Results with Devices that Utilize DM technology

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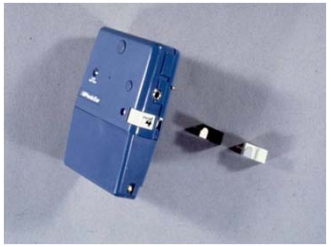
Overview

- Brief overview of Types of FM/Digital Processing
- First Study to compare Fixed FM with Adaptive FM
- Second Study to compare Fixed FM, Adaptive FM, and Adaptive Digital Technology

FM Technology

In Texas we say……



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FM Technology Advances

- Single-channel, body-worn transmitters/receivers in the 80's
- Small, multi-channel FM receivers integrated into behind-the-ear hearing aids in the 90's
- NOW…even Smaller Mini Microphones which may lead to greater acceptance

- Perhaps most exciting of all the changes is the advent of digital transmission which impacts not only the signal quality but also channel management

Review of Signal Processing Changes

- Traditional FM System
  - Level of FM signal is fixed above level of HA signal
  - +10 signal-to-noise ratio (SNR)
- Adaptive FM System
  - SNR varies depending on ambient noise level
  - If noise exceeds 57 dB SPL…the FM Advantaged is increased
- Adaptive Digital Modulation System
  - Digital processing is intended to provide even greater SNR at higher noise levels compared to Traditional and Adaptive FM Systems.

Traditional FM vs Adaptive FM
(Thibodeau, 2010)

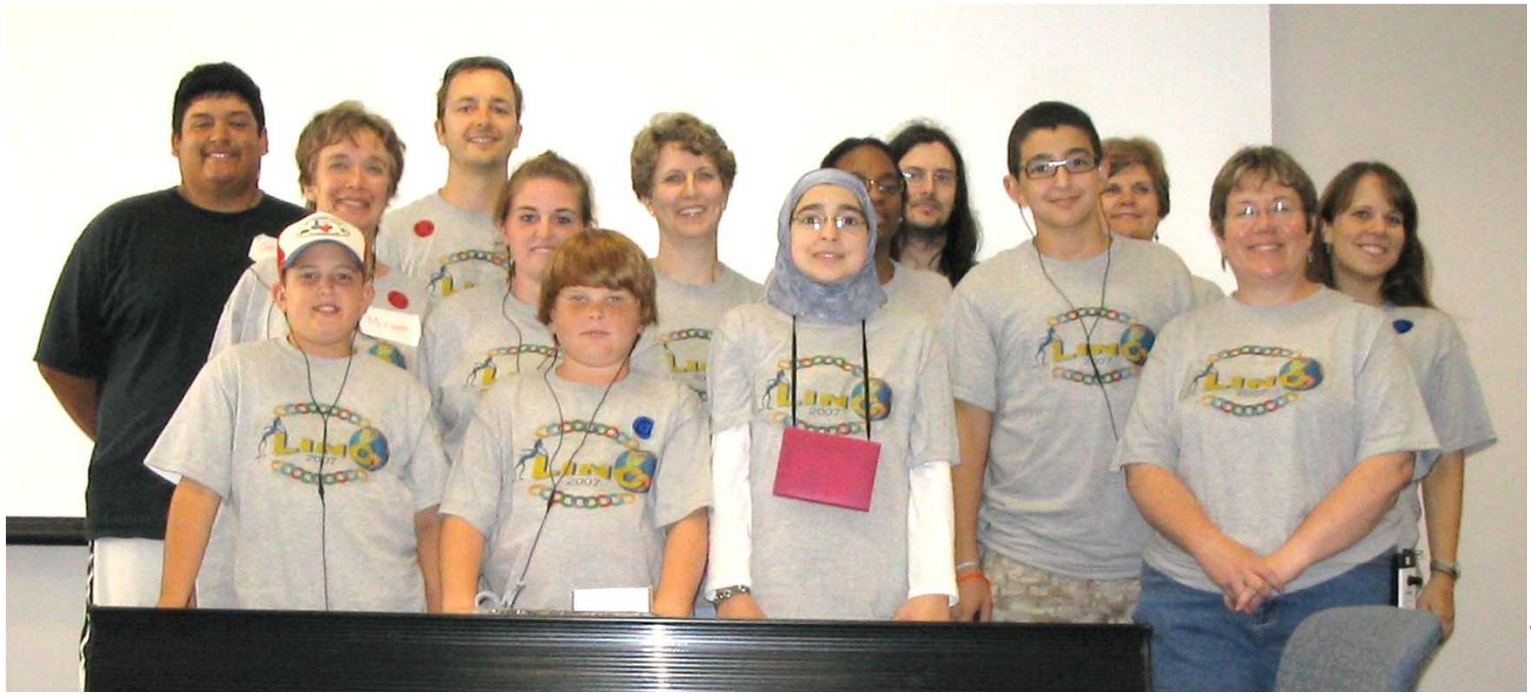
Purpose: To compare benefits of Adaptive FM and Fixed FM Systems through objective and subjective measures in adults and teens in clinical and real-world settings.

Experimental Design

- Control for Bias in Examiners and Subjects
- Evaluate in a variety of settings with adults and children
- Obtain feedback from those with previous FM experience
- Use sensitive speech recognition materials

SUBJECTS

- 5 adults and 5 teens with primarily moderate-to-severe hearing loss who wore binaural behind-the-ear hearing aids
- All experienced FM users and agreed to use the system over a one-week period



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METHODS

- Audiometric evaluation
- Electroacoustic analysis of hearing aids
- Connection via DAI to body-worn test unit
- Two individual and one group test session
- The sessions were conducted in a large classroom with four speakers placed at the corners to present classroom noise and one at the front to deliver the speech.

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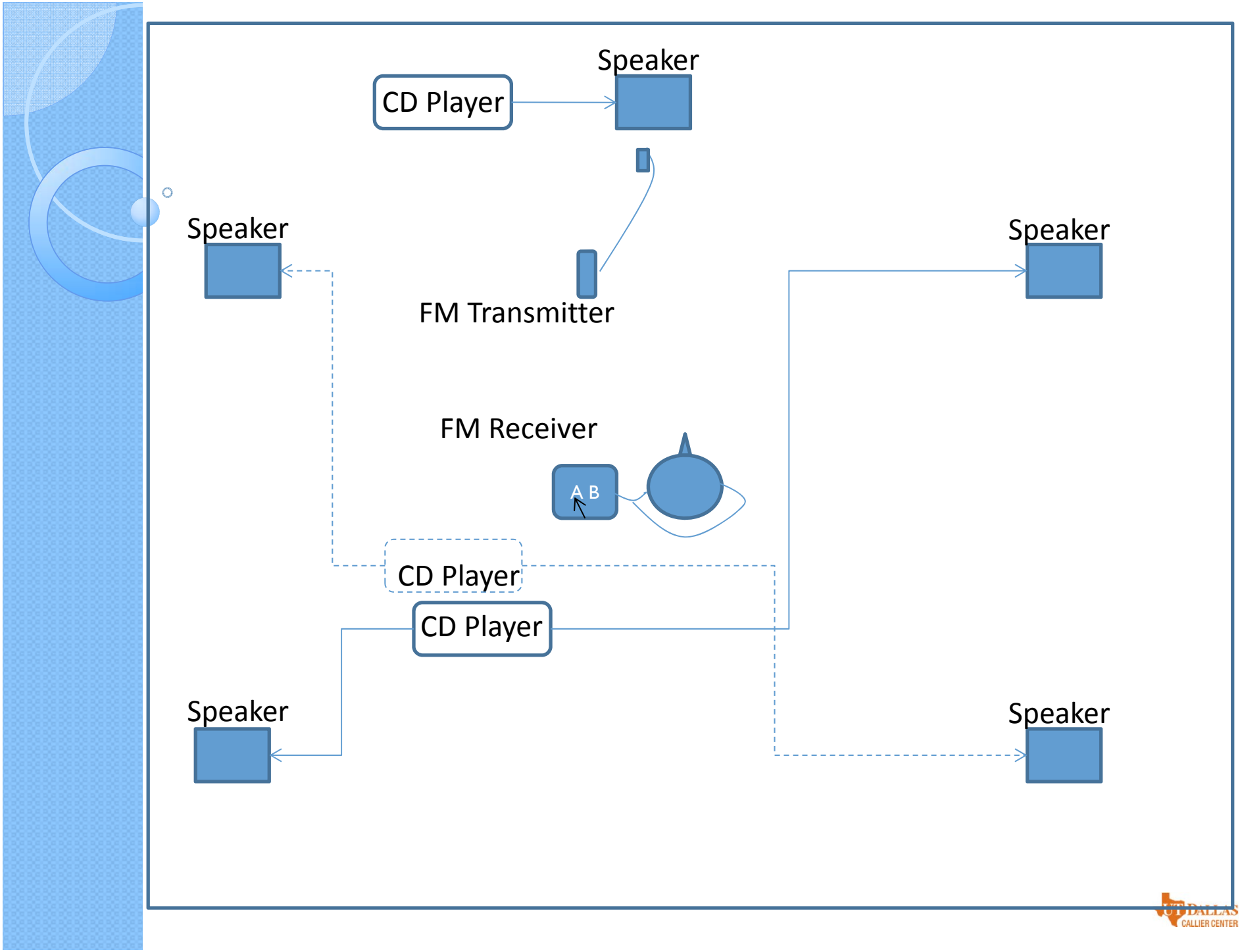
Speaker
CD Player
Speaker
Speaker
FM Transmitter
Speaker
FM Receiver
A B
CD Player
CD Player
Speaker
Speaker

Test Arrangement

Objective Measures

- HINT and SPIN sentences presented at 5 noise levels: 54, 63, 68, 73, and 80 dBA with speech delivered to the FM microphone at 84 dBA.
- Classroom noise from two sources delivered to four speakers

  (Schafer & Thibodeau, 2006)
- Within each measure, the order of noise levels and type of FM setting were counterbalanced.

Subjective Measures

- Two classroom activities, one bus ride, and six lessons in the Dallas World Aquarium
- Participants were also asked to wear the device on both settings (Adaptive and Fixed) in their natural environments.

Classroom Activities

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Bus Ride

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Tour Guide at Dallas World Aquarium

During each activity,

they listened to A and B

The participants had two controls

(A or B) and were blinded to the type of processing for each control:

Fixed or Adaptive

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Sample Rating Card

Name: _____ (Classroom Activity_____)

How easy was it to understand the speaker during the "**First assignment**"?

very easy	easy	ok	hard	very hard
o	o	o	o	o

How did you perceive your own voice while carrying out the task?

Much too soft	too soft	normal	too loud	much too loud
o	o	o	o	o

How easy was it to understand the speaker during the "**Second assignment**"?

very easy	easy	ok	hard	very hard
o	o	o	o	o

How did you perceive your own voice while carrying out the task?

Much too soft	too soft	normal	too loud	much too loud
o	o	o	o	o

After listening to both assignments, what setting do you prefer better and why?

Setting "A" o Setting "B" o Both the same o

Why? _____

_____

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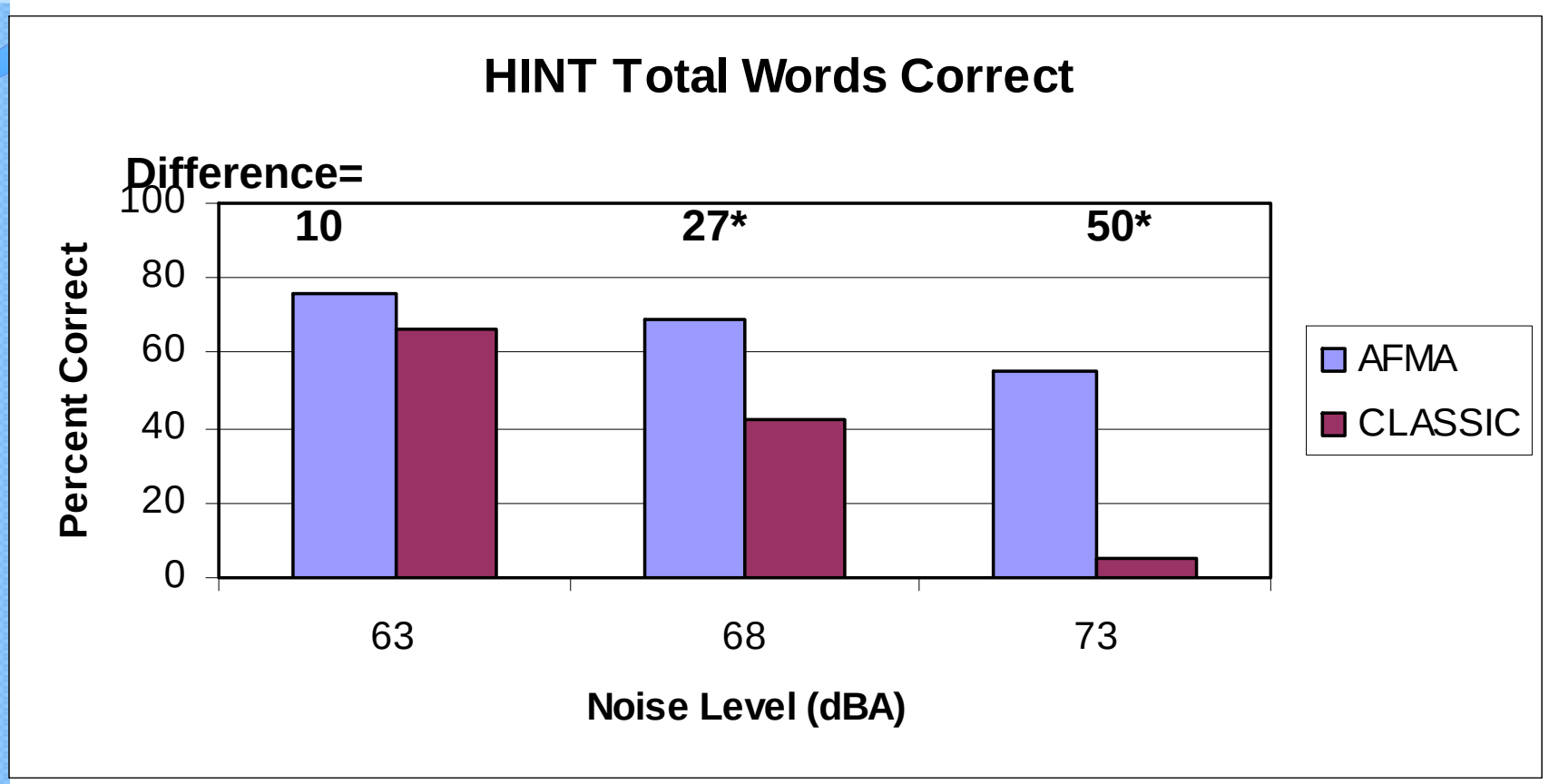
RESULTS: Objective Measures

- The average improvement across noise levels in HINT percent correct scores with Adaptive FM processing was
  - 22% (first word),
  - 21% (total words), and
  - 19% (total sentences).
- The average differences in total words correct between processing schemes increased as noise level increased from a -4% at the 54dBA noise level to a 50% increase at the 73 dBA noise level.


HINT Total Words Correct
Difference=
10
27*
50*
Percent Correct
100
80
60
40
20
0
63
68
73
Noise Level (dBA)
AFMA
CLASSIC

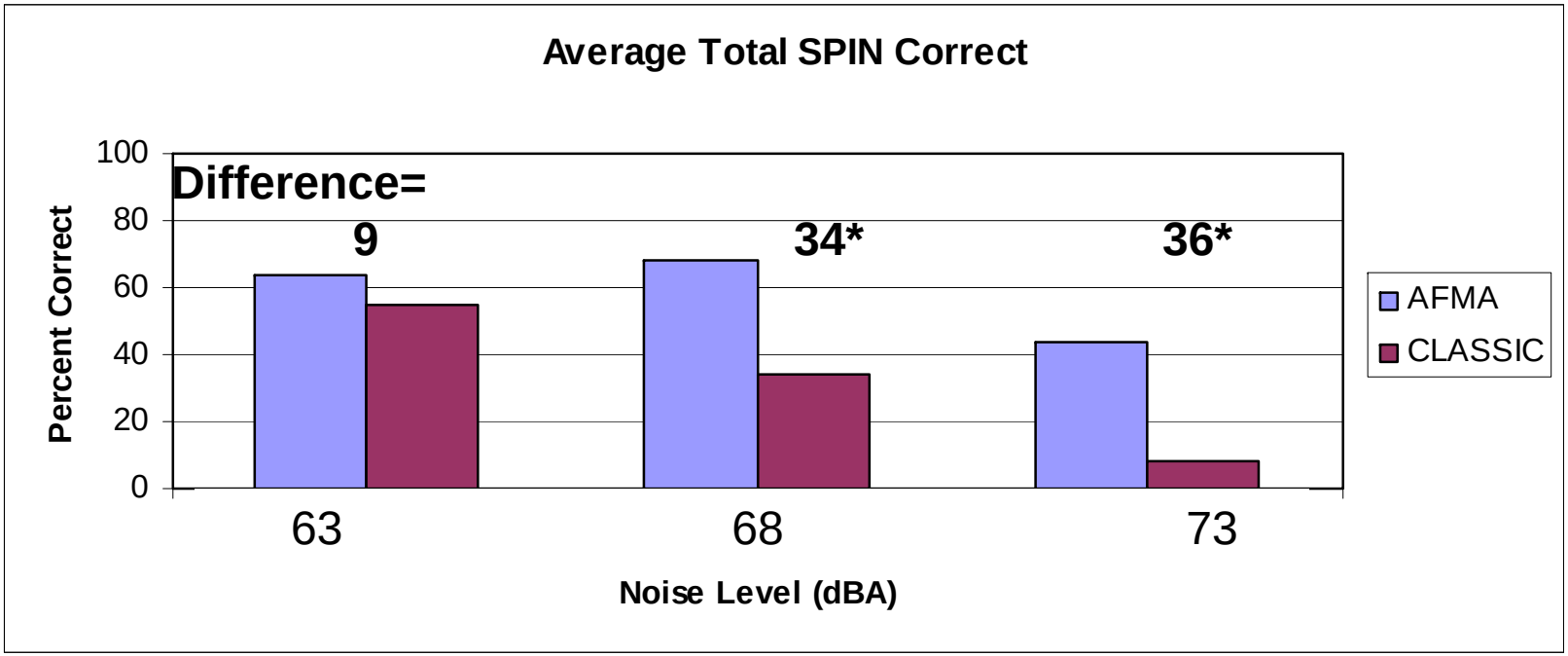
RESULTS: Objective Measures

- The average percent increase for Adaptive FM processing was greater for the SPIN sentences
  - 27% (HP),
  - 25% (LP), and
  - 26% (total final word correct)

  As with HINT, the improvement increased with noise level from 4% (HP) at the 54 dBA noise level to 42% at the 73 dBA noise level.

NOTE: 5 noise levels tested but results shown for only 3!

(54 and 80 dBA not shown)



Challenging Listening at the 80 dBA Level

- 54 dBA – No statistical difference between the Fixed and Adaptive FM
- 80 dBA – Not included in the statistical analysis because most listeners could not tolerate that listening condition!

INDIVIDUAL RESULTS

- 8 of the 10 individuals made significant improvements with the HINT sentences via Adaptive FM processing at one of the noise levels.
- The Adaptive FM processing was significantly better for 9 of the 10 participants on the low probability sentences of the SPIN at the 73 dBA noise level.

Subjective Results

SUBJECTIVE RESULTS

- The participants selected a preferred setting at the conclusion of each activity.
- For half of the activities, 100% of the participants chose Adaptive FM as the preferred setting.
- For the remaining activities Adaptive FM was also preferred by 80 to 90% of the participants.

Adaptive FM Processing with Implants
(Wolfe et al. 2009)

- Phonak Inspiro Transmitter and 2 different receivers: MLxi(Adaptive) and MLxs(Fixed)
- Listeners with Advanced Bionics and Cochlear Implants
- Repeated HINT sentences in 55, 65, 70, and 75 dBA of noise
- Found significant improvements in speech recognition for adaptive processing over fixed for both types of implant users

NEW DIGITAL MODULATION TECHNOLOGY

- This technology can be integrated into smaller components with wider bandwidth, provided the power consumption remains acceptable.
- The signal quality can be theoretically superior because FM channel noise is most likely not present
- Sampling rate and the numbers of bits to represent the integers determine the actual digital sound quality

Traditional FM vs Adaptive FM vs Adaptive Digital (Thibodeau, submitted)

Purpose: To compare speech recognition in noise with THREE wireless transmission systems: Fixed FM, Adaptive FM, and Adaptive Digital FM in clinical and real-world settings.

Based on the previous findings with the Adaptive FM processing, comparisons must be made for a series of noise levels.

It was likely that the greatest differences would be observed for the highest noise levels.

Experimental Design

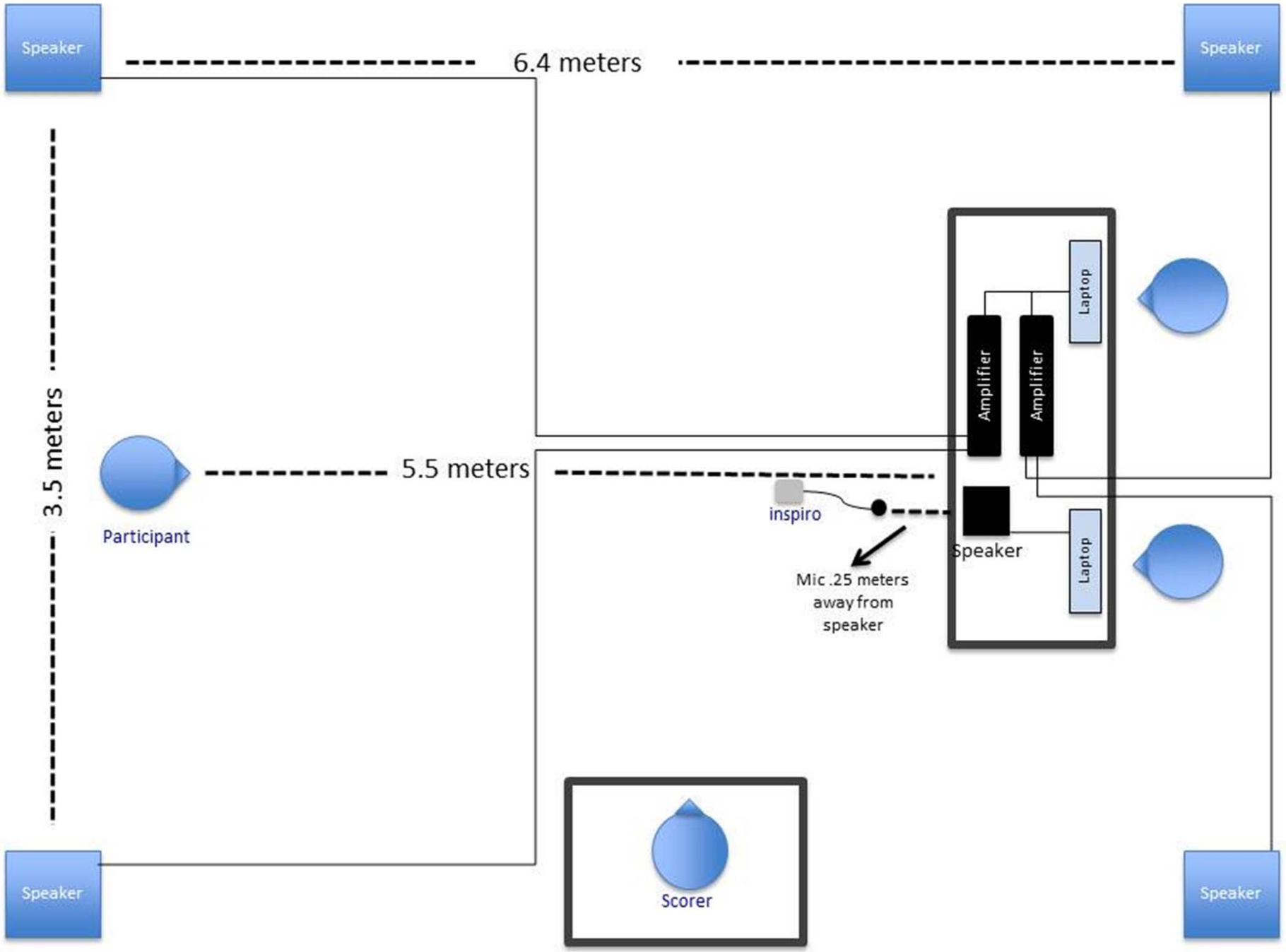
- Control for Bias in Examiners and Participants
- Evaluate in a variety of settings with adults and children
- Obtain feedback from those with previous FM experience
- Use sensitive speech recognition materials

PARTICIPANTS

- 5 adults and 6 teens/young adults with primarily moderate-to-severe hearing loss who wore binaural behind-the-ear hearing aids
- All experienced FM users and agreed to use the system during a trip to the aquarium
- 6 had participated in the first study

METHODS

- Audiometric evaluation
- Electroacoustic analysis of hearing aids
- Connection via DAI to body-worn test unit
- Individual objective testing session
  - Conducted in a large classroom with four speakers placed at the corners to present classroom noise and one at the front to deliver the speech.


Speaker
6.4 meters
Speaker
3.5 meters
Amplifier
Amplifier
Laptop
Participant
5.5 meters
inspiro
Speaker
Laptop
Mic .25 meters
away from
speaker
Scorer
Speaker
Speaker

Stimuli

Clinical Testing

- HINT sentences
- Classroom Noise

(Schafer & Thibodeau, 2006)

Real World Testing

Live Voice Presentation of "Lessons" about aquarium exhibits (eg waterfall, penguins, sloth)

Ambient Noise ranged from 65 to 85 dBA

Objective Measures

- The starting HINT test was selected randomly for each participant and subsequent lists were administered in order.
- The starting noise levels and were counterbalanced for each participant and sequential levels were presented thereafter.
- The switch settings and technology condition were randomized across test units, with participants and examiners blinded to each condition.

Subjective Measures

- Four lessons were conducted in the Dallas World Aquarium
  - After listening to three to four sentences from each lesson, participants were instructed to change the setting on their test unit.
  - After each session was completed, participants rated their difficulty listening in each setting.

Double Blinded

- The participants had three settings available on their test unit and were blinded to the type of processing for each setting: Fixed FM, Adaptive FM, and Adaptive Digital
- During each activity, participants listened to each of the three settings by moving the dial on the test unit to setting 1, 2, or 3.
- The processing for each setting was unknown to listeners and examiners!

Sample Rating Card

Name: _____ Dallas Aquarium World Location #_____ Box #_____

a) How easy was it to understand the speaker on Setting 1?

very easy	easy	ok	hard	very hard
o	o	o	o	o

Please Explain_____

b) How easy was it to understand the speaker on Setting 2?

very easy	easy	ok	hard	very hard
o	o	o	o	o

Please Explain_____

c) How easy was it to understand the speaker during on Setting 3?

very easy	easy	ok	hard	very hard
o	o	o	o	o

Please Explain_____

d) After listening to all three settings, what setting do you prefer?

Setting "1" o Setting "2" o Setting "3" o All the same o

Why? _____

_____

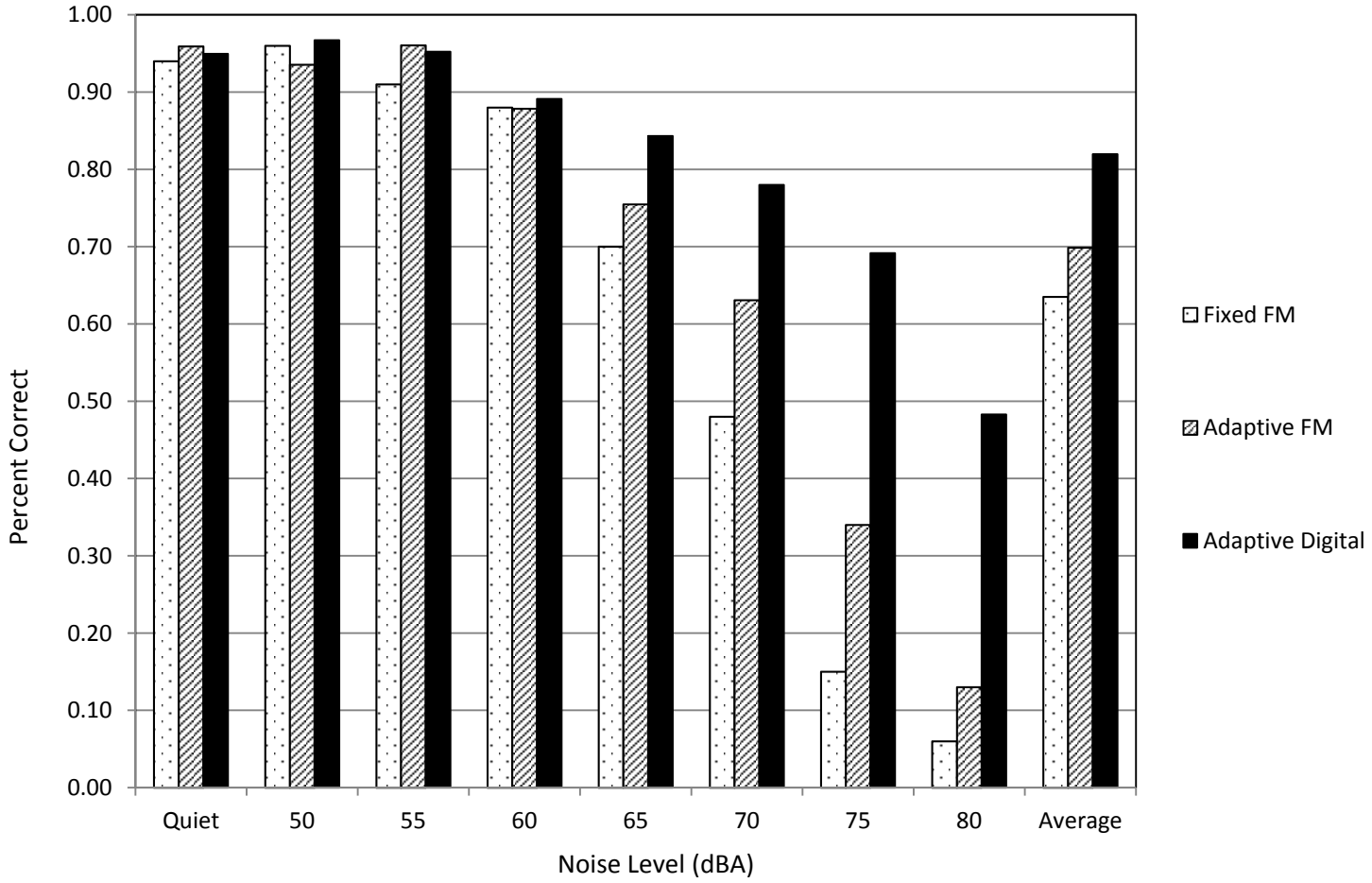
_____

RESULTS

Objective Measures

- Adaptive Digital technology resulted in significant improvements for 65, 70, 75, and 80 dBA noise levels over Fixed and Adaptive technology.
- The average improvement in speech recognition at the **80dBA** level by
  - Adaptive Digital over the current Adaptive FM was 35%!
  - And Adaptive Digital over Fixed FM technology was 42%!

HINT Results (N=10)



INDIVIDUAL RESULTS

At the 80 dBA noise level…..

9 scored <10% for Fixed FM

6 scored <10% for Adaptive FM,

1 scored <10% for the Adaptive Digital

The highest score at the 80 dBA noise was 81% (#2) for the Adaptive Digital technology!

INDIVIDUAL RESULTS

- The results from one listener who had a profound loss were not included in the data analysis because of her extreme difficulty with speech recognition in noise.
- With the Fixed and Adaptive FM technology she scored ≤20% for the Quiet and low noise-level conditions.
- However, with the Adaptive Digital technology, she was able to hear some words through the 75 dBA noise level and achieved her highest score (41%) at the 55 dBA noise level.
- Use of this Adaptive Digital technology with visual cues from the talker's face would most likely have resulted in much higher performance.

SUBJECTIVE RESULTS

- The participants selected a preferred setting at the conclusion of each activity.
- Eight of the participants (73%) selected the Adaptive Digital Technology as the preferred setting at the four stations.
- One selected Adaptive FM (#4) and one selected both Adaptive Digital and Adaptive FM (#7) across the listening stations.
- One of the participants who participated in the previous study (Thibodeau, 2010) commented that this new system was a "dramatic improvement" over the best one she tried in the previous study.

Comments about listening via Fixed FM Technology

Can only hear every other word due to background noise being overpowering

Couldn't hear the voice at all

I heard Doc T talk but it was very low sounding

Not easy to hear, requires concentration

I heard her ok she had a medium voice

Very low in volume but could tell what was said

I was unaware anyone was speaking

Hard to understand with walking and noise

Comments about listening via Adaptive FM Technology

Very soft and directional

The water was loud and I barely heard the voice

The voice was muffled

Voice and background equally loud hard to distinguish

You can't hear her, sounds like my ear is off

Very very low, unable to hear

I know you were speaking but not really understand anything

Hard to hear the speech

Comments about listening via Adaptive Digital Technology

Great clarity over waterfall

The water made it hard but the voice was heard

Very clear and crisp, comfortable noise

Voice much louder than background

Love (setting) 3! Great SOUND

I hear her very well sounds loud

Still a little scratchy, but completely understandable

Even with background noise I could understand speaker easily

Loved this! Easy to understand and background noise was significantly reduced

Clear understood really good

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SUMMARY

- The Adaptive Digital processing resulted in significant improvements for participants in the four highest noise level conditions.
- The benefits of Adaptive Digital processing increased with increasing noise levels.
- Adaptive Digital processing was also the preferred technology for most of the listeners in the real-world setting.

- Newer Adaptive Digital Technology allows for greater communication across noise levels than was possible before!

- JUST IMAGINE……..

Teens with hearing loss who use this technology may actually have to explain to their normal-hearing peers what the senior boys said at the pep rally!

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Let's cheer for New Technology!!

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