How Hearing Aids and Hearing Loss Affect Cognitive Ability

Brent Edwards, Ph.D.
Vice President, Research
Starkey Hearing Technologies

Can you hear me?

If you are having technical problems, please stay logged on and call Audiology Online at 1-800-753-2160

This session is available for 1/.1 CEU.

Must stay logged on for the full session.

Must successfully complete a short quiz.

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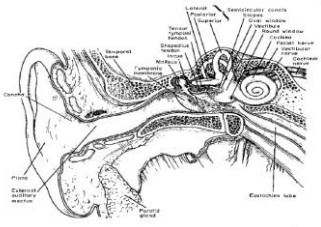
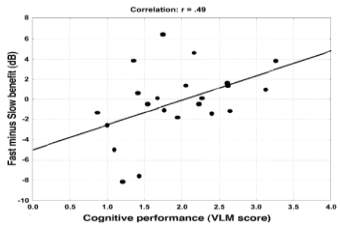


Top down Effect



Lunner and Sundewall-Thorén, 2007

THE QUARTERLY JOURNAL OF EXPERIMENTAL PSYCHOLOGY
2005, 58A (1), 22–33

Psychology Press
Taylor & Francis Group

Hearing loss and perceptual effort: Downstream effects on older adults' memory for speech

Sandra L. McCoy and Patricia A. Tun
Brandeis University, Waltham, MA, USA

L. Clarke Cox
Boston University, Boston, MA, USA

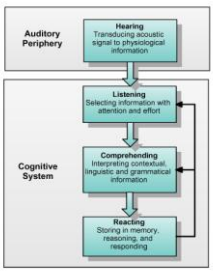
Marianne Colangelo, Raj A. Stewart, and Arthur Wingfield
Brandeis University, Waltham, MA, USA

- Distortion from auditory periphery can cause:
  - Increased cognitive load
  - Increased mental fatigue
  - Poorer memory
  - Poorer auditory scene analysis
  - Difficult focusing
  - Poorer mental health

How does hearing loss affect cognitive function?

How does hearing loss affect cognitive function?

How can hearing aids affect cognitive function?



Edwards, 2007

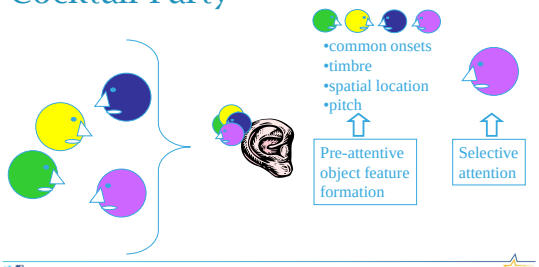
Auditory Scene Analysis

- What is Auditory Scene Analysis?
  - "the organization of sound scenes according to their inferred sources" (Bregman, 1990)
  - "Ability to know your environment and identify objects through sound" (Me, Now)

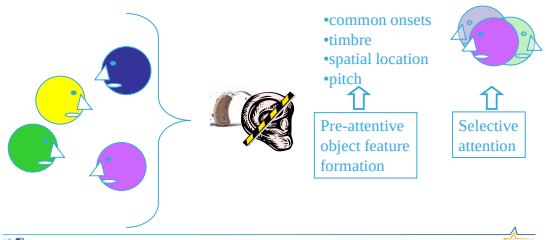
ASA Cues

- Harmonicity
- Common onsets/offsets
- Common modulations
- Spatial location
- Timbre

Cocktail Party



Cocktail Party



Research Goals

- Investigate effects of hearing loss and hearing aids on higher-order auditory perception
  - Need for new complex speech perception tests
    - Auditory scene analysis
    - Switching attention
  - Measure effect of hearing aids on cognitive function

PROJECT 1:
LISTENING EFFORT

Tassos Sarampalis, UC Berkeley
Erv Hafter, UC Berkeley
Sridhar Kalluri, Starkey Research

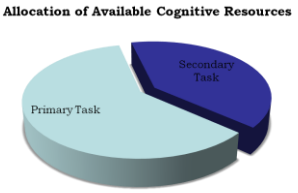
Research Goal

- Measure the effect of hearing aids on listening effort
- Look at Noise Reduction and Directionality
  - Do these features reduce listening effort?

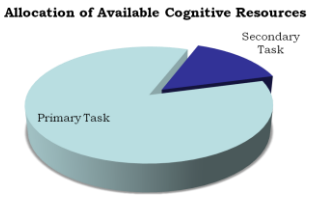
Method

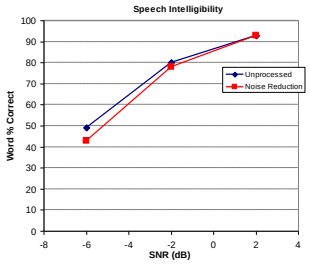
- Dual-attention task
  - Speech in noise while simultaneously performing a complex visual task

Measuring effort (dual task)

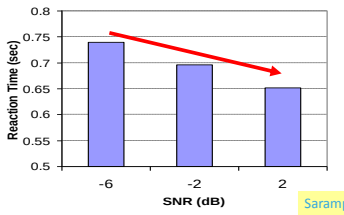


Measuring effort (dual task)



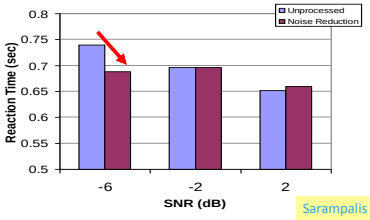


Directional Microphones reduces listening effort

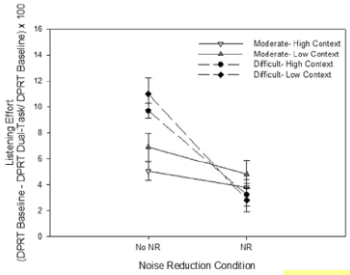


Sarampalis et al., 2009

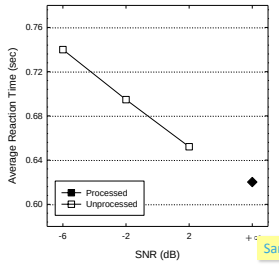
Noise Reduction reduces listening effort



Sarampalis et al., 2009



Desjardins and Doherty, 2014



Sarampalis et al., 2009

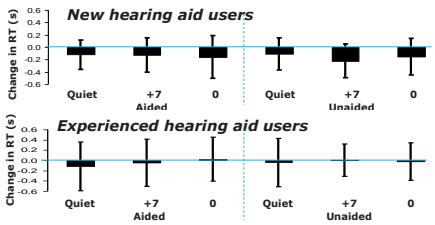
Conclusion

- Noise reduction and directional technology not only improve sound quality and (for directional) speech understanding…
  - They also reduce listening effort
    - Even when no improvement in speech understanding!

PROJECT #2:
NEW USER ACCLIMATIZATION

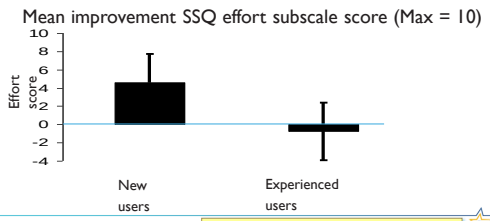
Piers Dawes, Manchester University
Kevin Munro, Manchester University

Effect of 12-week acclimatization



Dawes et al., *Int. Conf. on Cognition and Hearing*, 2011

Effect of 12-week acclimatization on self-reported effort



Dawes et al., *Int. Conf. on Cognition and Hearing*, 2011

Conclusion

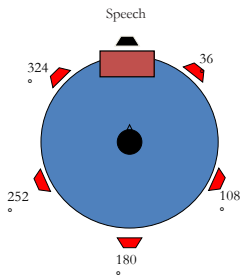
- New users will experience a benefit to listening effort from their hearing aids
  - But it may take up to 12 weeks for them to adjust and their brain to adapt

PROJECT #3:
FATIGUE

Ben Hornsby, Vanderbilt University

Mental Fatigue

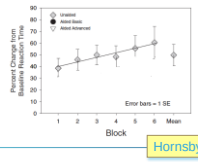
- Testing in a reverberation chamber (RT60 ~450 ms)
  - Noise: 5 speaker cafeteria babble fixed @ 55 dBA
- Listen to and repeat NU6 words in noise (individualized SNR ~70% correct)
  - Present strings of 8-12 words (random length)
    - Store last 5 words in memory for recall
- While doing this remain vigilant for a visual signal



Hornsby, *2013*

Mental Fatigue Objective Assessment: Reaction time

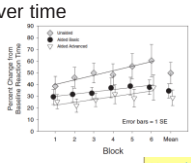
- Unaided multi-task RTs increased over time
  - Onset of fatigue



Hornsby, *2013*

Mental Fatigue Objective Assessment: Reaction time

- Unaided multi-task RTs increased over time
  - Onset of fatigue
- No change in aided RTs over time
  - No fatigue



Hornsby, *2013*

Conclusion

- Hearing aids can reduce mental fatigue from extended listening to speech in noise
  - Patients less exhausted after an hour of socializing
  - Patients can engage more with family and friends

PROJECT #4:
BINAURAL HEARING

Jing Xia, Starkey Research
Sridhar Kalluri, Starkey Research

Binaural Function

- Aided binaural function not widely considered until recently
  - Focus has been on audibility, speech intelligibility measures

Binaural Function

- Benefit from binaural hearing includes:
  - Localization
  - Better-ear listening
  - Auditory scene analysis
    - source segregation, selective attention
  - Precedence
  - Echo perception
  - Binaural squelch
  - Distance perception
  - Sense of space
  - Loudness
  - Listening effort

Goal

- Determine the effect of spatial cues on cognitive load in a multi-talker environment

Method

- Dual-attention task
  - Speech in presence of other speech
- Eight normal-hearing young adults (18-25 years, average: 21 years old)
- Presentation over headphones

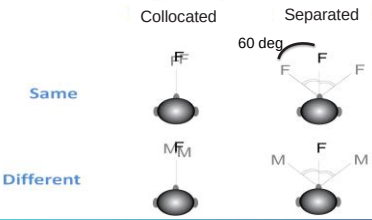
Auditory Stimuli

- CRM sentences with 4 colors, 8 numbers, and 8 call signs
- Talkers: 3 females, 3 males
- Subject to repeat the color and number that follow call sign: Baron

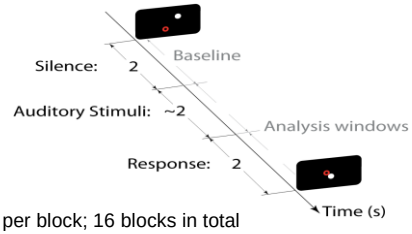
Simultaneous Visual Task

- Target: white solid circle, 60 pixels in diameter, moving around the black screen in a random pattern
- Cursor: red open circle, same size as target
- Subject follows the white dot with the red circle

Conditions

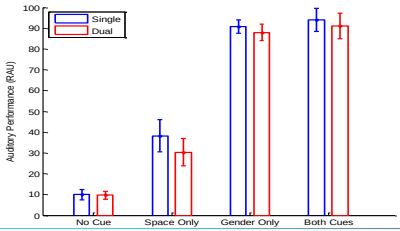


1 Dual-task Trial

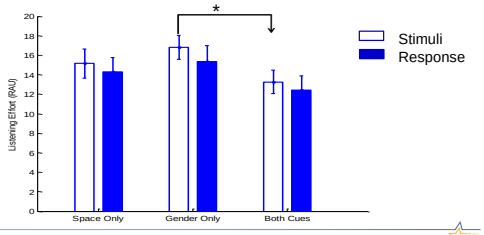


8 trials per block; 16 blocks in total

No improvement in auditory performance from addition of space to gender cue



Listening effort reduces when spatial cue added to gender cue



Summary

- Binaural hearing can reduce cognitive load
  - a benefit of wearing 2 hearing aids could be reduced listening effort
  - Technology that improves spatial hearing could reduce listening effort

PROJECT #5:
SEMANTIC INFORMATION TESTING

Erv Hafter, UC Berkeley
Jing Xia, Starkey Research

Goal

- Develop a test that realistically represents social situations with
  - multiple streams of conversations
  - Switching of attention
  - Semantic understanding of content
- Primary cue is spatial location

Semantic Information Tracking

The times were rough as I tried to establish myself in the field, but the projects were finally starting to pour in. Now I could finally enjoy some of the things I had always longed for, like building my dream house. But that night, though I was grateful to be there, I was more grateful that sleep was near [Q1].

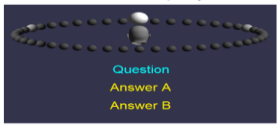
Hafter et al., *ARO*, 2012

Semantic vs Phonetic
Information Reception

Auditory Stream

Ever since a young child ***she had been instinctively nervous,*** jumping at shadows all too often. At one time it had made her parents laugh.

Visual Display

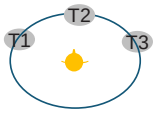


Phonetic Question:
The woman was
A) instinctively nervous
B) usually calm

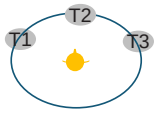
replace keywords with synonyms

Semantic Question:
The woman was
A) easily startled
B) usually calm

3 independent talkers, separated by 60 degrees



3 independent talkers, separated by 60 degrees
Identify where the information is going to come from with 0-2 seconds warning



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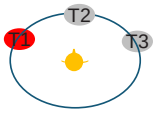

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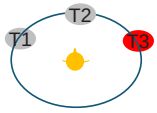
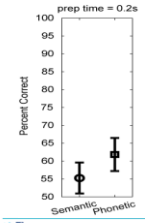


Dynamics of attention switching for semantic versus phonetic processing



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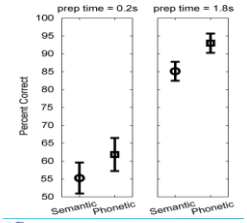

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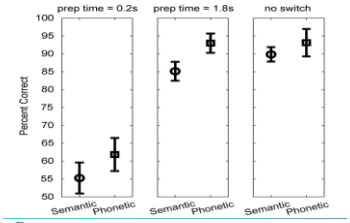
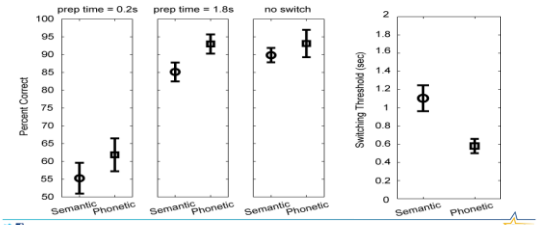


Dynamics of attention switching for semantic versus phonetic processing



Summary

- Methodology to test in more realistic complex listening environments and probe:
  - Ability to monitor multiple streams
  - Ability to switch attention
  - Semantic rather than phonemic reception

HEARING LOSS AND DEMENTIA

ORIGINAL CONTRIBUTION

Hearing Loss and Incident Dementia

Frank R. Lin, MD, PhD; E. Jeffrey Metter, MD; Richard J. O'Brien, MD, PhD; Susan M. Resnick, PhD; Alan B. Zonderman, PhD; Luigi Ferrucci, MD, PhD

ORIGINAL INVESTIGATION

ONLINE FIRST

Hearing Loss and Cognitive Decline in Older Adults

Frank R. Lin, MD, PhD; Kristine Yaffe, MD; Jin Xia, MS; Qian-Li Xue, PhD; Tamara B. Harris, MD, MS; Elizabeth Purchase-Helzner, PhD; Suzanne Satterfield, MD, DrPH; Hilsa N. Ayonayon, PhD; Luigi Ferrucci, MD, PhD; Eleanor M. Simonsick, PhD; for the Health ABC Study Group

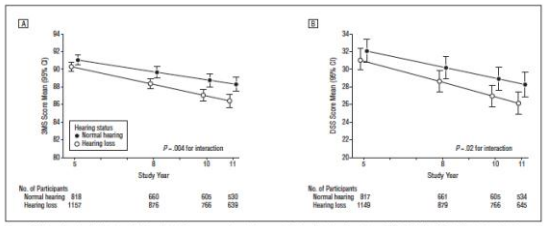


Figure. Multivariate mixed-effects models for adjusted mean scores by study year and by baseline hearing status. A, Modified Mini-Mental State Examination (3MS). B, Digit Symbol Substitution (DSS) test. Error bars indicate 95% CIs. All models are adjusted for age, sex, race/ethnicity, education, study site, smoking status, hypertension, diabetes mellitus, and stroke history. The interaction term is between hearing loss and time. Study year 5 is 2001-2002, study year 8 is 2004-2005, study year 10 is 2006-2007, and study year 11 is 2007-2008.

Lin et al., 2013

Take-away Message

- For older people, those with greater hearing loss are also more at risk for cognitive decline and dementia
- Two possibilities:
  1. Hearing loss not responsible for cognitive decline
     - Common cause such as vascular problems
  2. Hearing loss is responsible for cognitive decline
     - HL results in social isolation, which causes in cognitive decline
- Unknown whether hearing aids can impact this effect

Conclusion

- Hearing aids can affect cognitive abilities
  - Potentially remediate the effects of hearing loss on cognitive function
- Hearing aid features could be designed specifically to improve cognitive ability
  - Not just speech understanding, sound quality
- New diagnostics and outcome measures will improve treatment for patients

Thank you!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