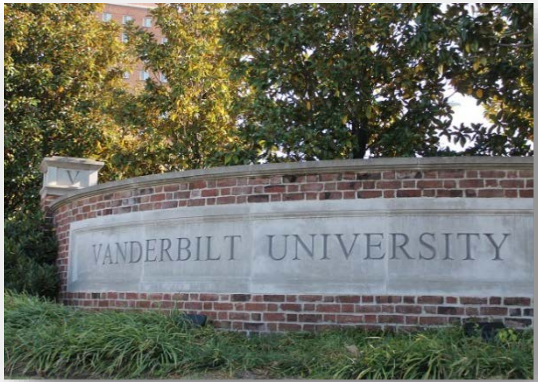
The Potential Benefits and Limitations of Hearing Aid Microphone Technologies for Adults and Children



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OF AUDIOLOGY
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Acknowledgements

People who do the hard work:

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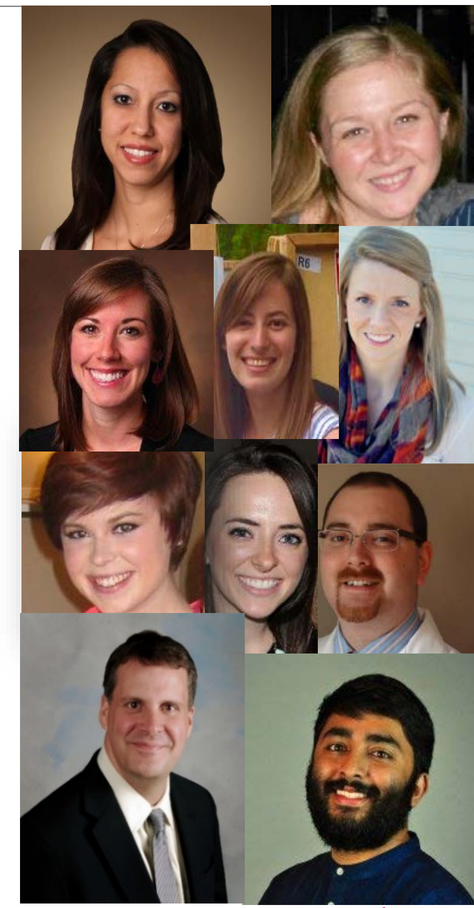

NIH NIDCD

PHONAK

sonova HEAR THE WORLD

oticon PEOPLE FIRST

Learner Outcomes

Upon completion, participants will be able to:

1) describe listening environments where hearing aid microphone technologies are expected to reduce listening effort for adults

2) describe listening environments where hearing aid microphone technologies are expected to reduce listening effort for school-aged children

Outline

Listing effort

- What is it?
- Why is it important?
- How do we measure it?
- What affects it?

Strategies for reducing listening effort

- Hearing aids
- Digital noise reduction
- Directional microphones

Spoiler Alert!

Listenin… earing loss, wit…

Dual-tas… ure listening…

Hearing…

Advanc…
- In "na…
- Wher…

Listening Effort

Mentally tired while listening

Increased concentration

Cognitive resources necessary for speech recognition

Why Study Listening Effort?

Patients report feeling mentally drained

It's part of the communication experience

Listening effort may be distinct from speech recognition performance

Implications of Sustained Increases in Effort

Mental fatigue

Communicative disengagement

Increased need for recovery after work

Decreased subjective well-being

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Measuring Effort

Subjective reports

- Standardized questionnaires
- Patient reports

Physiologic measures

- Pupil dilation
- Skin conductance

Recall tasks

- Paired associates
- Free recall

Reaction time measures

- Response time
- Dual task

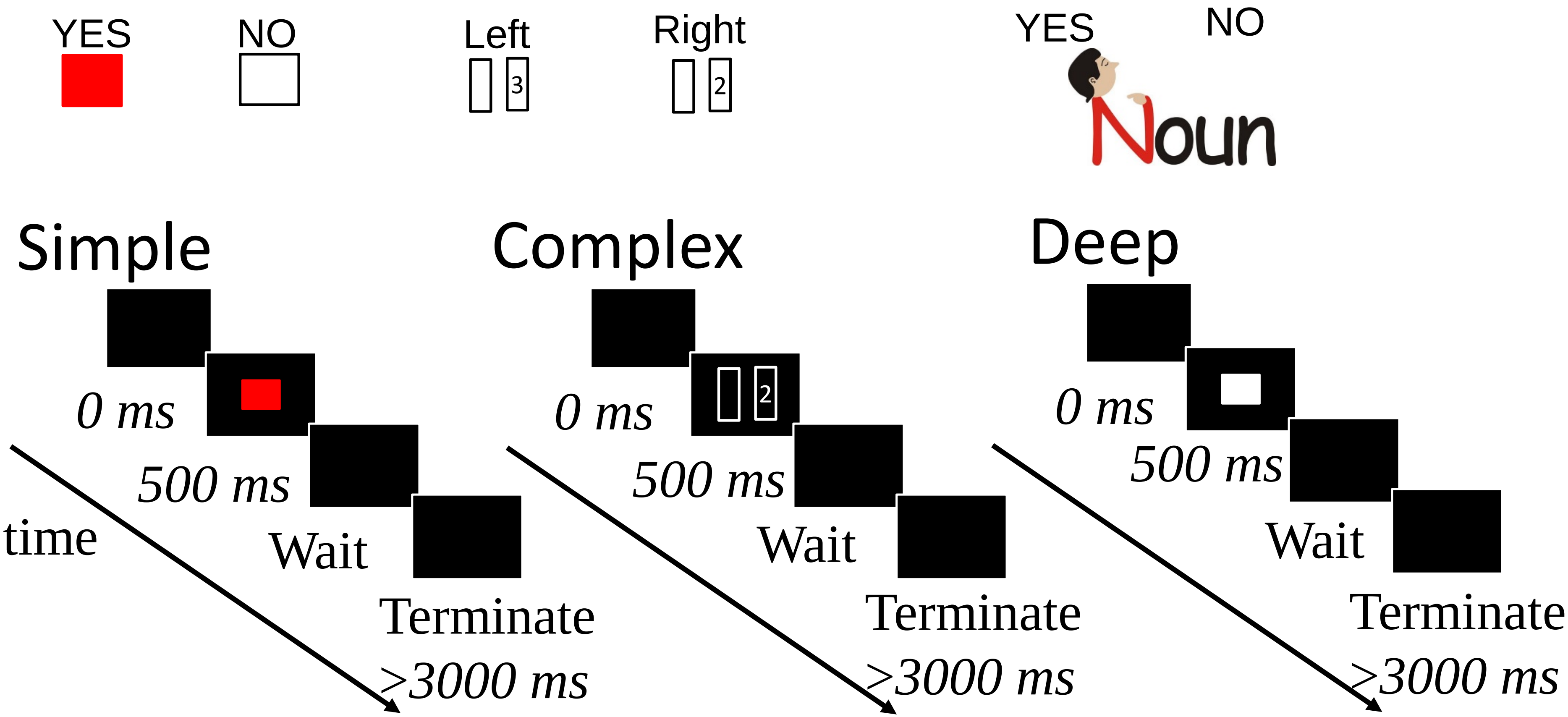
Effort in Adults: Dual-Task Paradigms

Participants
- 17 young adults with normal hearing
- 17 older adults with hearing loss

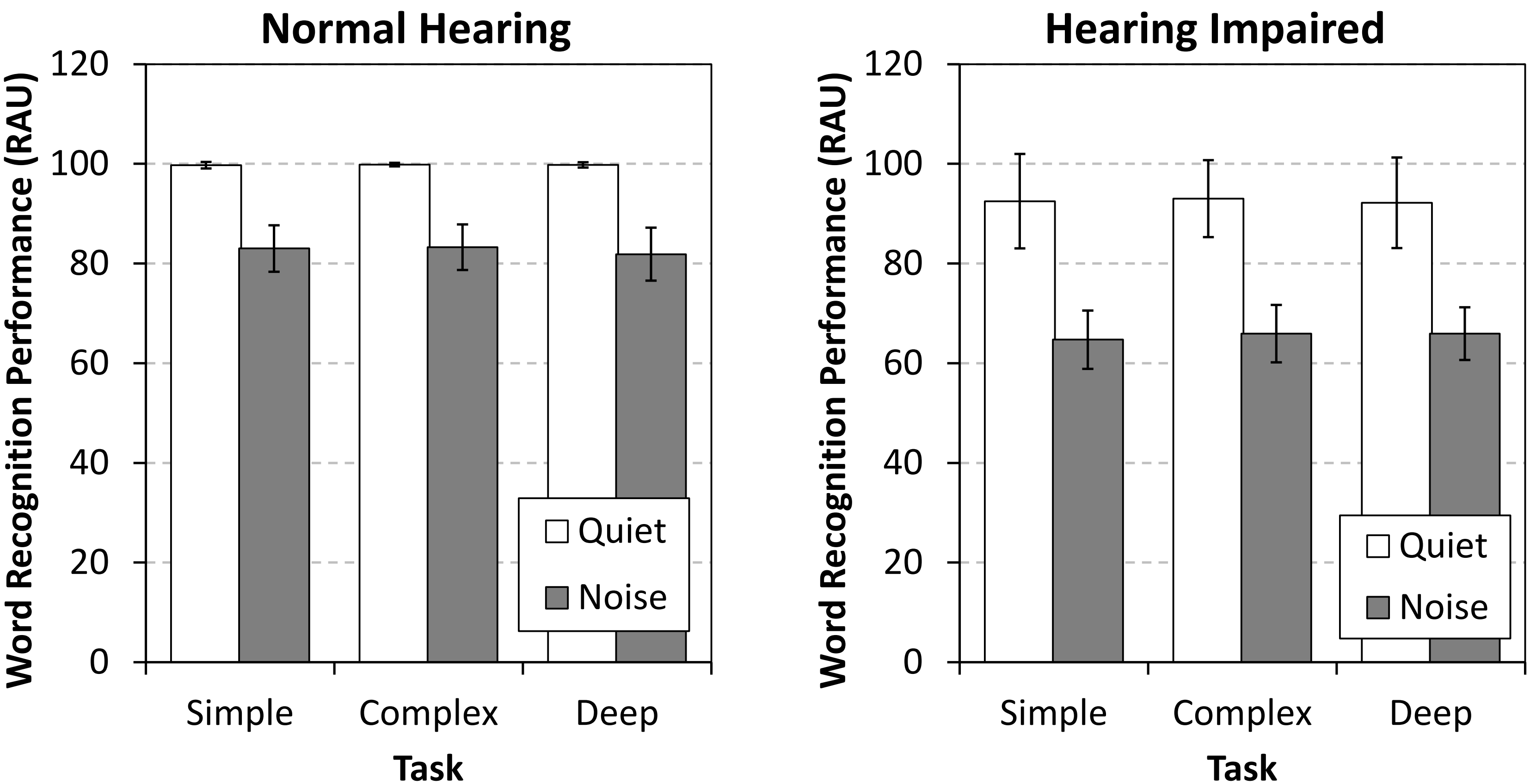
Materials
- Monosyllable word recognition
- Physical response time

Conditions
- Quiet
- Noise

Dual-Task Paradigms

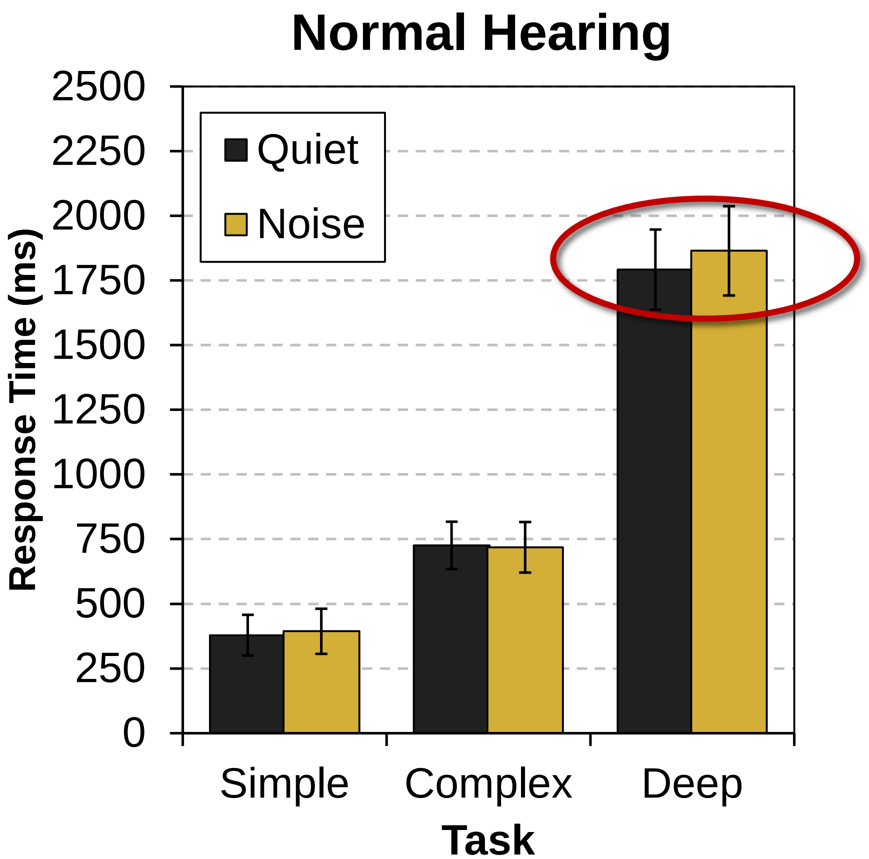


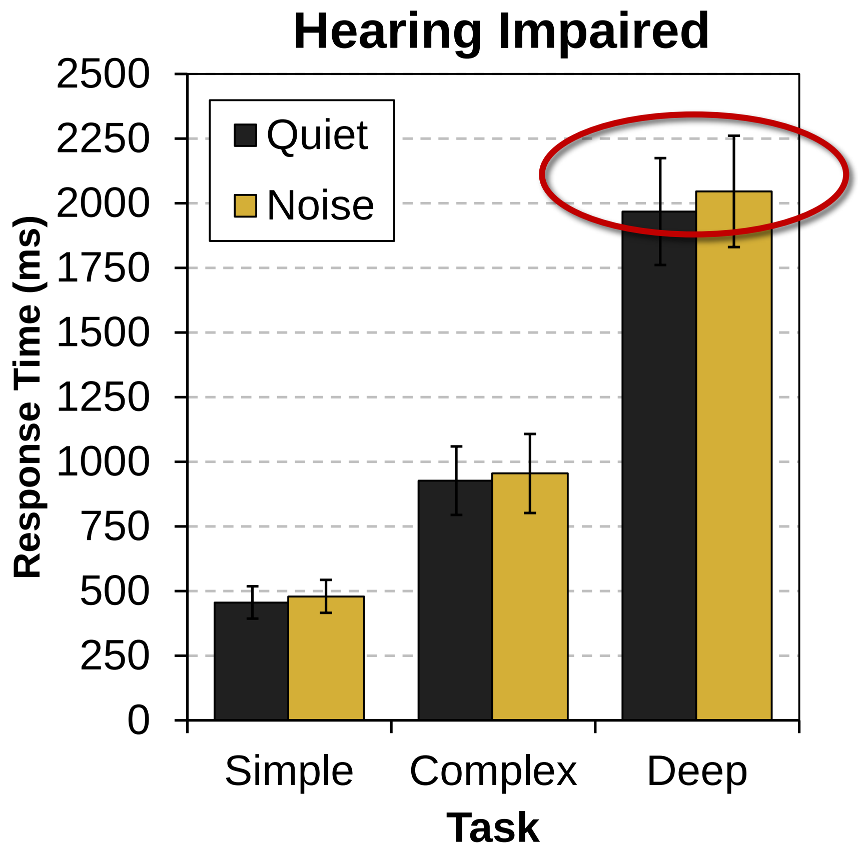
Word Recognition Performance



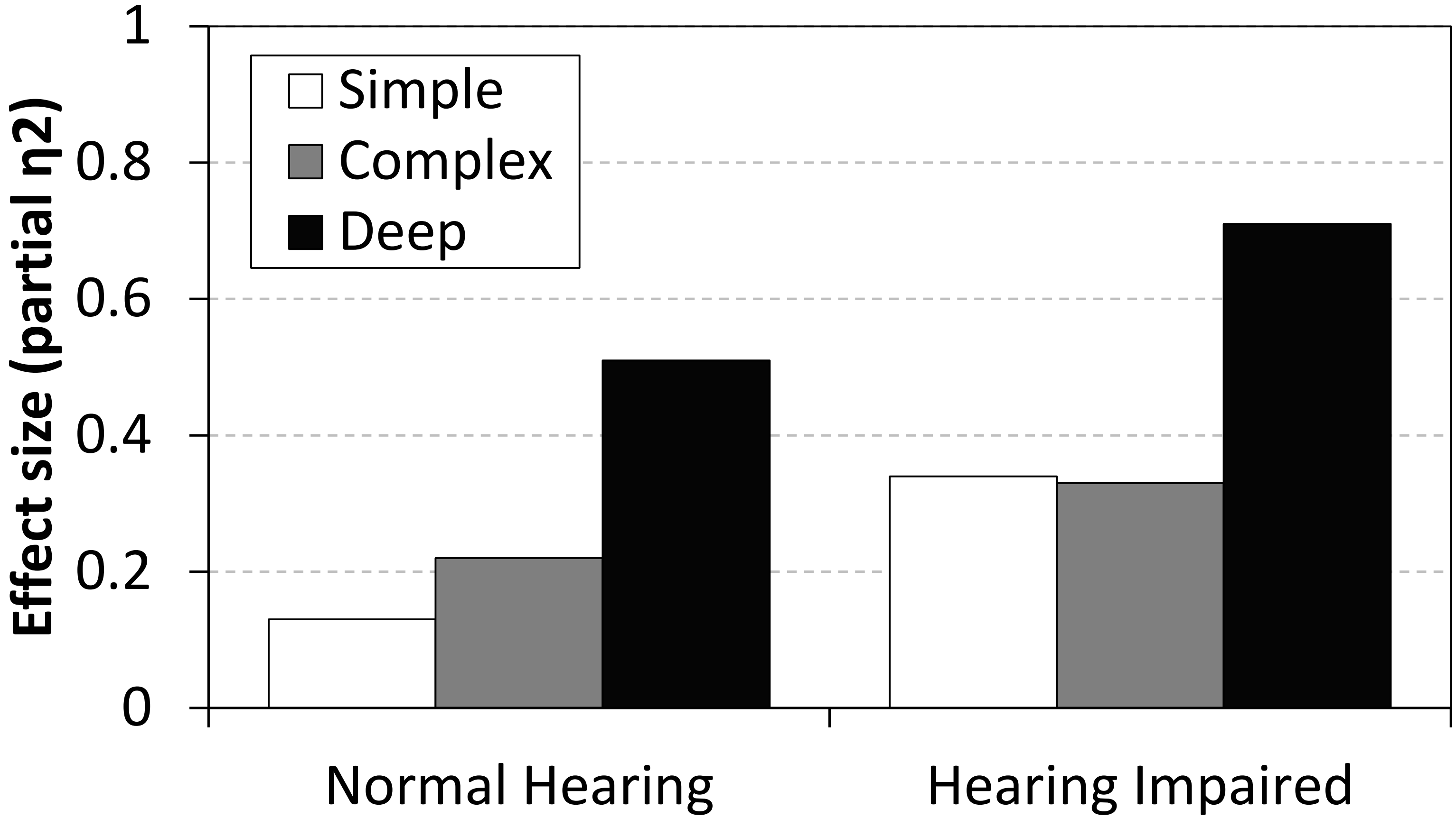
Data from Picou & Ricketts (2014) *Ear Hear, 35,* 611-622

Response Times



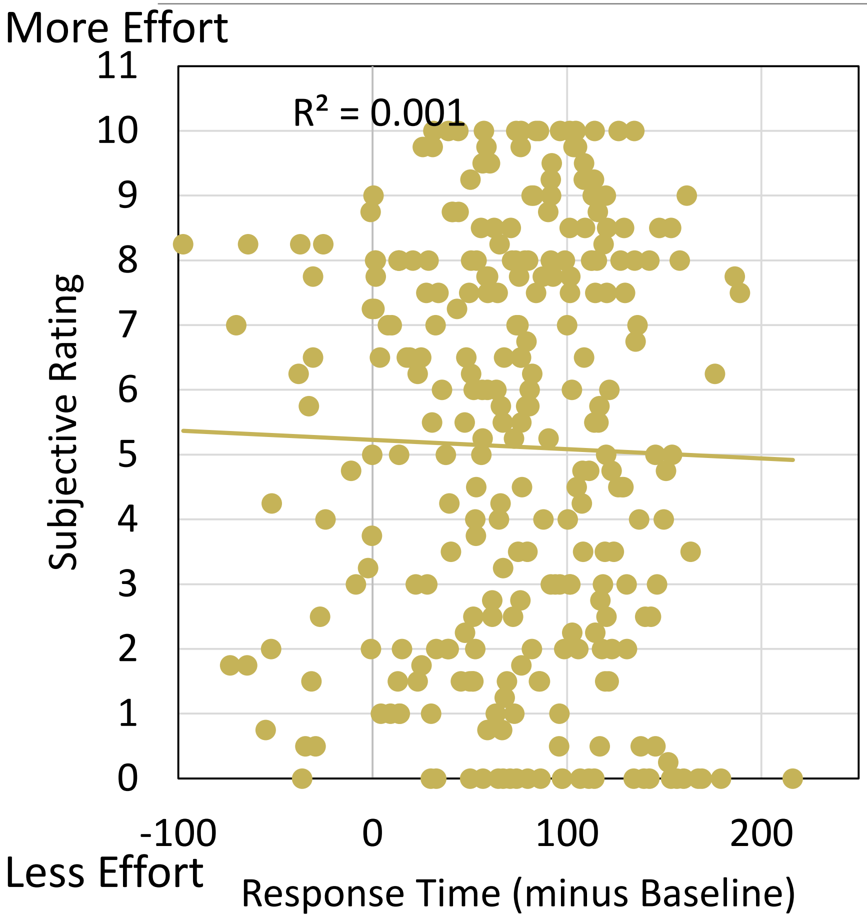


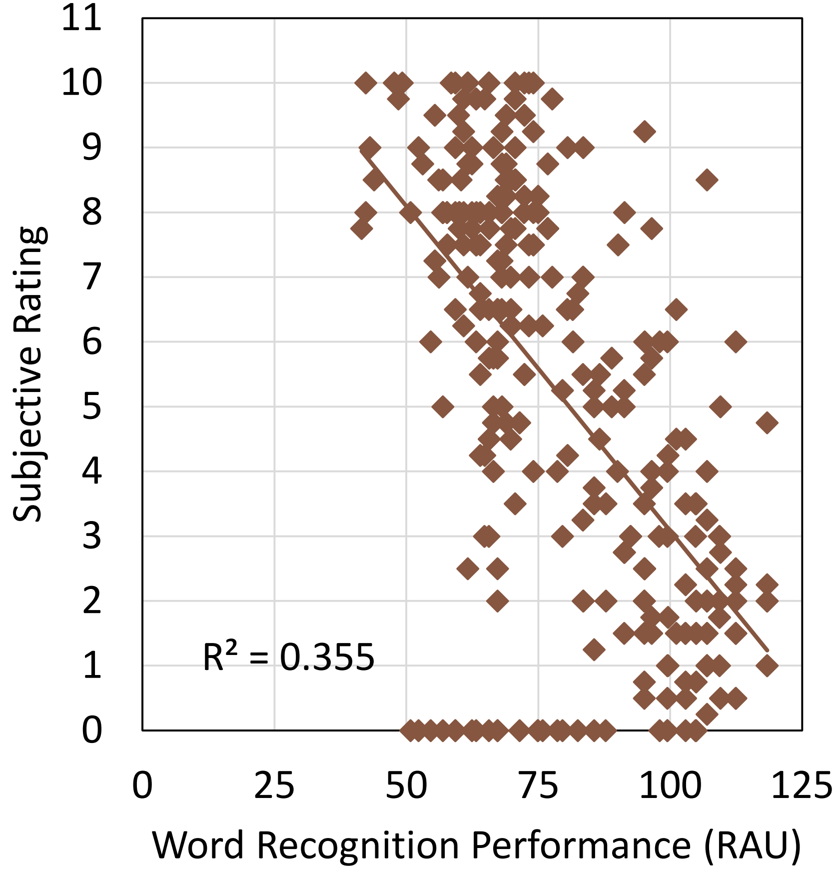
Effect Size



Data from Picou & Ricketts (2014) *Ear Hear, 35,* 611-622

Subjective Ratings: How much effort did you put in to hear what was said?





Is there anything we can do to get participants to answer about "effort"?

How hard did you have to work? Remember, this is different than how many words you got right.

Very hard — Not at all hard

0 5 10

How tired of listening do you feel?

Very tired — Not at all tired

0 5 10

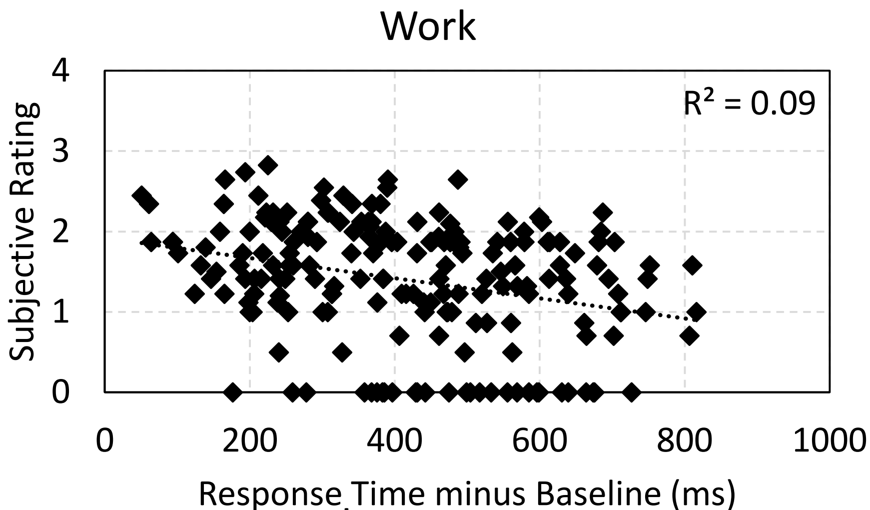
How likely are you to do something to improve the situation? For example, as the talker to speak up or move to a quiet room?

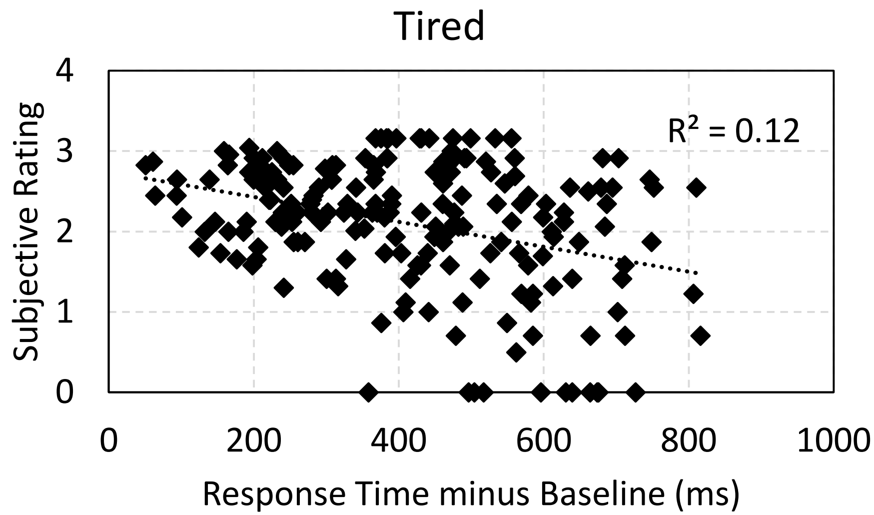
Very likely — Not at all likely

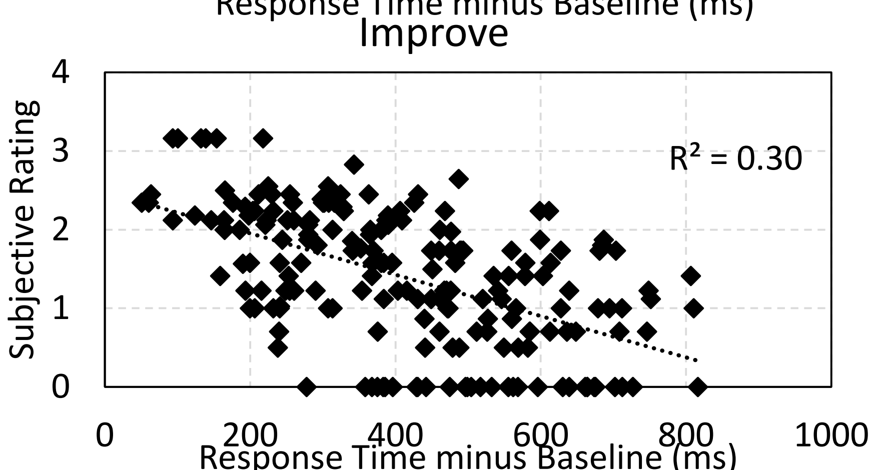
0 5 10

Picou, Moore, & Ricketts (2017) *J Speech Lang Hear Res, 60, 199 - 211*

Changing the wording can change the relationship between response times and subjective rating

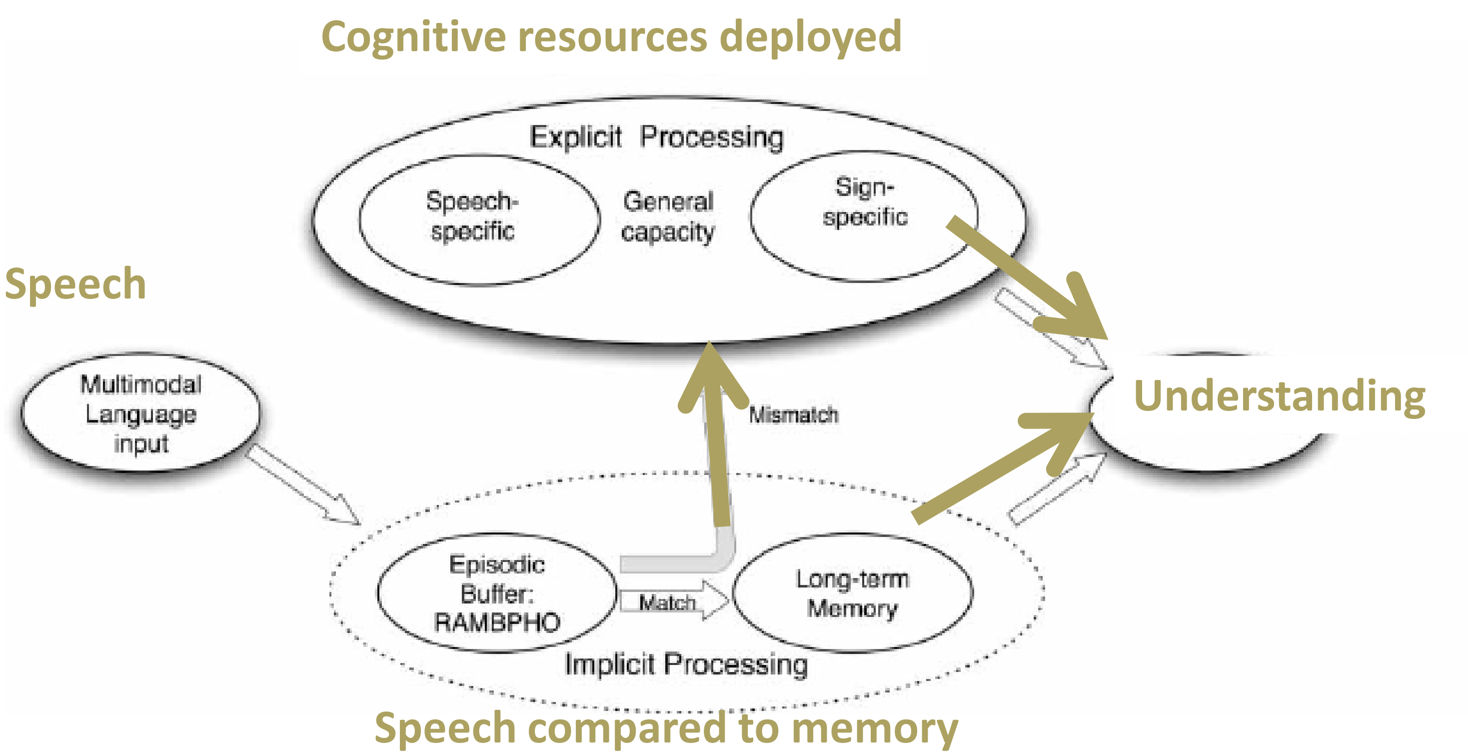






Picou, Moore, & Ricketts (2017) *JSLHR, 60, 199 - 211*

Modeling Effort



Ease of Language Understanding Model

Rönnberg (2003) *IJA, 42*, 68-76 / Rönnberg et al. (2008), *IJA, 47,* S99-S105

Factors Affecting Effort

Individual Factors

- Age
- Hearing loss
- Working memory capacity
- Verbal processing speed

Environmental Factors

- Background noise
- Visual cues
- Reverberation

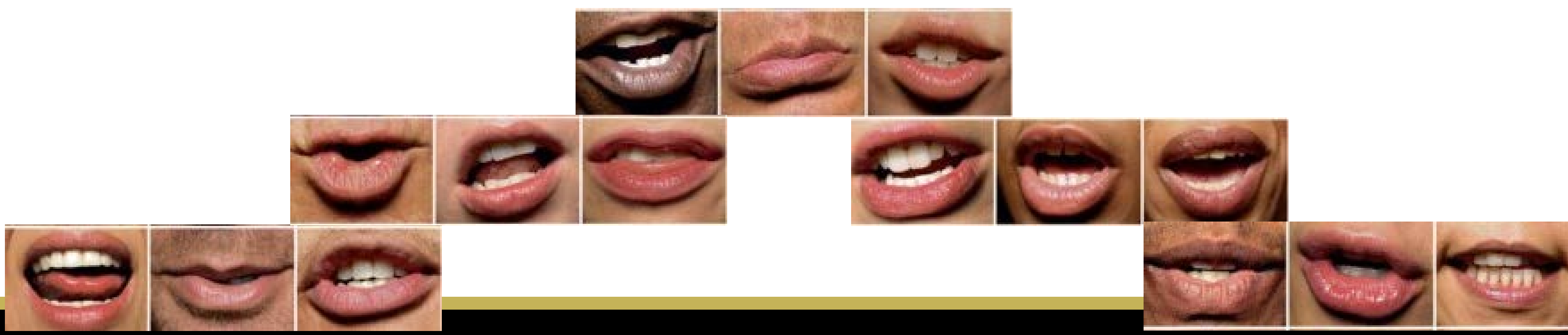
Background Noise

Background noise
- Increase effort

Visual Cues

Visual cues

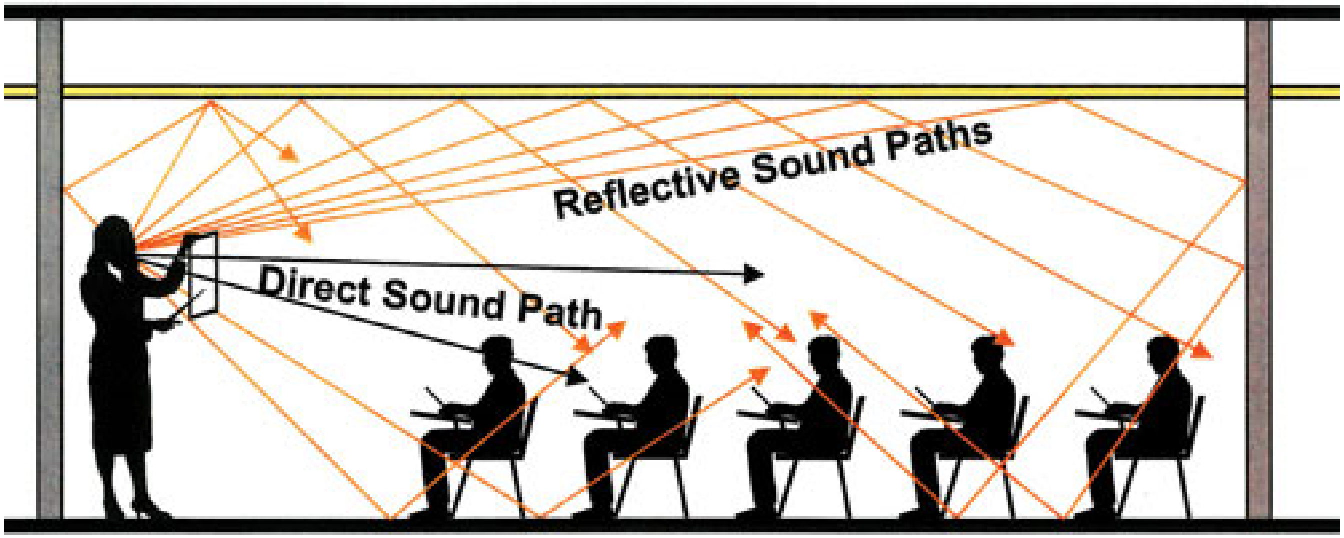
- Decrease effort if speech recognition improves
- Increase effort if speech recognition same
  - For all listeners (Fraser et al 2010)
  - For some listeners (Picou et al 2011)



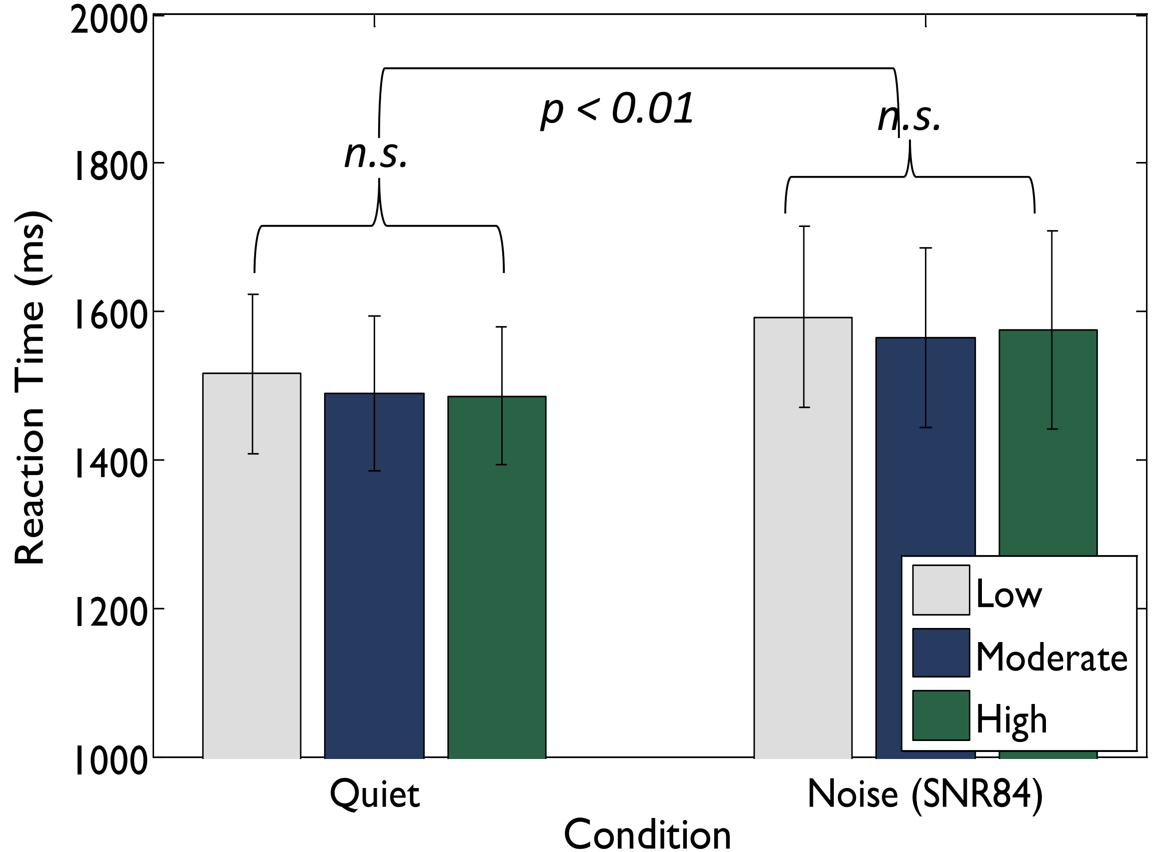
Reverberation

Reverberation

- Increase effort?



Reverberation (Normal Hearing)



Reverberation did NOT increase listening effort either when SNR or when WR was matched

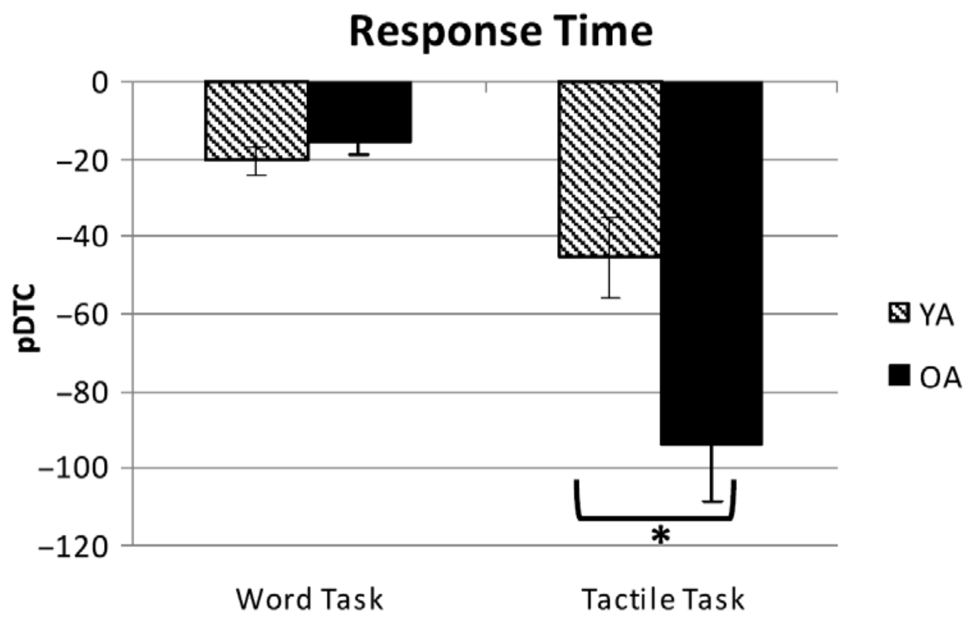
Age

2 groups of participants
- Young adults with NH
- Older adults with NH

Dual-task paradigm
- Sentence recognition
- Vibrotactile pattern recognition

Results suggest that age increases listening effort, even within population with normal hearing

Figure 3. Mean response times and standard errors plotted as pDTC by task (word task and tactile task) and age (YA depicted by striped bars; OA depicted by solid bars) for the equated level condition. Brackets and asterisks denote comparisons that were significant (*p = .011).



Hearing Loss

2 groups of participants

- Older adults with NH
- Older adults with HL

Running memory task

- Words presented in a string presented randomly; participant recalls the 3 most recent words

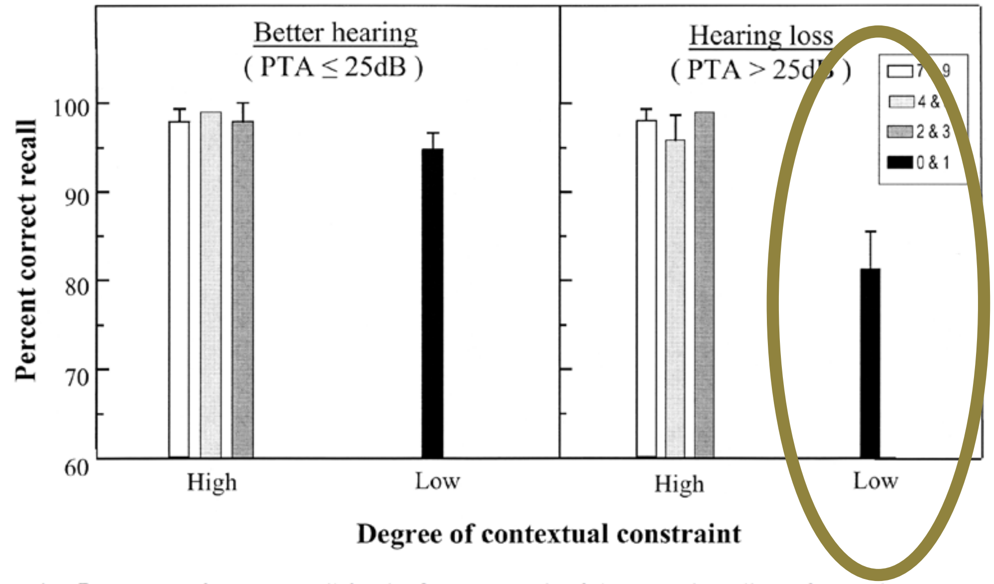


Figure 1. Percentage of correct recall for the first two words of three-word recall sets for word sequences with high contextual constraints (2nd-through 9th-order approximations to English) and low contextual constraints (0- and 1st-order approximations). Data are shown for better hearing participants (pure tone average, PTA, less than or equal to 25 dB HL; left panel) and for participants with hearing loss (PTA greater than 25 dB HL; right panel). Error bars represent one standard error. Error bars are absent where they were too small to plot.

Results indicate that, with limited context, hearing loss increased listening effort

Working Memory Capacity

Definition

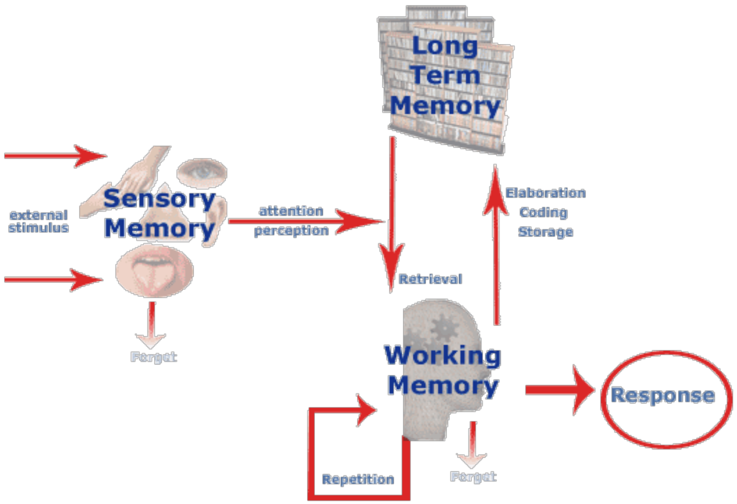
- Mental resources available for storage and processing of information

Relationships with other variables

- Age ("old" versus "young")
- Hearing loss (?)
- Speech recognition in noise

Measurement tool

- Automated Operation Span Task (AOSPAN)



Verbal Processing Speed

Definition

- The time it takes a listener to recognize familiar language information

Relationships with other variables

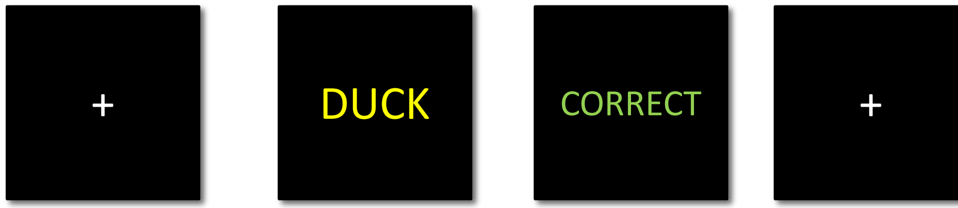
- Age
- Speech recognition in noise

Measurement tools

- Lexical decision task

Lexical Decision Task

“WORD” Trial

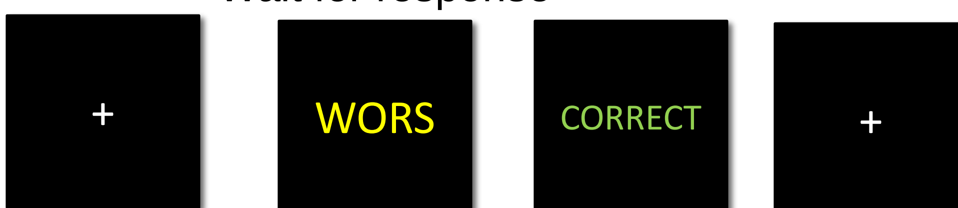


Wait for response

Feedback

“NON-WORD” Trial

Wait for response



Clinical Implications

Patients who might experience more effort generally

- Older adults
- Patients with hearing loss
- Smaller working memory capacity
- Slower verbal processing

Patients may feel more tired when

- Background noise is present
- Visual cues are unavailable
- In reverberation (?)

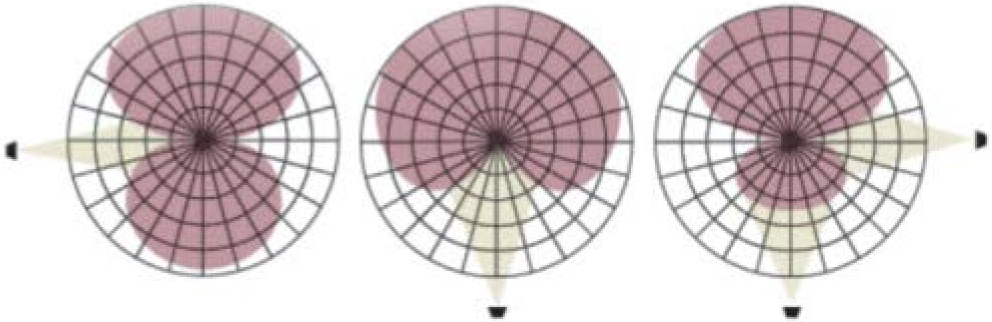
What can we do to *improve* listening effort?

Hearing Aids & Listening Effort

Hearing Aids

Digital Noise Reduction

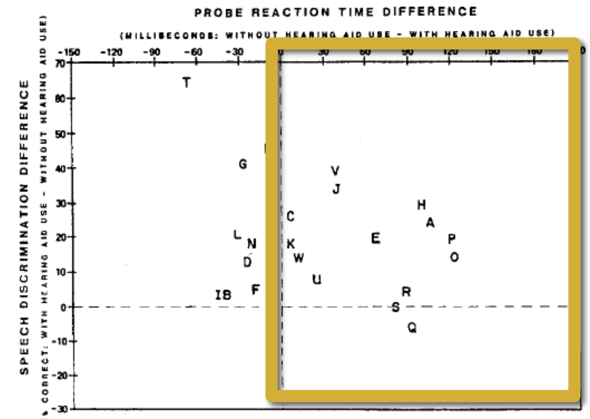
Directional Microphones

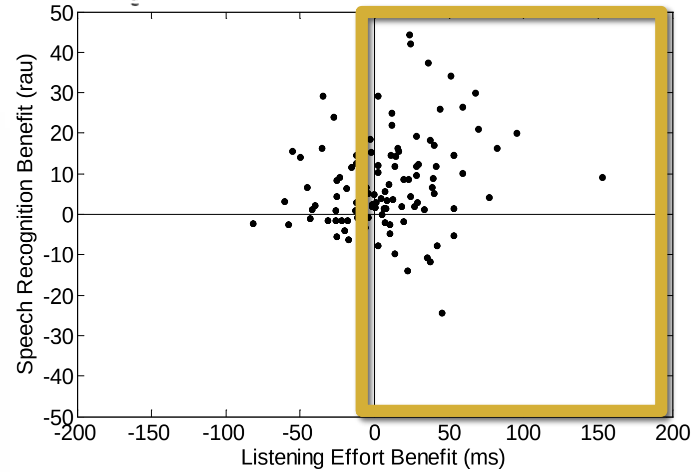


Hearing Aids

Downs (1982) *JSHD,* 189 - 193

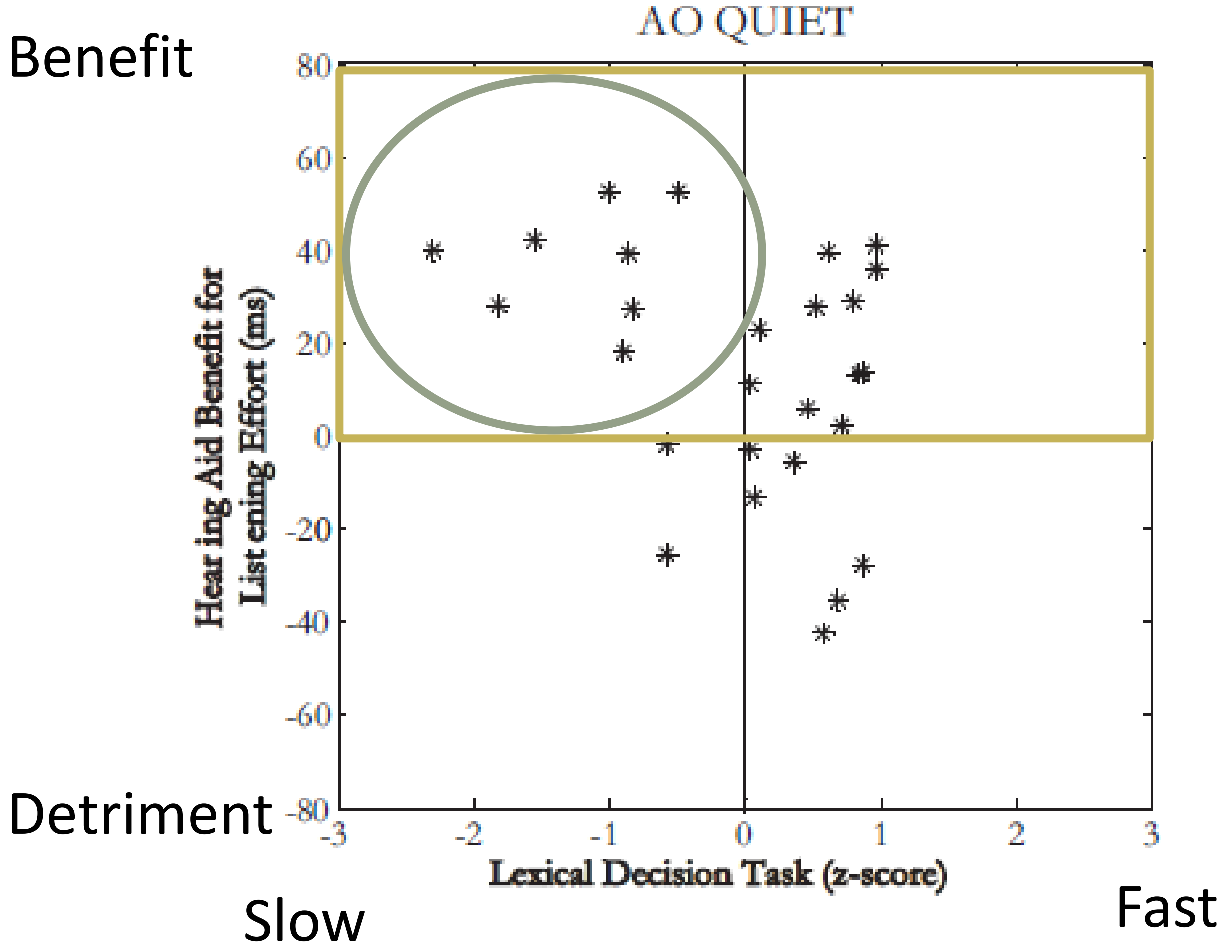
Reduce effort for many





Picou et al (2013) *Ear Hear, 34,* e52 - 64

HA Benefit
& Verbal Processing Speed



Picou et al (2013) *Ear Hear, 34,* e52 - 64

Model Predictions

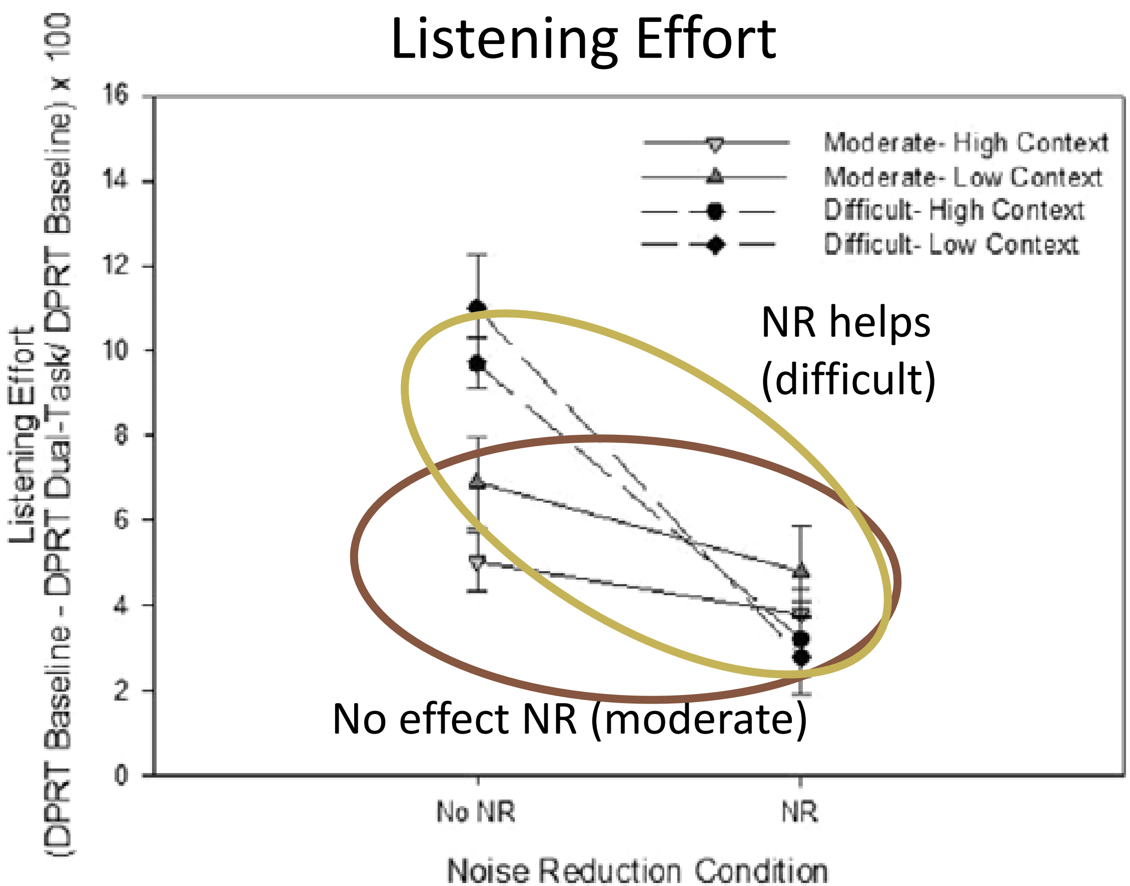
Digital noise reduction

- Reduce effort (?)

Microphone technology

- Reduce effort (?)

Noise Reduction & Listening Effort



Directional Technology & Listening Effort

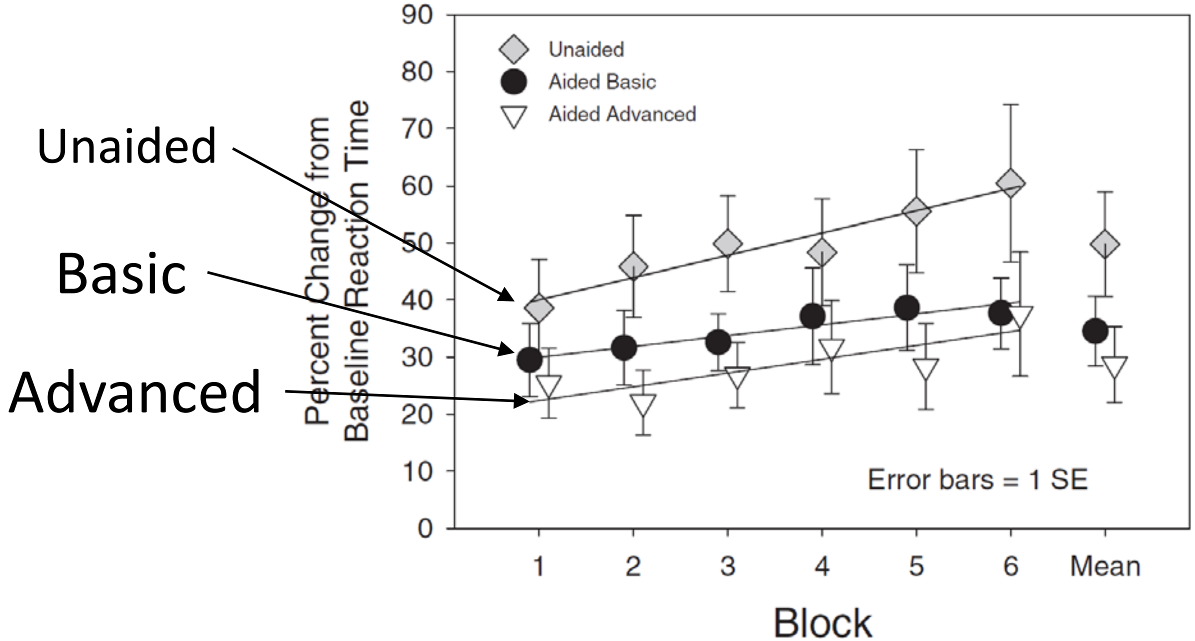


Fig. 5. Percent change from baseline reaction time as a function of block/time for each listening condition. Error bars = 1 SE. Solid lines show a best fit linear regression. "Mean" data show normalized RTs, averaged across all blocks, for each listening condition.

Directional Technology & Listening Effort

Participants

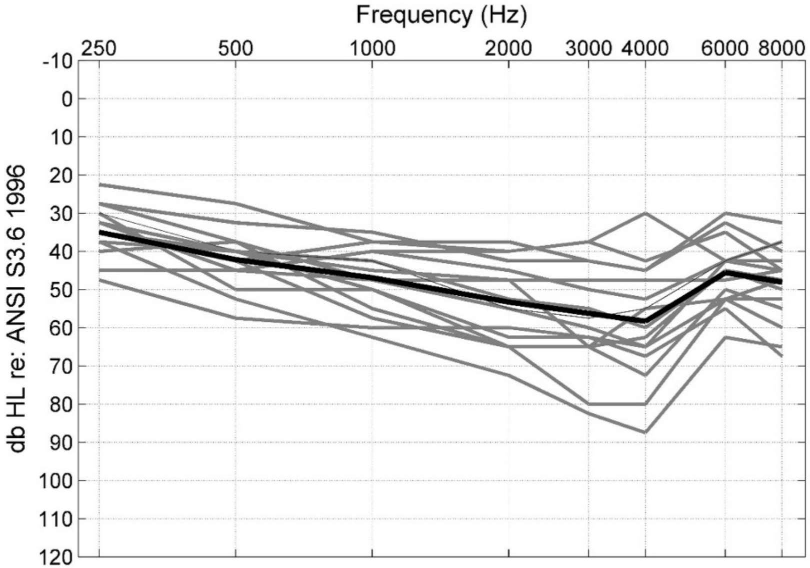
- 16 adults with bilateral sensorineural hearing loss

Materials

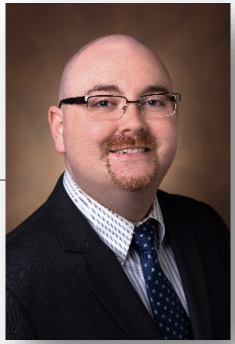
- Semantic dual-task paradigm

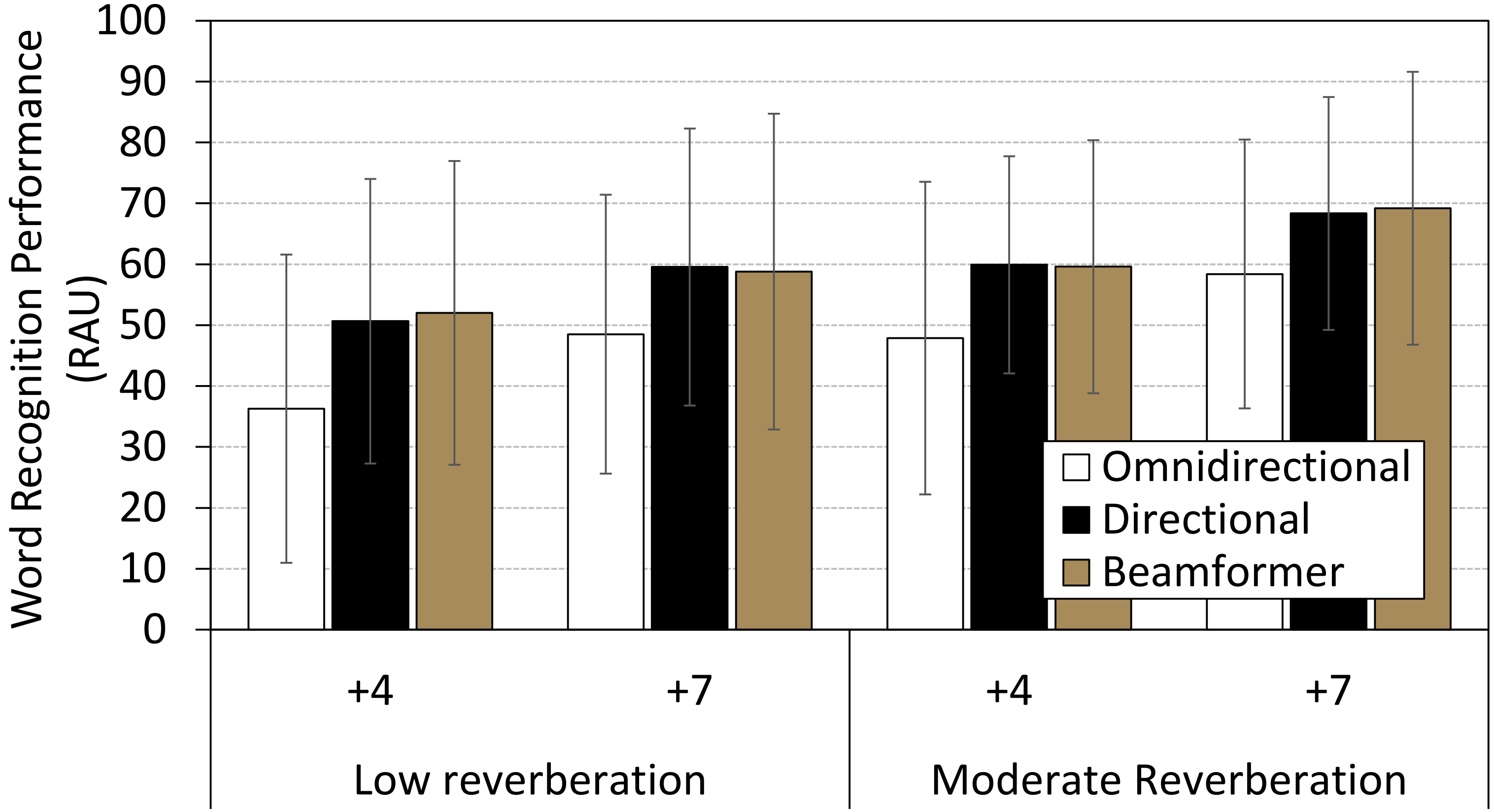
Conditions

- Test environments
  - Low and moderate reverberation
  - +4 and +7 dB SNR
- Hearing aid conditions
  - Omnidirectional
  - Adaptive directional
  - Fixed beamformer



Directional Technology & Listening Effort





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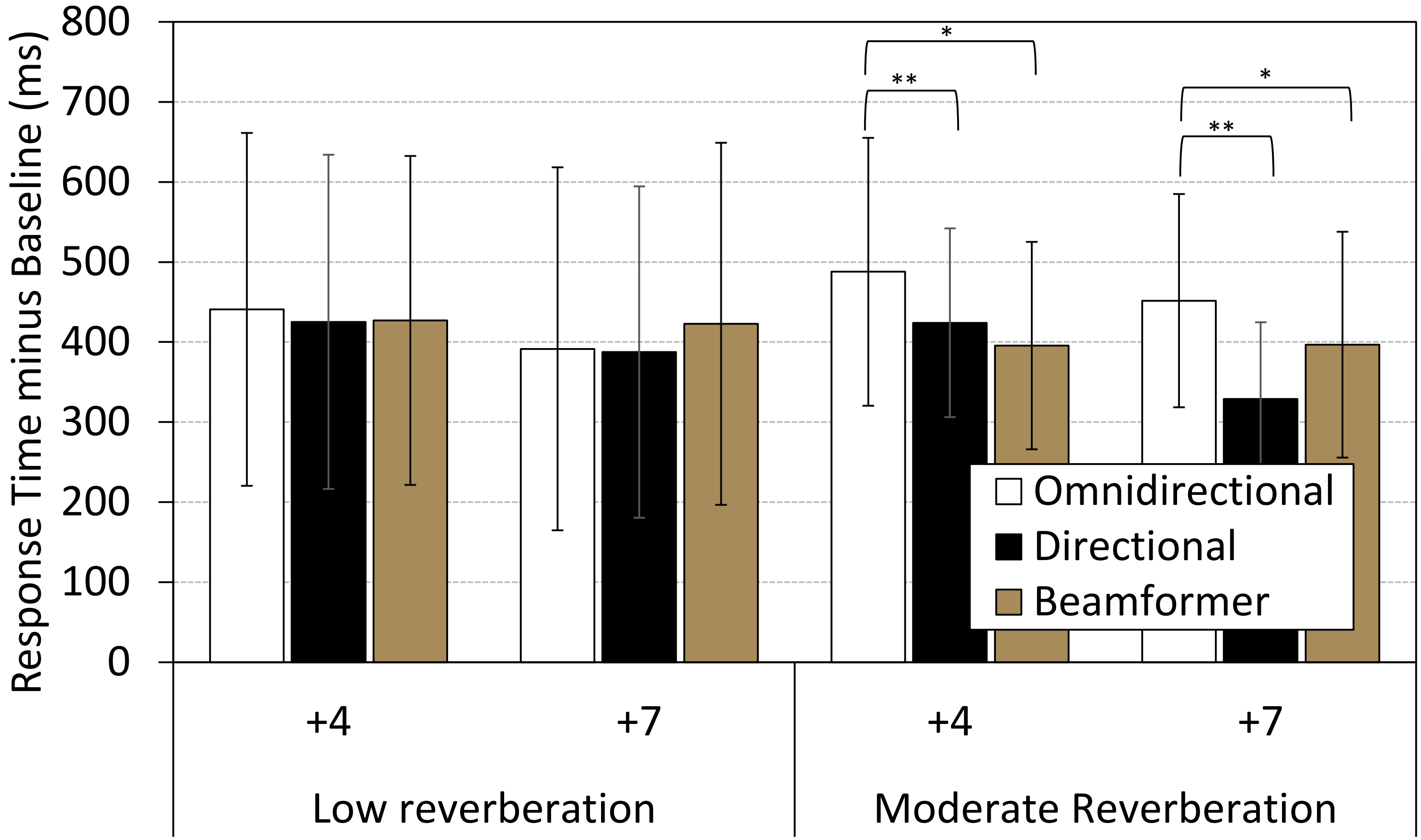
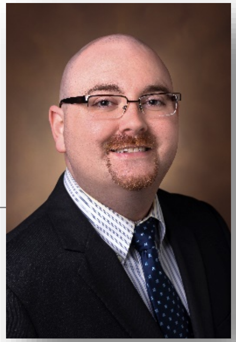
Directional Technology & Listening Effort

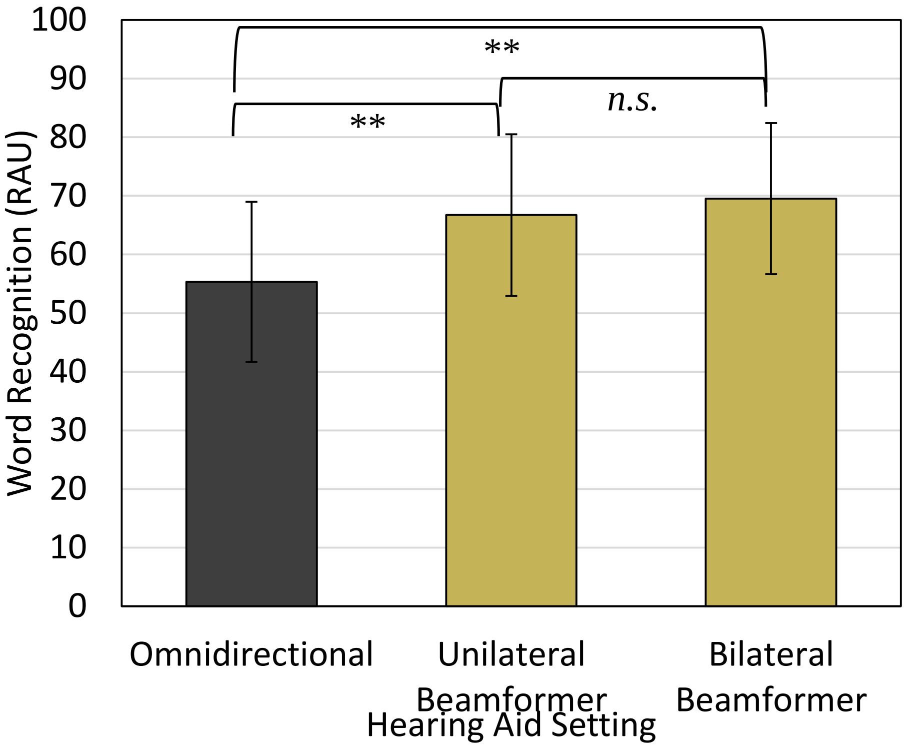




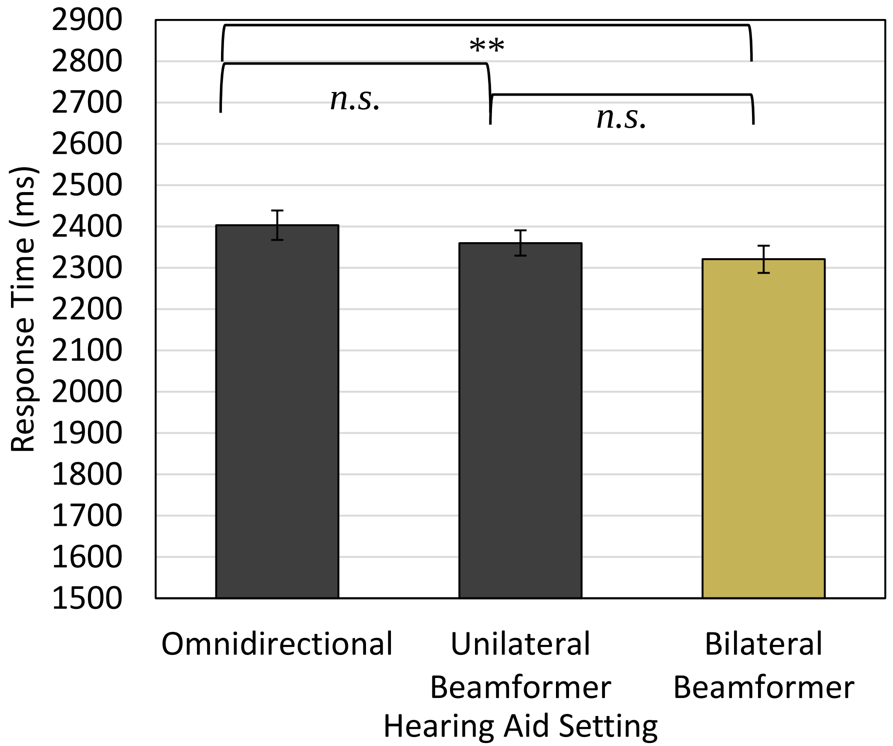
Picou, Moore, & Ricketts (2017) *JSLHR, 199 - 211*

Follow up Study Confirms Subjective Ratings

WORD RECOGNITION

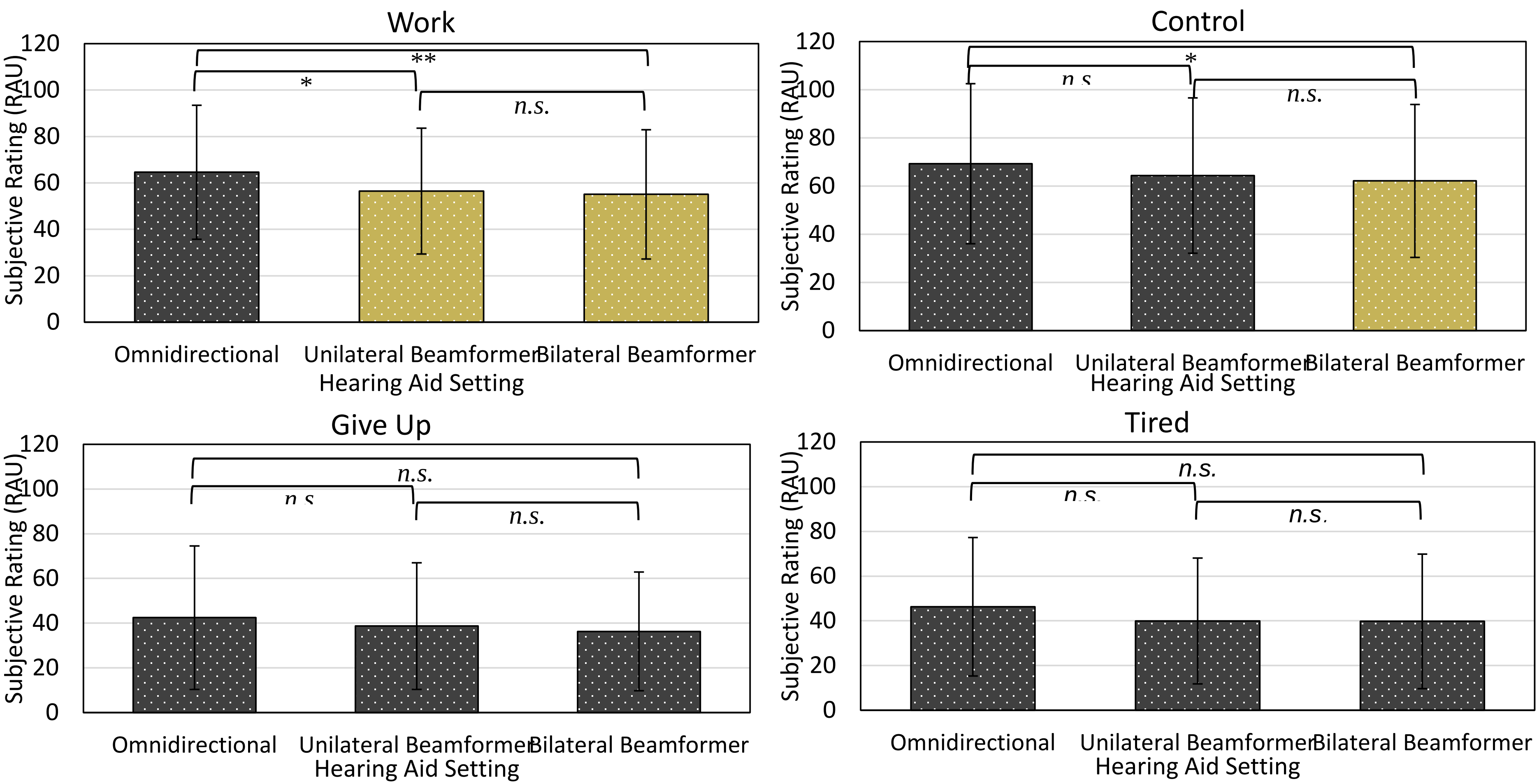


LISTENING EFFORT



Picou & Ricketts (in progress)

Asking about someone's desire to improve the situation gives us the same answer as the RTs

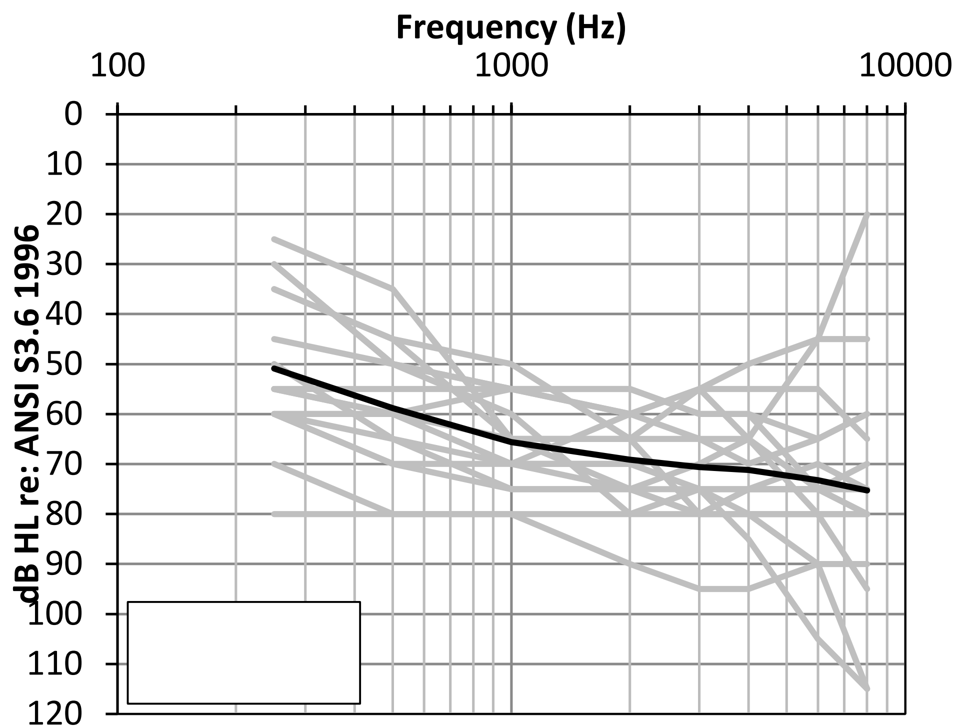


What about listeners with more severe hearing loss?

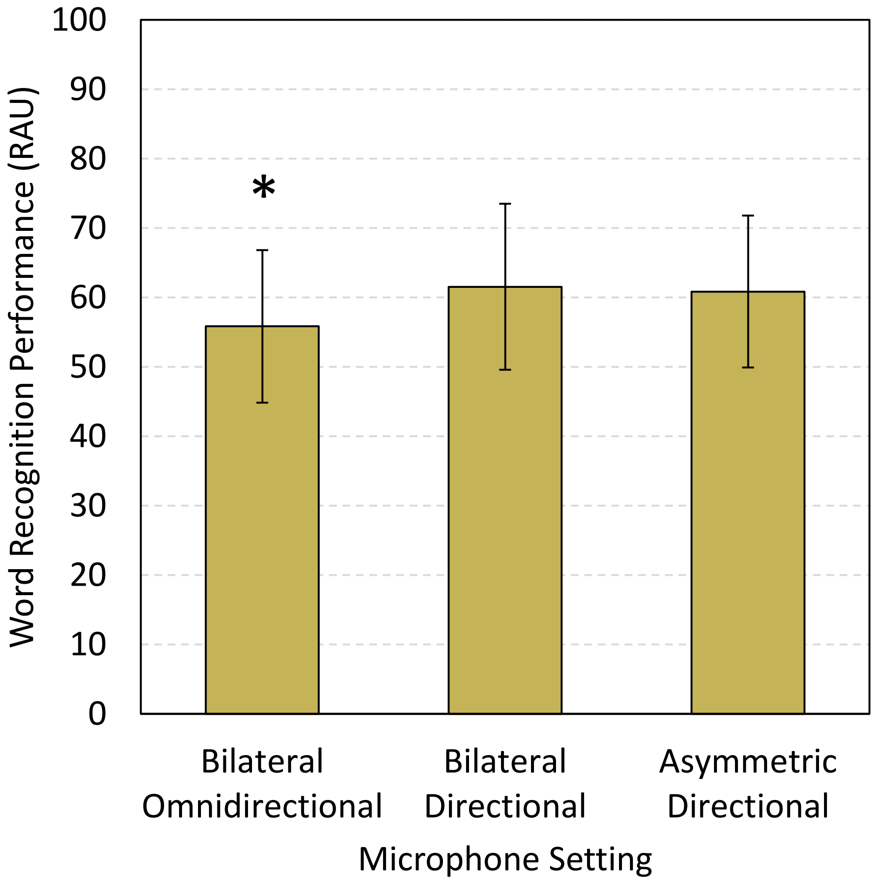
Eighteen adults with symmetrical, sensorineural hearing loss

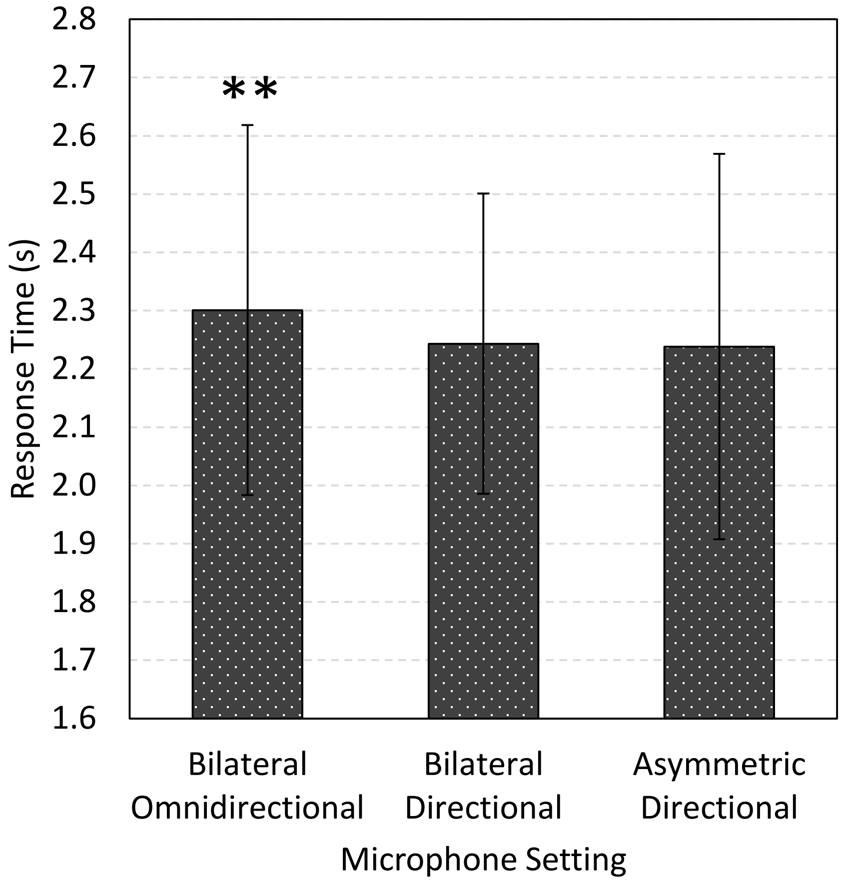
Fit with research hearing aids
- Bilateral omnidirectional
- Bilateral directional
- Asymmetric directionality

Evaluated on
- Listening effort (dual task)
- Sentence recognition
- Localization / memory

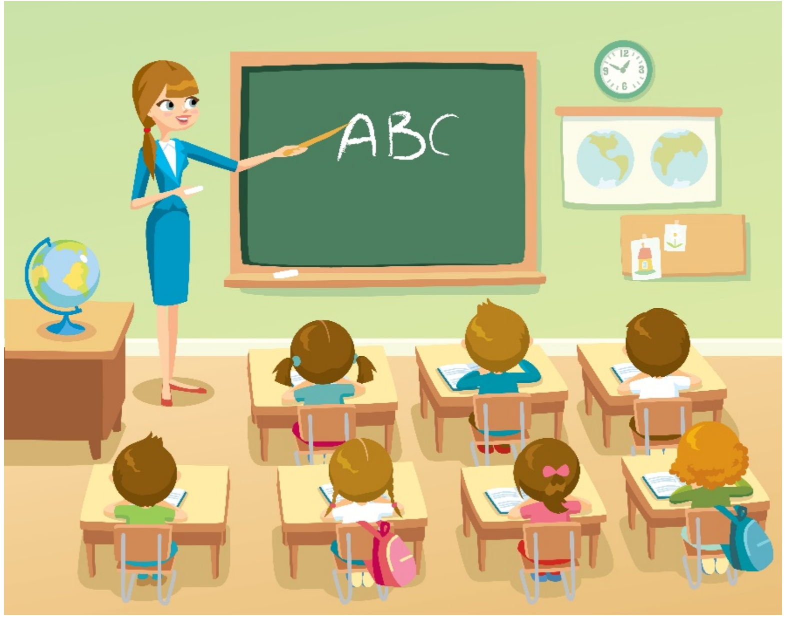


Listeners with severe hearing loss exhibit directional benefit for listening effort





School-Aged Children



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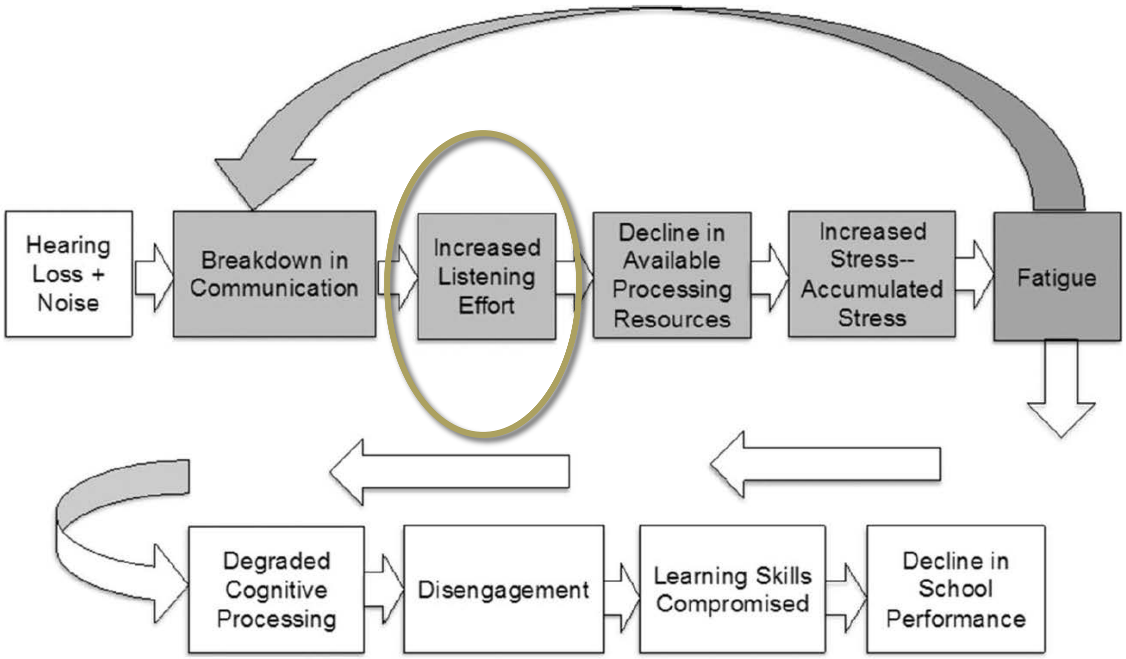
Listening Effort in Classrooms

Implications of increased effort may be even greater for children than adults

- Content acquisition
- Language development
- Incidental learning
- Social development
- Time on task

Implications of Sustained Effort for Students

Figure 1. Conceptual Model Linking Hearing Loss to Fatigue and School Performance. Shaded areas represent events that occur repeatedly throughout the school day.



Effort in Kids: Dual-Task Paradigms

Participants

- 17 young adults with normal hearing
- 17 school-aged children with normal hearing

Materials

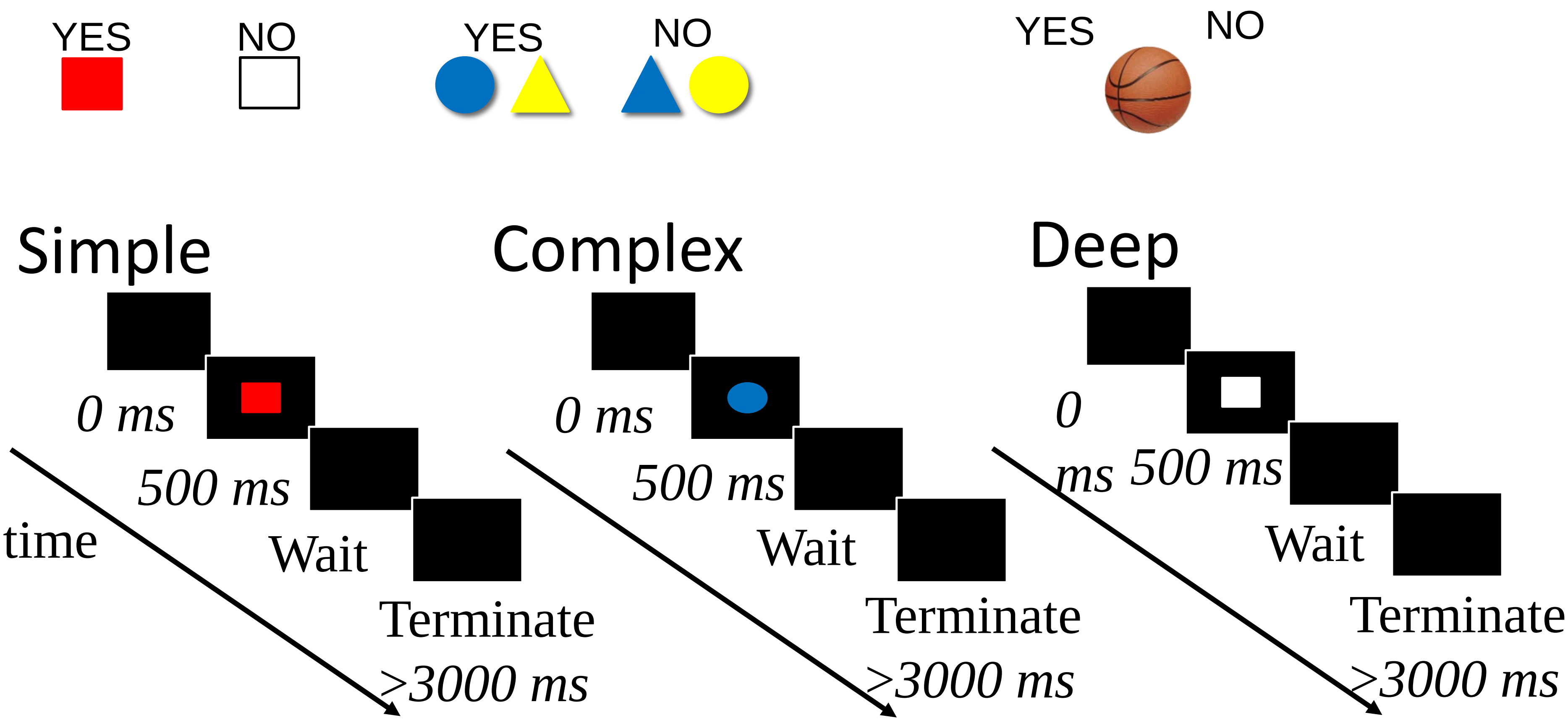
- Monosyllable word recognition
- Physical response time

Conditions

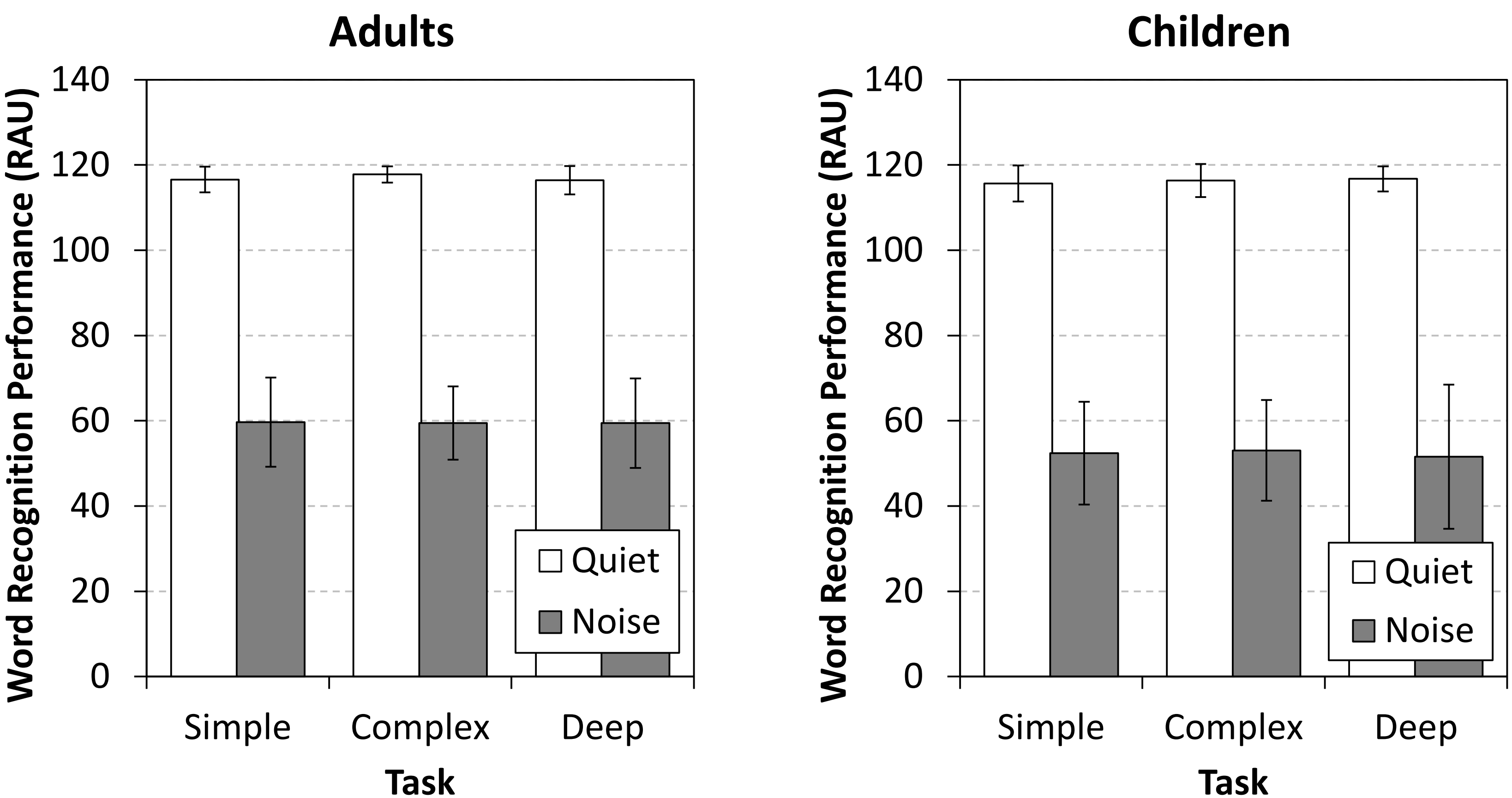
- Quiet or Noise

Picou, Charles, & Ricketts (2017) *Am J Audiol, 26,* 143-154

Dual-Task Paradigms



Word Recognition Performance



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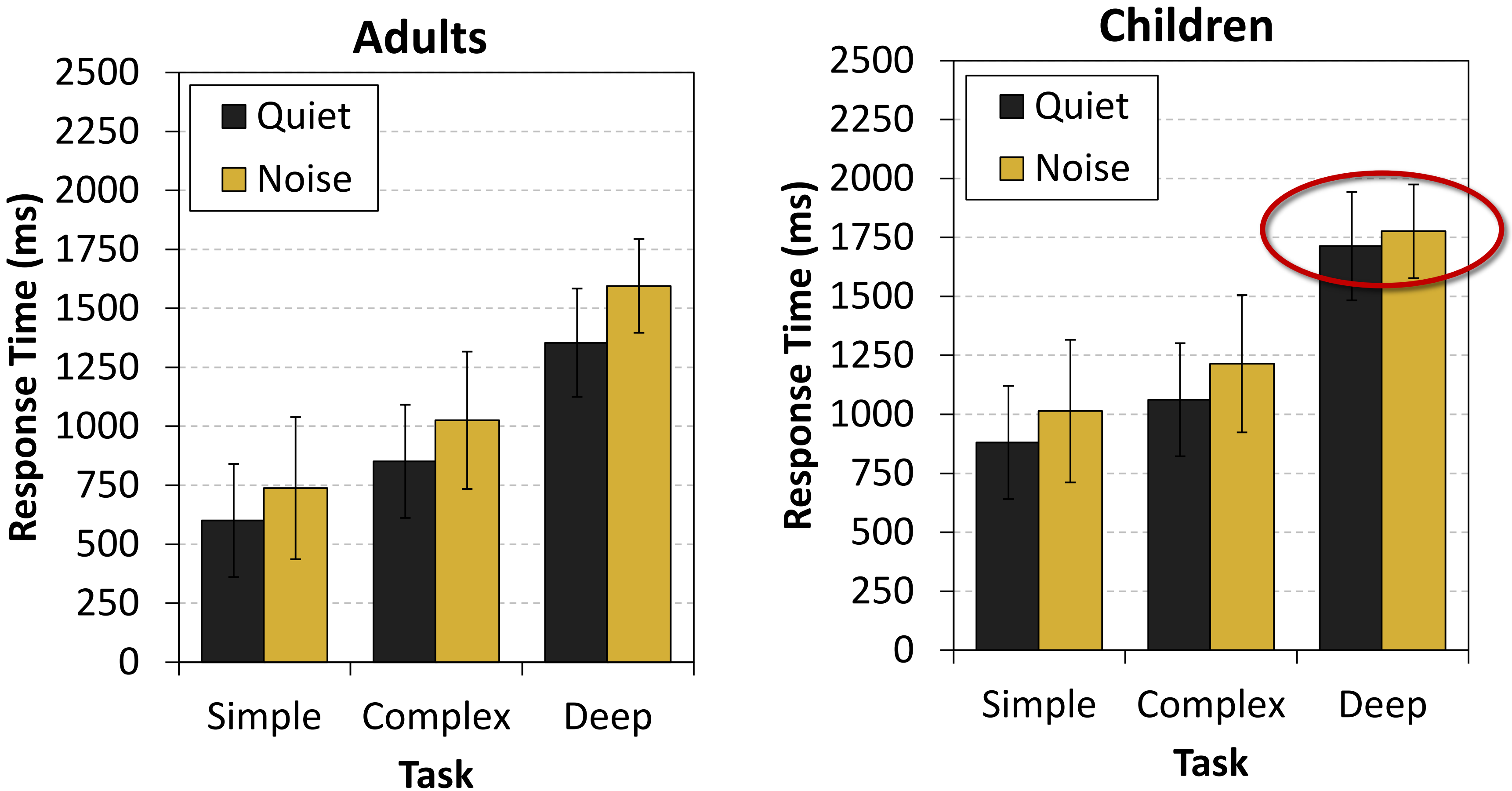
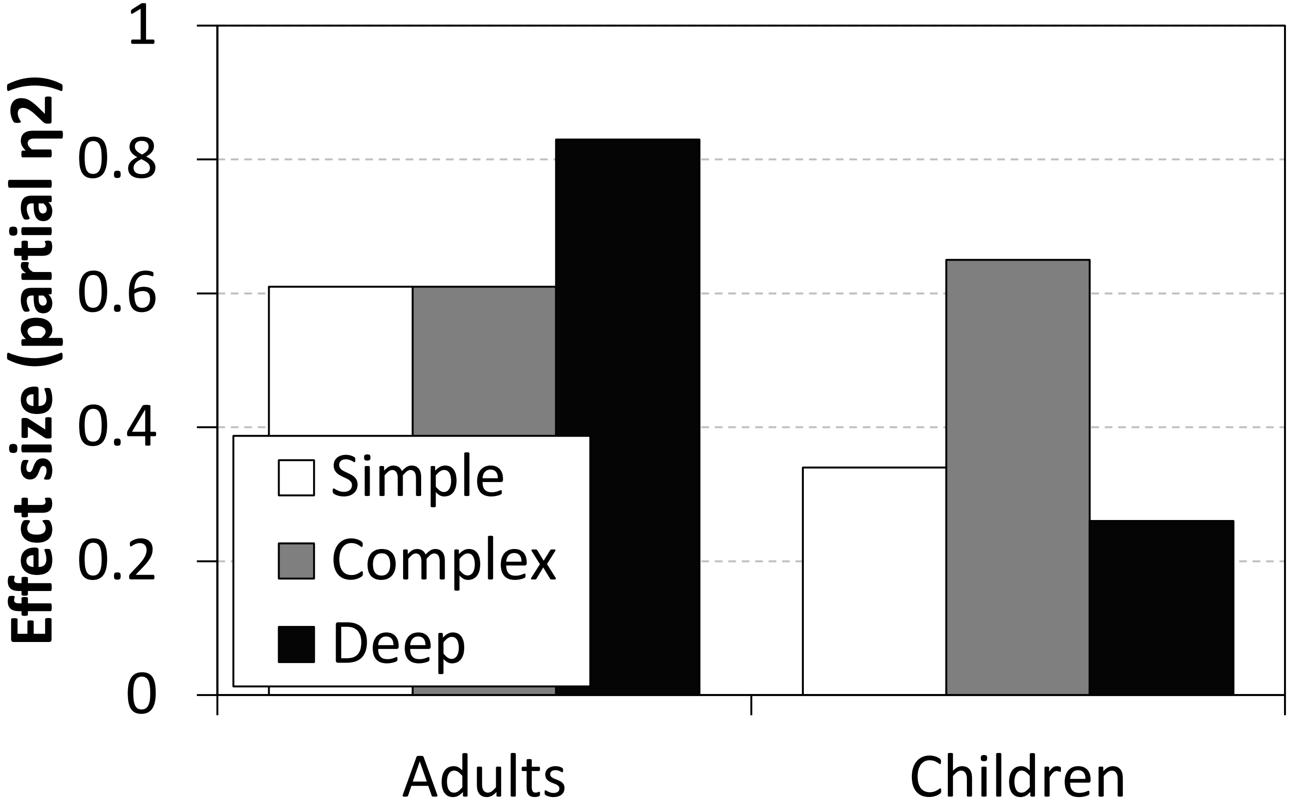
Response Times

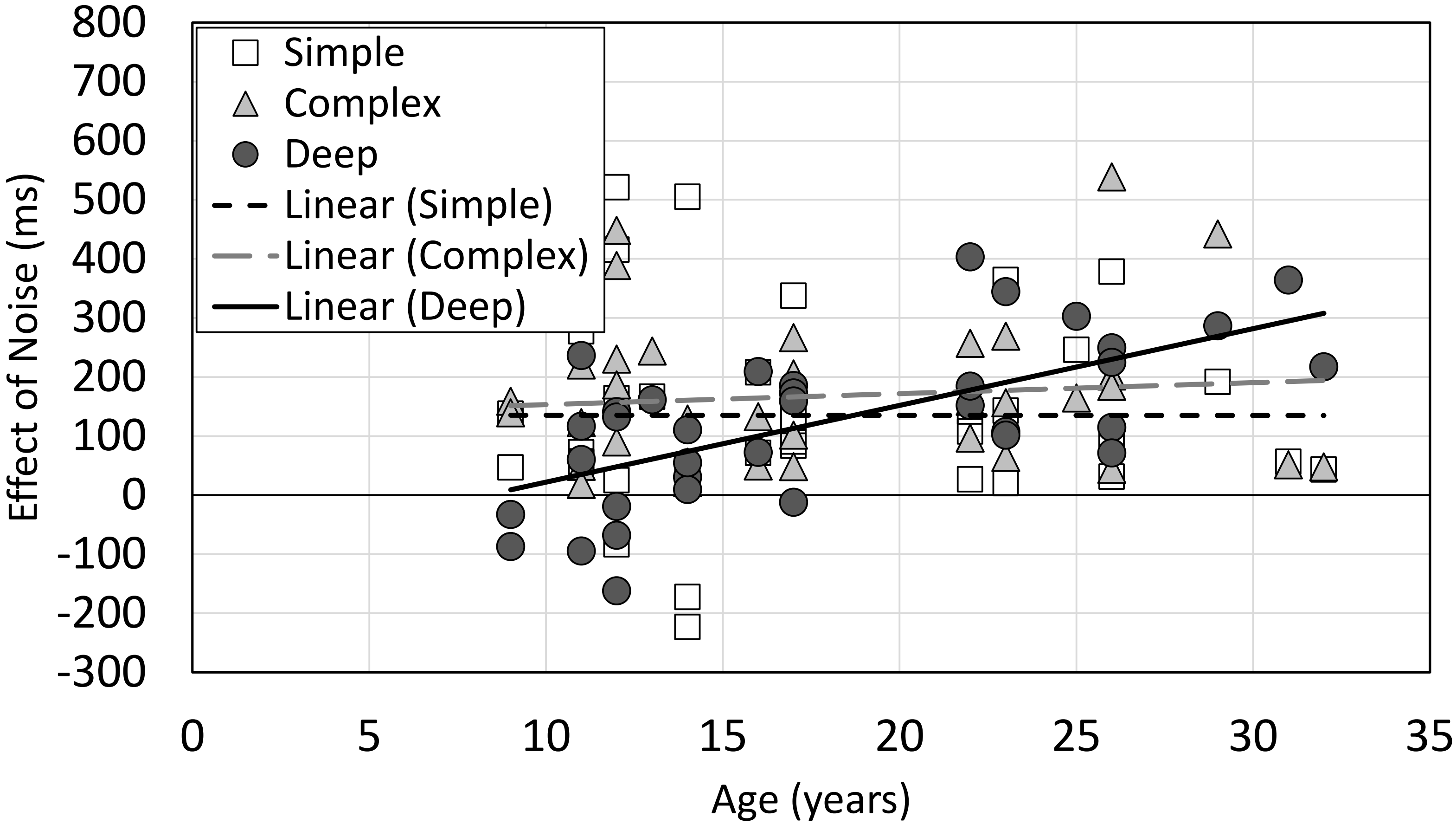


Picou, Charles, & Ricketts (2017) *Am J Audiol, 26,* 143-154

Effect Size


1
0.8
0.6
0.4
0.2
0
Effect size (partial η2)
Simple
Complex
Deep
Adults
Children

Dual-Task Paradigms: Effects of Age



Can Hearing Aid Microphone Technology Make Listening in the Classroom Easier?

Methods

Participants

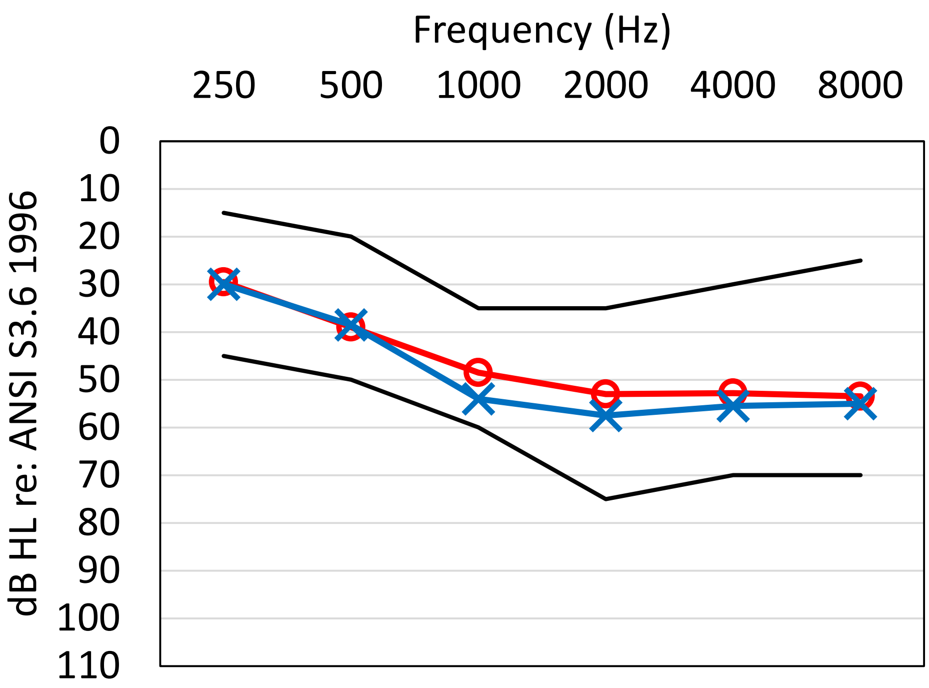
- 20 school-aged children with bilateral hearing loss

Materials

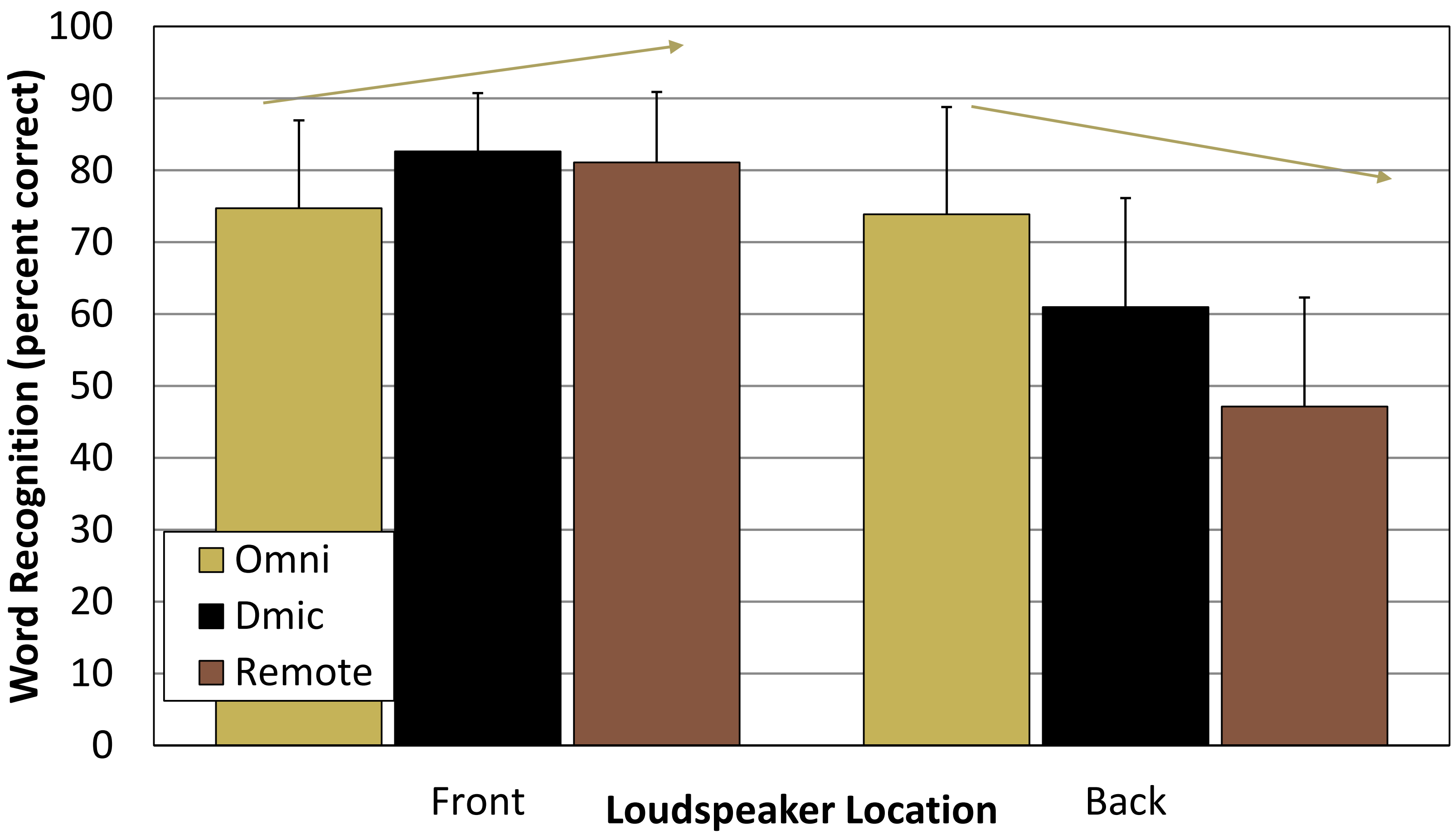
- Complex dual-task paradigm

Conditions

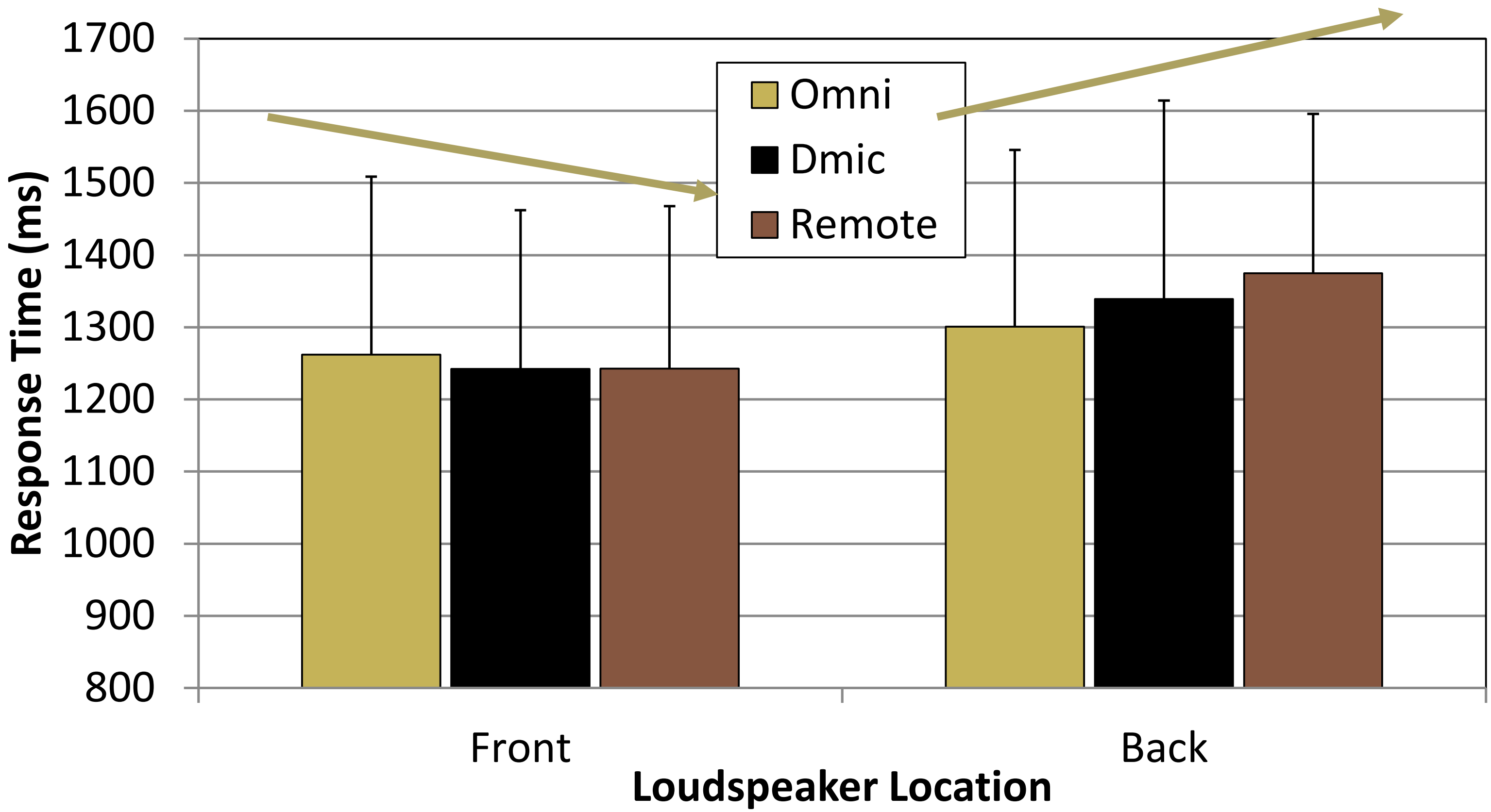
- Speaker location
  - Front
  - Back
- Hearing aid programs
  - Omnidirectional
  - Directional
  - FM + omnidirectional



Hearing aid microphone technology can improve speech recognition, but not if the talker is in the "wrong" place



Having the talker in the "wrong" place significantly hurts listening effort



Implications of Increased Effort for Students

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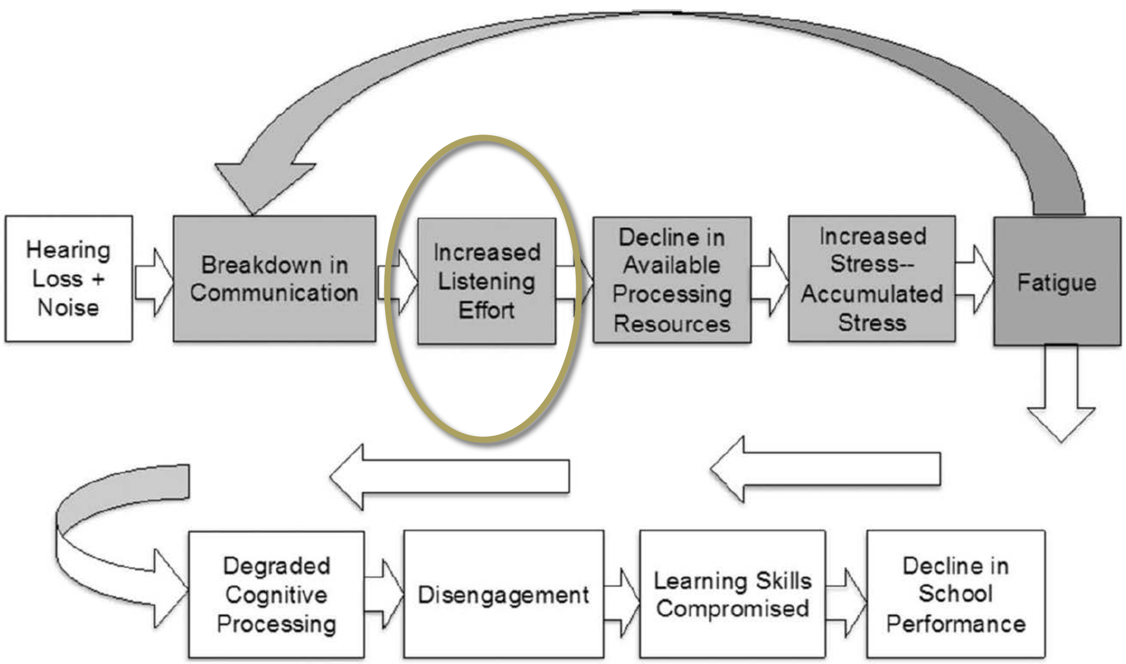
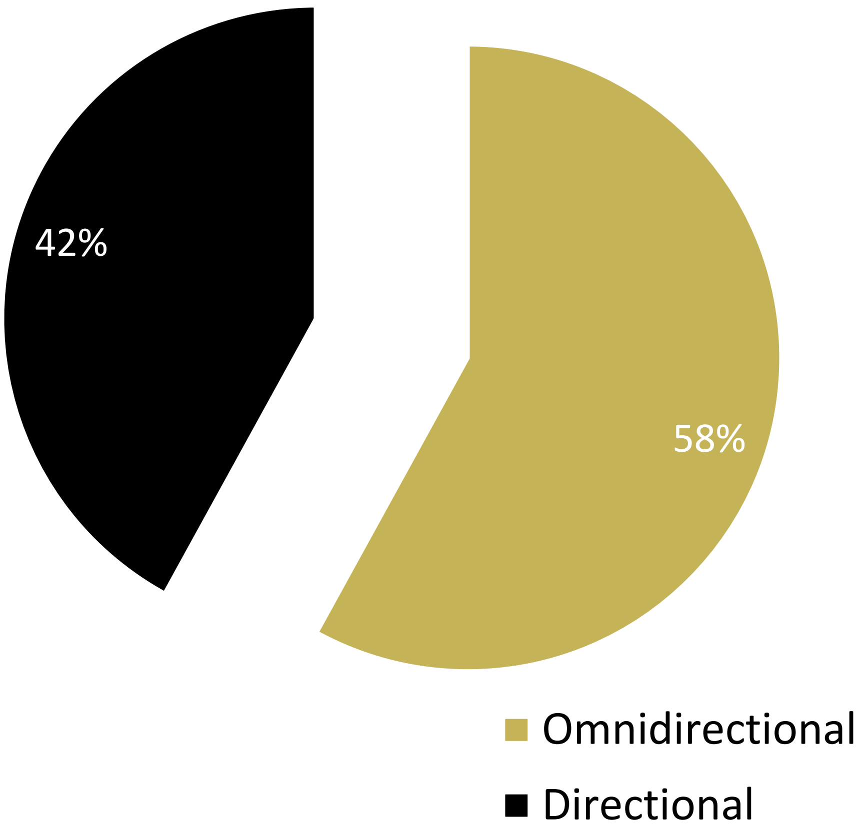


Bess & Hornsby (2014) *Perspect Hear Hear Disord Child, 24,* 25 - 39

How often is directional technology helpful in a *REAL* classroom?

Directional Technology: Evidence from Classroom



- Directional advantage expected 42% of the time
- More than the approximate 1/3 of the time for adults (Walden et al., 2004)
- Proportion depended on the specific child (8-70%)

Ricketts, Picou, & Galster (2017) *JSLHR, 60,* 263 - 275

How Should We Fit Directional Microphones for School-Aged Children?

What do you think? What do you do?

1) Never? Probably not

2) Full time bilateral? Probably not

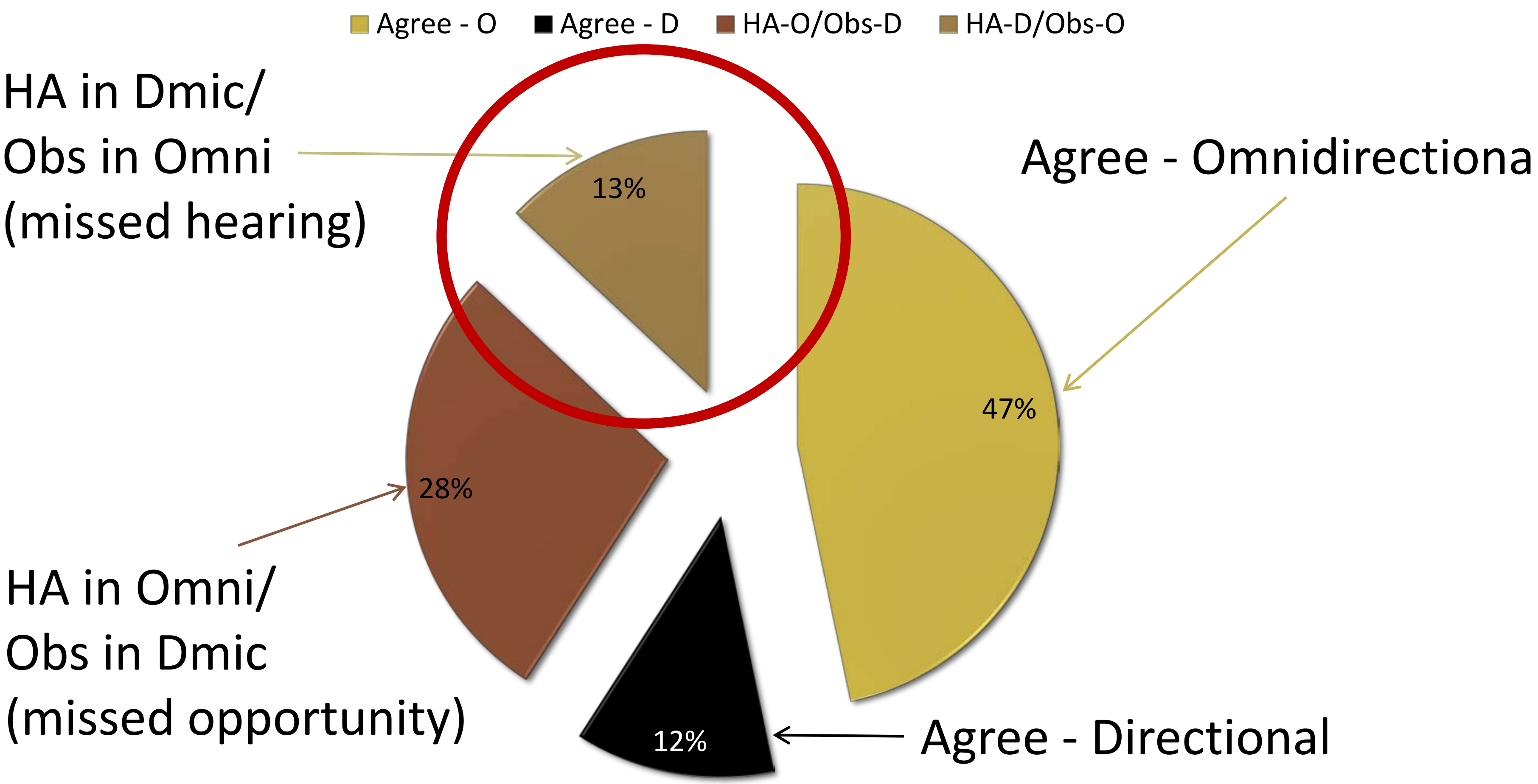
3) Manual switch? For specific patients

4) Full time asymmetric? Probably not

5) Automatic switch? Pretty good, but limited by intent

Ricketts, Picou, & Galster (2017) *JSLHR,* 263 - 275

Directional Technology: Automatic Classification



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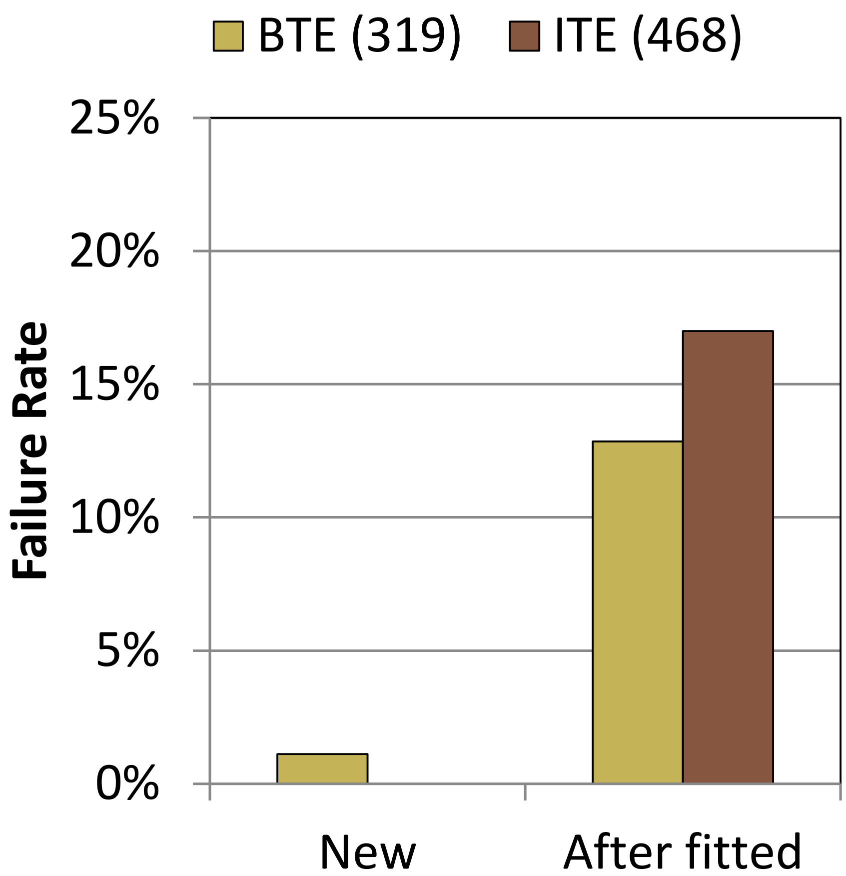
Okay, but do they *REALLY* work?

Directional Technology: Failure Rate

Clinically assessed directional function using probe microphone measurements on all instruments before fittings and after every two month trial.

VA sites in FL and TN

Highest failure rates were in July, August, and September



Directional Technology: Verification

Listening check

Speech recognition tests

Front-to-back ratio (FBR)

Test box techniques

Summary

Listening effort is a problem

Exacerbated by
- Background noise
- Lack of visual cues
- Hearing loss
- Cognitive abilities

Improved by
- Hearing aids
- Directional technologies
  - Adults – reverberation
  - School-aged children – talkers in front, NOT behind

Clinical Implications

Strategies to reduce effort

- Counsel on environmental modification
- Fit hearing aids
- Fit directional technologies
- Use automatic switching for (most) school-aged children
- Verify directional microphone function

Learner Outcomes

Upon completion, participants will be able to:

1) describe listening environments where hearing aid microphone technologies are expected to reduce listening effort for adults

Moderate reverberation with talker in the front

2) describe listening environments where hearing aid microphone technologies are expected to reduce listening effort for school-aged children

Moderate reverberation with talker in the front – definitely NOT with talker behind


Thank You!
Questions?