications

- CADS can improve speech recognition in noise for all students.
- Dynamic CADS provide better speech recognition in noise than fixed-gain CADS.
- Personal FM provides the largest improvement in speech recognition in noise.
- Be careful when using a personal RF system with a CAD system of a different manufacturer.
- Little to no speech recognition in noise improvement with Phonak CADS + Personal FM vs. Personal FM alone.
  - But CADS may improve classroom acoustics in real world.

Bluetooth & Near-field Digital Induction

HiBAN
10.6 MHz Digital Induction

Bluetooth

TVLink

Phonak Remote Mic

Why use a streamer?

Bluetooth & Near-field Digital Induction

HiBAN
10.6 MHz Digital Induction

Bluetooth

TVLink

Phonak Remote Mic

Near-field Magnetic Inductive Transmission

- Allows for efficient transfer of audio signal in near-field → Between ears
- Low power requirements
- Can transfer substantial amount of information when paired with Codec (similar to MP3)

Near-field Digital Magnetic Inductive Transmission

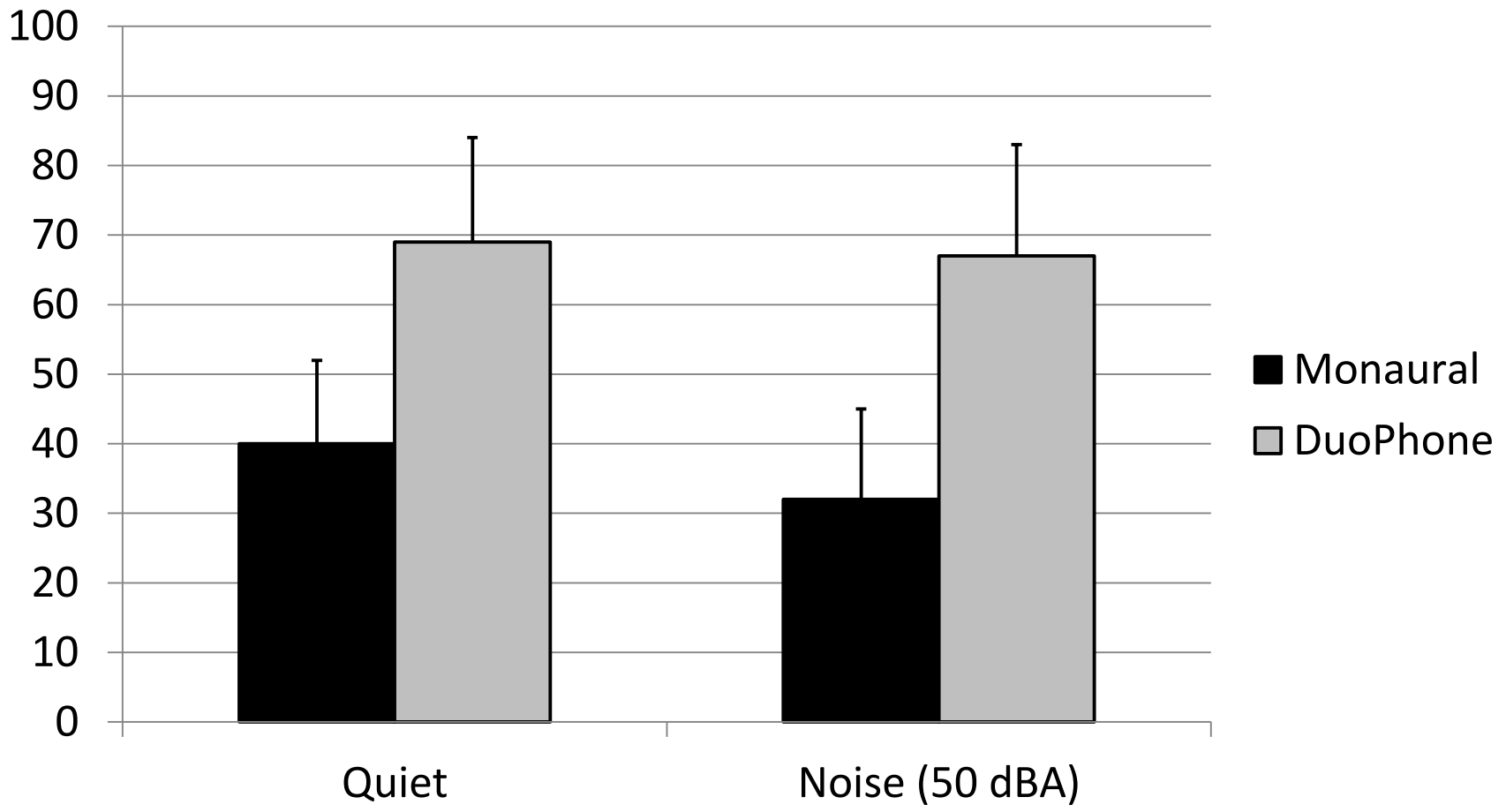
- To share audio information between ears (Streaming)

- Phonak HiBAN – Hearing Instrument Body Area Network
- Digital inductive transfer at 10.6 MHz
  - **Transfer of telephone signal -- DuoPhone** 
  - Binaural directionality -- StereoZoom 
  - Focused listening – Focus to the left/right -- ZoomControl 
  - Wind noise management 
  - Bilateral adjustments – Quick Sync
- Oticon Binaural
  - Preservation of binaural cues → localization

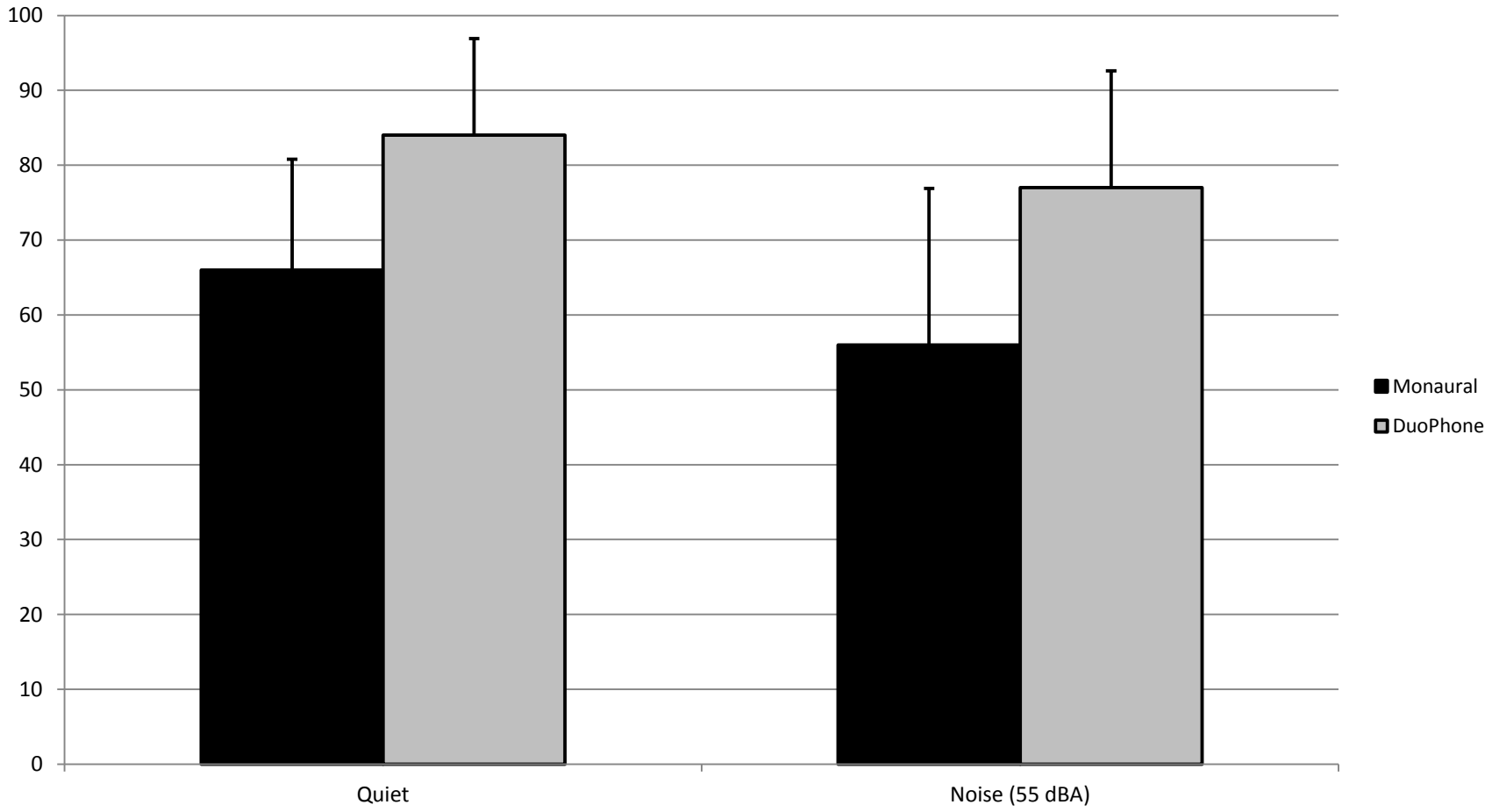
Evaluating DuoPhone for telephone use

- Tested word recognition on the telephone in quiet and in noise for children with hearing aids
  - 14 children (6-14 years-old)
    - Recorded CNC words
  - 10 children (2-5 years-old)
    - NU-CHIPs words via live voice (open-set)

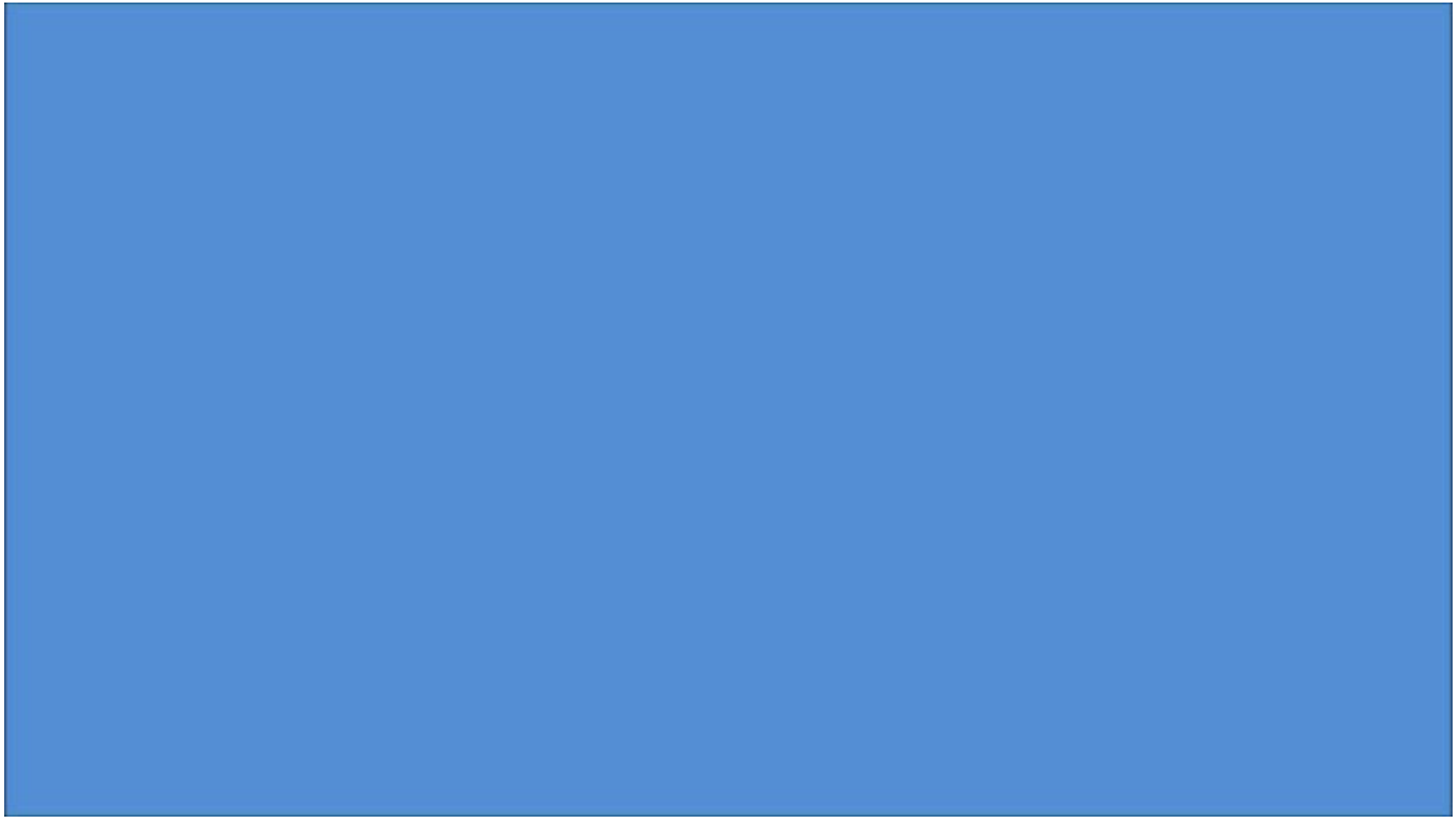
Mean CNC word recognition scores for older children (6-14 years-old)



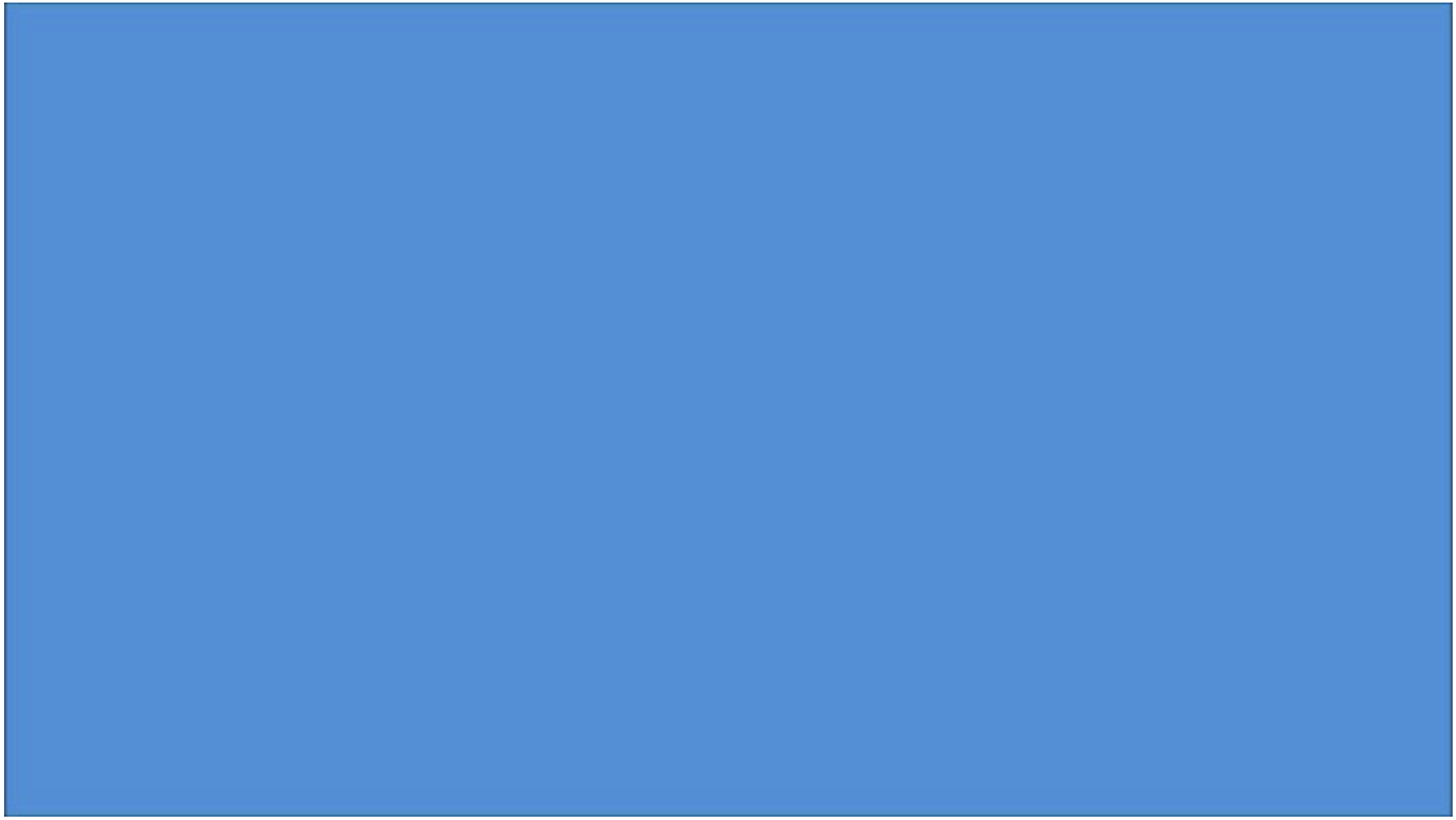
Mean NU-CHIP word recognition scores for younger children (2-5 years-old)



Hailey: The One-Eared Phone Listener



Hailey and the DuoPhone



Conclusions/Clinical Implications

- Don’t settle for good. Shoot for the moon! Great outcomes are possible when we properly use the best hearing technology available today.
- Roger > Dynamic FM > Fixed-gain FM
- Dynamic CAD can provide better speech recognition in noise than fixed-gain CAD.
- Children need to hear with 2 ears whenever possible.

Thank You for Your Attention!

www.heartsforhearing.org