Connected Aural Rehabilitation: Past, Present & Future

Terry Chisolm, Ph.D.

Beyond the Audiology Clinic: Innovations & Possibilities in Connected Health

NCRAR

September 18-20, 2013

USF UNIVERSITY OF SOUTH FLORIDA

Tampa, FL

USF UNIVERSITY OF SOUTH FLORIDA

Affiliations

Dept. of Communication Sciences & Disorders

Bay Pines VA Healthcare System

USF
UNIVERSITY OF SOUTH FLORIDA

Connected Aural Rehabilitation

"Those who cannot remember the past are condemned to repeat it" Santayana

UNIVERSITY OF SOUTH FLORIDA

"Innovative technological advances have served as a catalyst in stimulating new thinking to address old problems….

UNIVERSITY OF SOUTH FLORIDA

“technological limitations have also served as a constraint on our thinking”
(Hearing Journal, Dec. 2013)

USF UNIVERSITY OF SOUTH FLORIDA

Pattern of Technological Development

- Similar to a game of leapfrog
- Innovative technological advance
- Leap forward
- Although more effective, problem not always solved
- Face unexpected hurdles which need to be surmounted

Levitt et al., 2012

UNIVERSITY OF SOUTH FLORIDA

Pattern of Technological Development

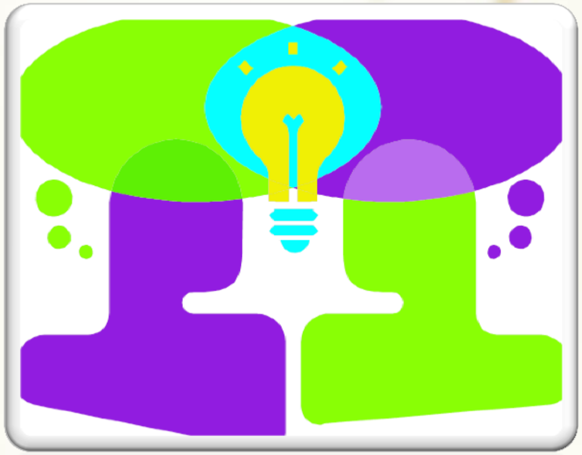
- New ideas in Rehabilitative Audiology
- New technological advances

Levitt et al., 2012

UNIVERSITY OF SOUTH FLORIDA

Pattern of Technological Development

- New ideas in Rehabilitative Audiology
- New technological advances
- Synergy necessary to take the next leap forward



Levitt et al., 2012

UNIVERSITY OF SOUTH FLORIDA

Goal of Presentation

Examine changes in our thinking about **Connected Aural Rehabilitation** with each successful leap forward that we have taken

UNIVERSITY OF SOUTH FLORIDA

Goal of Presentation

Plan ahead with **new thinking** for **surmounting** the next **hurdle** that we will face

DEFINING AURAL REHABILITATION

UNIVERSITY OF SOUTH FLORIDA

Adult Aural Rehabilitation

(Boothroyd, 2007)

UNIVERSITY OF SOUTH FLORIDA

Adult Aural Rehabilitation

(Boothroyd, 2007)

- Defined holistically as the reduction of hearing-loss-induced deficits of
- Function, activity, participation, and quality of life

- Through a combination of

USF
UNIVERSITY OF SOUTH FLORIDA

Adult Aural Rehabilitation

(Boothroyd, 2007)

- Defined holistically as the reduction of hearing-loss-induced deficits of
- Function, activity, participation, and quality of life
- Through a combination of

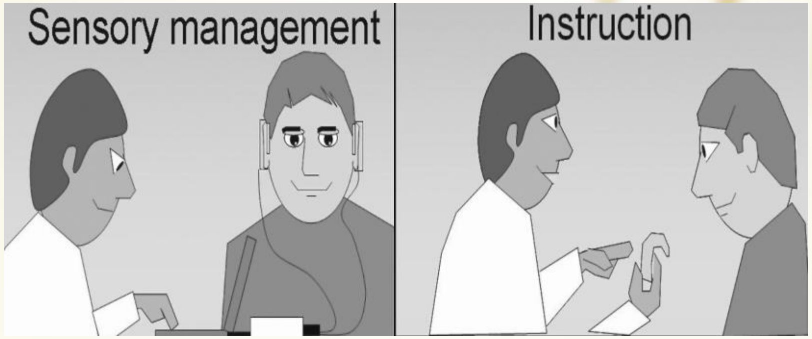
USF UNIVERSITY OF SOUTH FLORIDA

Adult Aural Rehabilitation

(Boothroyd, 2007)

- Defined holistically as the reduction of hearing-loss-induced deficits of
- Function, activity, participation, and quality of life

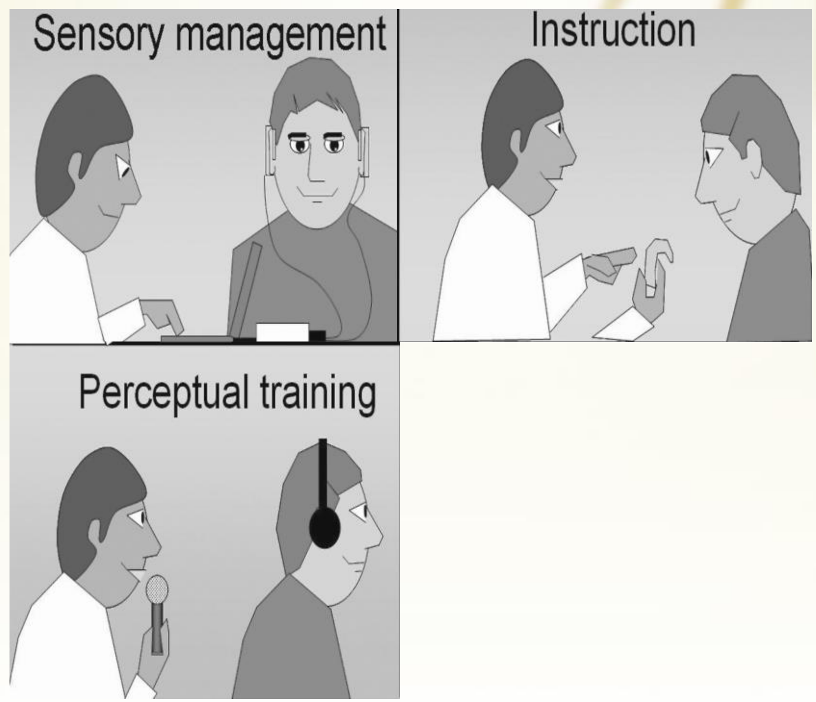
- Through a combination of



Adult Aural Rehabilitation

(Boothroyd, 2007)

- Defined holistically as the reduction of hearing-loss-induced deficits of
- Function, activity, participation, and quality of life
- Through a combination of

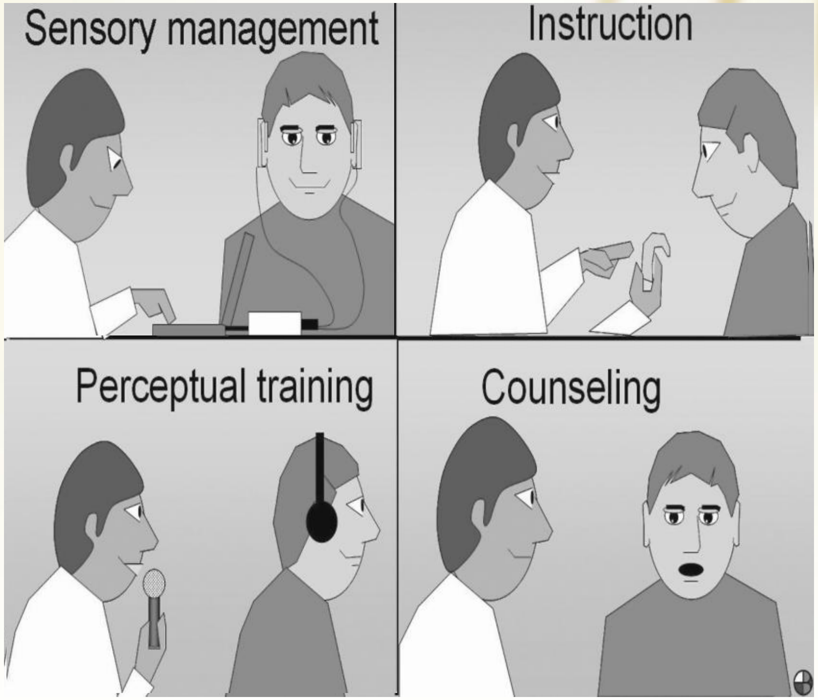


USF
UNIVERSITY OF SOUTH FLORIDA

Adult Aural Rehabilitation

(Boothroyd, 2007)

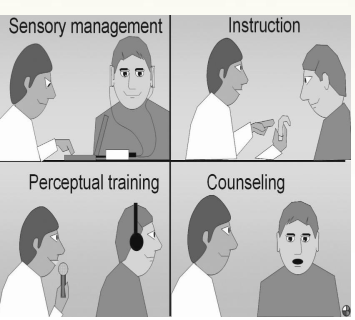
- Defined holistically as the reduction of hearing-loss-induced deficits of
- Function, activity, participation, and quality of life
- Through a combination of



USF UNIVERSITY OF SOUTH FLORIDA

AR in the Pre-Electronic Era

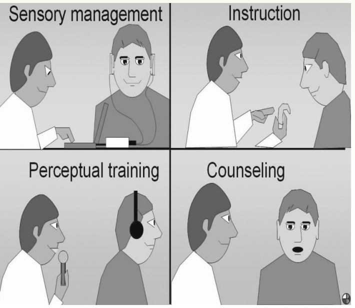
- Oral schools for the deaf
  - Speech production training with due emphasis on listening skills



USF
UNIVERSITY OF SOUTH FLORIDA

AR in the Pre-Electronic Era

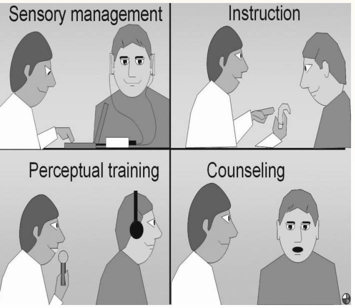
- Oral schools for the deaf
  - Moderate hearing loss could benefit from speech comprehension training using an **acoustic horn**



USF
UNIVERSITY OF SOUTH FLORIDA

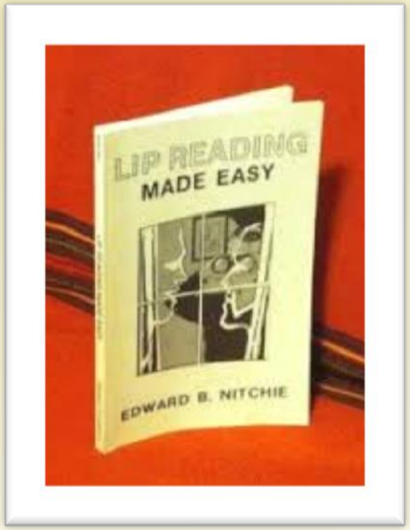
AR in the Pre-Electronic Era

- Severe to profound hearing loss
- Acoustic horn provided insufficient amplification for sound to be audible

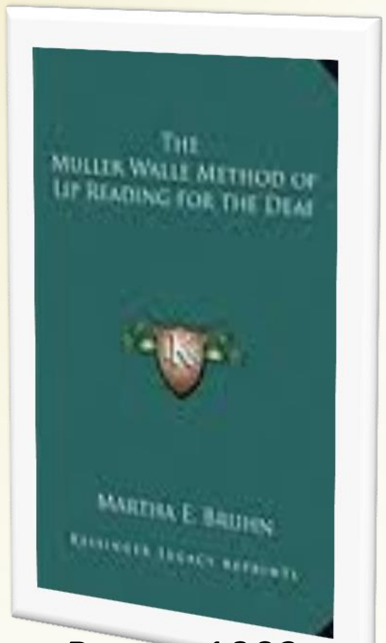


UNIVERSITY OF SOUTH FLORIDA

AR in the Pre-Electronic Era

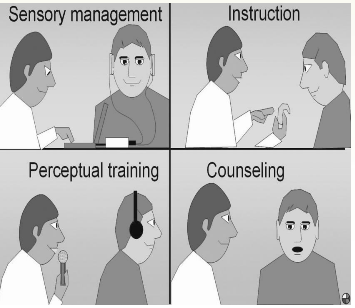


Nitchie (1903)



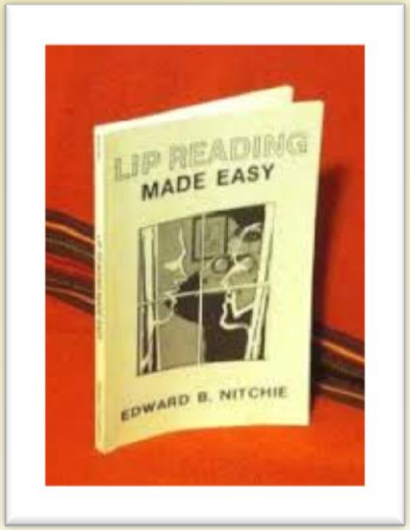
Braun, 1902

- **Use of <u>vision</u> to help develop speech comprehension skills**

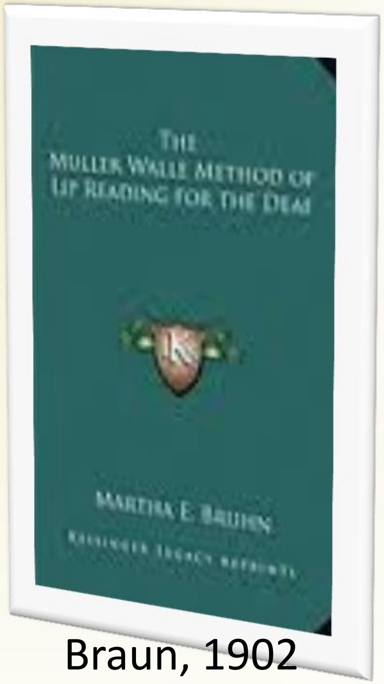


USF
UNIVERSITY OF
SOUTH FLORIDA

AR in the Pre-Electronic Era

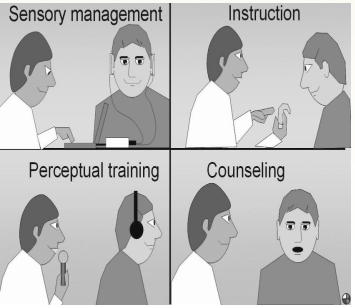


Nitchie (1903)



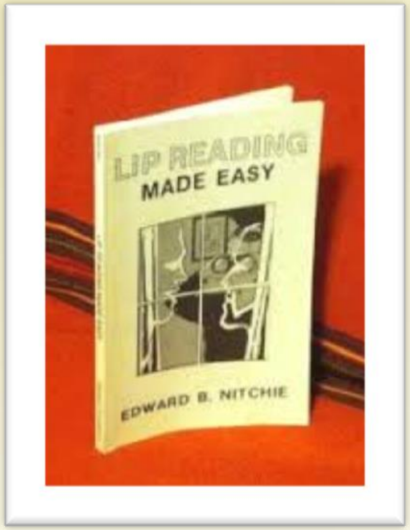
Braun, 1902

- **Lip-reading**
  - **"the eye as a substitute for deaf ears"**

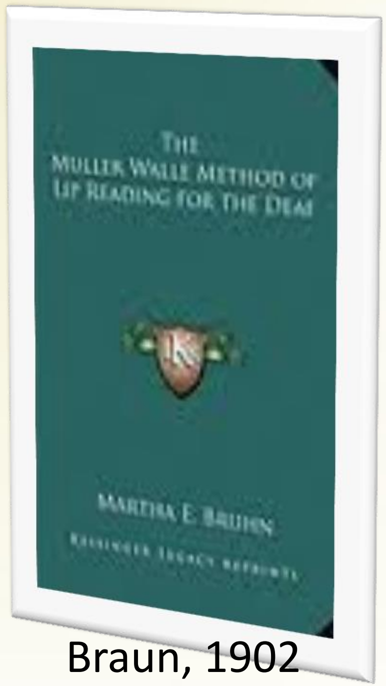


USF
UNIVERSITY OF
SOUTH FLORIDA

AR in the Pre-Electronic Era

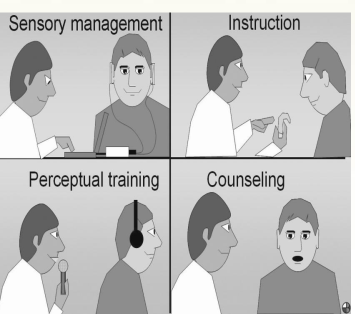


Nitchie (1903)



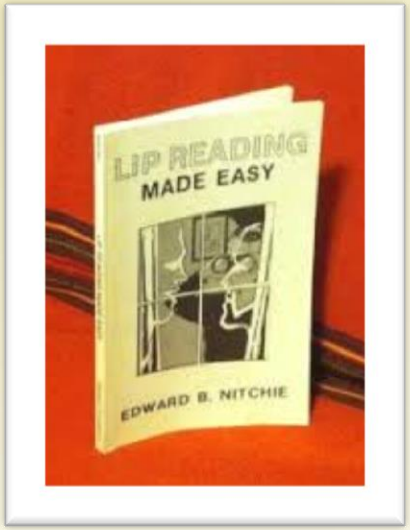
Braun, 1902

- **Differed in how much emphasis placed on learning facial patterns of individual sounds before moving on to speech in context**

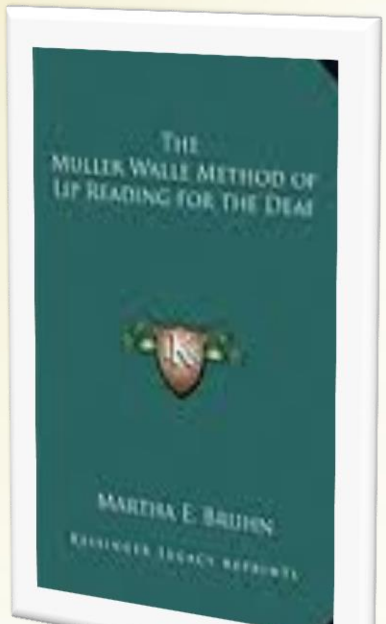


UNIVERSITY OF SOUTH FLORIDA

AR in the Pre-Electronic Era

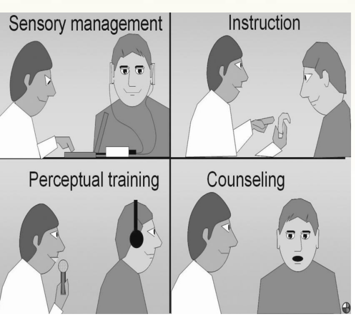


Nitchie (1903)



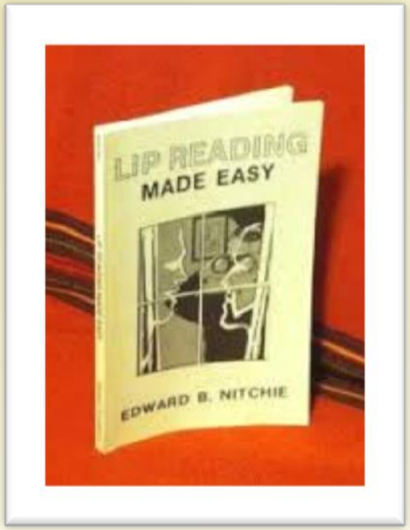
Braun, 1902

- ***Implication for Connected AR:***
  - ***Analytic vs. Synthetic approaches***

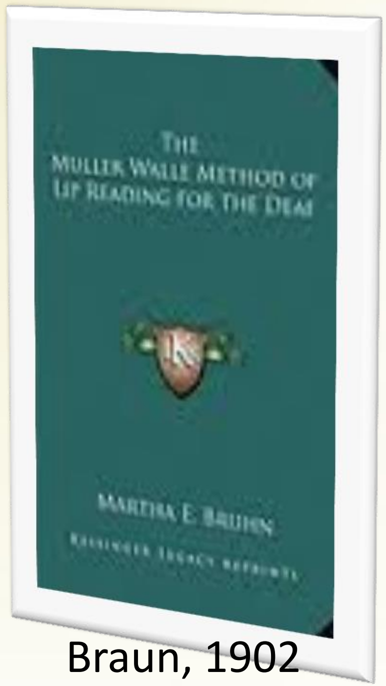


UNIVERSITY OF SOUTH FLORIDA

AR in the Pre-Electronic Era

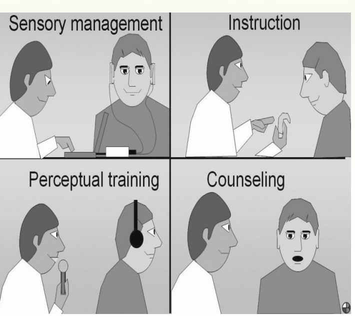


Nitchie (1903)



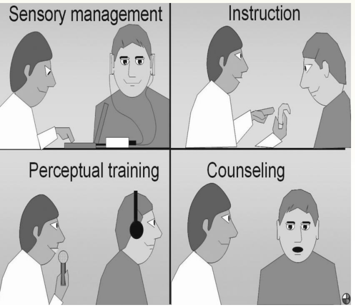
Braun, 1902

- **Lip-reading, treated as a separate form of speech communication**
- **Rather than an inherent component of normal speech communication**



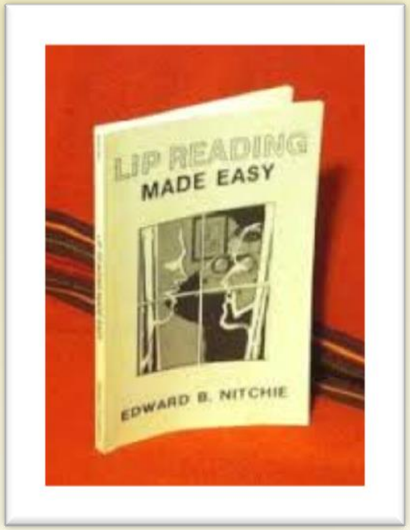
Use of Visual Cues in Speech Communication

- Individuals with normal hearing use visual speech cues in background noise or when acoustic speech signal distorted
  - (e.g., Sumby & Pollack, 1954; Erber 1971; 1975)
- Adults with hearing loss dependent on speech cues in a similar way

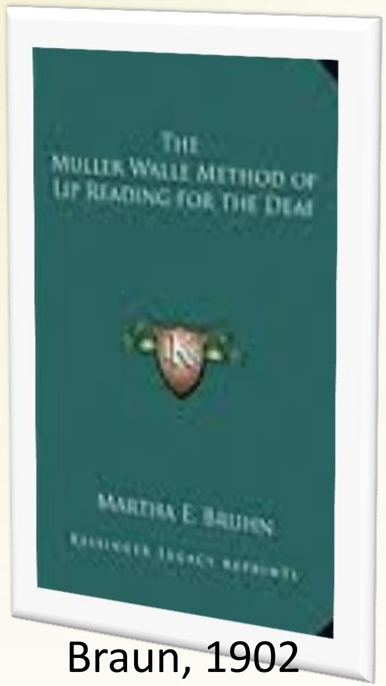


UNIVERSITY OF SOUTH FLORIDA

AR in the Pre-Electronic Era

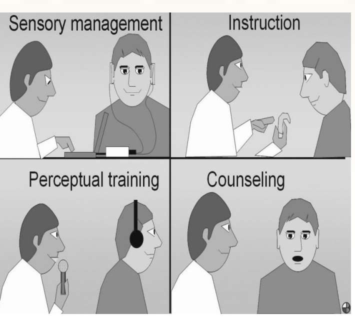


Nitchie (1903)



Braun, 1902

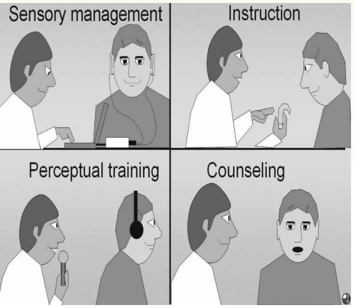
- *Implication for Connected AR:*
  - *Auditory alone vs. auditory-visual training*



UNIVERSITY OF SOUTH FLORIDA

AR in the Electronic Era

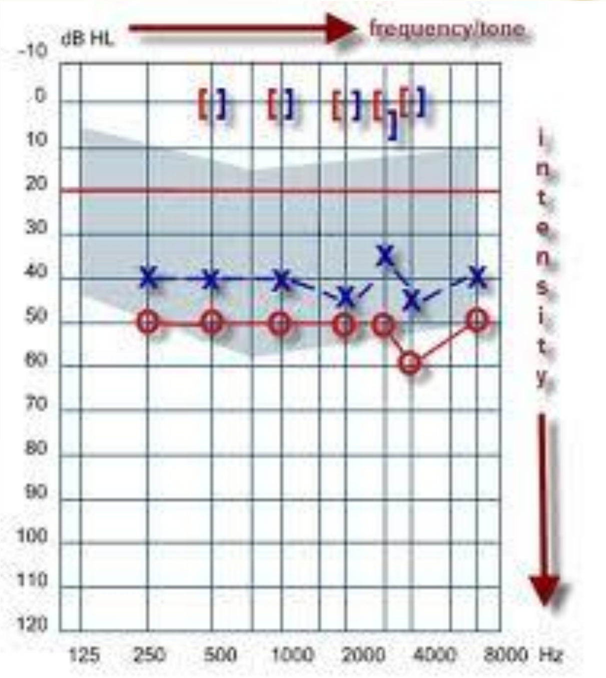
- Electronic hearing aids
  - Significant improvement in auditory rehabilitation

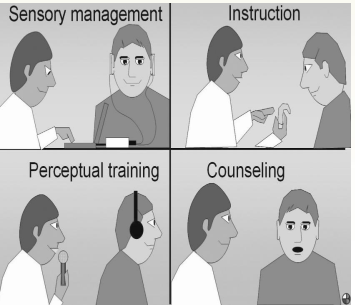


USF UNIVERSITY OF SOUTH FLORIDA

AR in the Electronic Era

- **Electronic hearing aids**
  - **"Mirroring" the audiogram**
  - **Worked well with conductive hearing loss or mild SNHL**

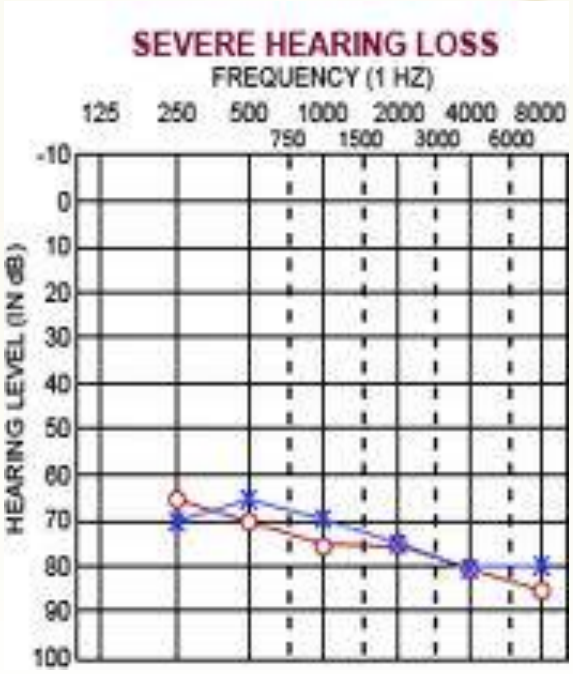


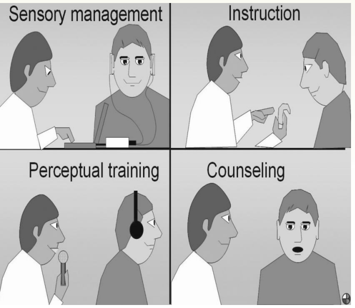


UNIVERSITY OF SOUTH FLORIDA

AR in the Electronic Era

- **Moderate and severe hearing loss**
  - “Mirroring” the audiogram resulted in over-amplification
- **Electronic Hearing Aids**
  - Innovative new technology
  - SNHL involved more than simple elevation of auditory thresholds

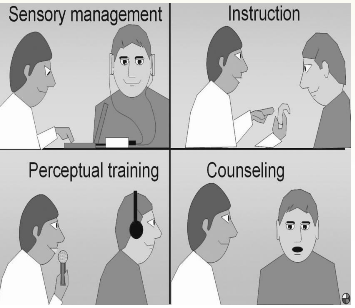


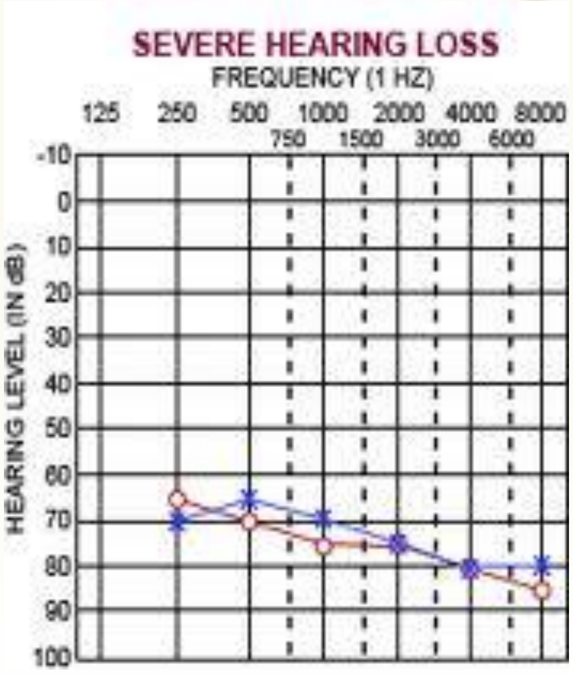


USF
UNIVERSITY OF SOUTH FLORIDA

AR in the Electronic Era

- ***Implication for Connected AR:***
  - ***Hearing aids alone are not the solution***
  - ***Speech perception training also needed***



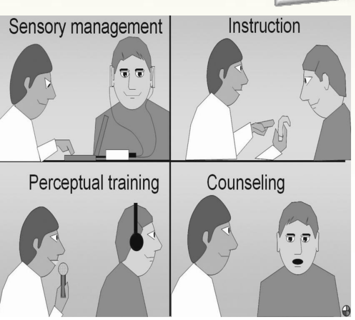


UNIVERSITY OF SOUTH FLORIDA

Speech Perception Training

- Group hearing aids with children at oral skills for the deaf

- National Research Council study (Silverman & Hirsh, 1951)
  - Long term training with a group hearing aid
  - Speech recognition scores improved 30 percentage points
  - After 2 years of training

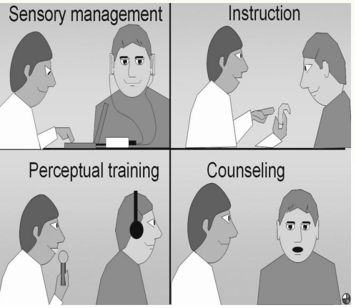


USF
UNIVERSITY OF SOUTH FLORIDA

Speech Perception Training

- Group hearing aids with children at oral skills for the deaf

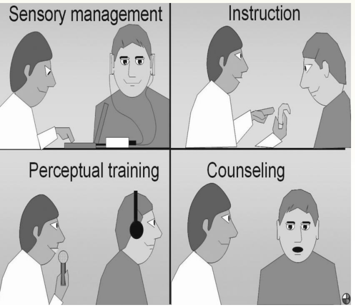
- ***Implication for Connected AR:***
  - ***How long of duration do we need for training?***



UNIVERSITY OF SOUTH FLORIDA

AR and the Transistor

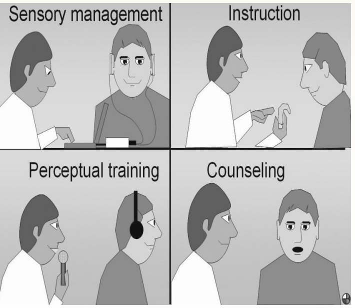
- Development of ***complex signal processors*** that were small enough to fit in or on the ear



USF
UNIVERSITY OF
SOUTH FLORIDA

AR and the Transistor

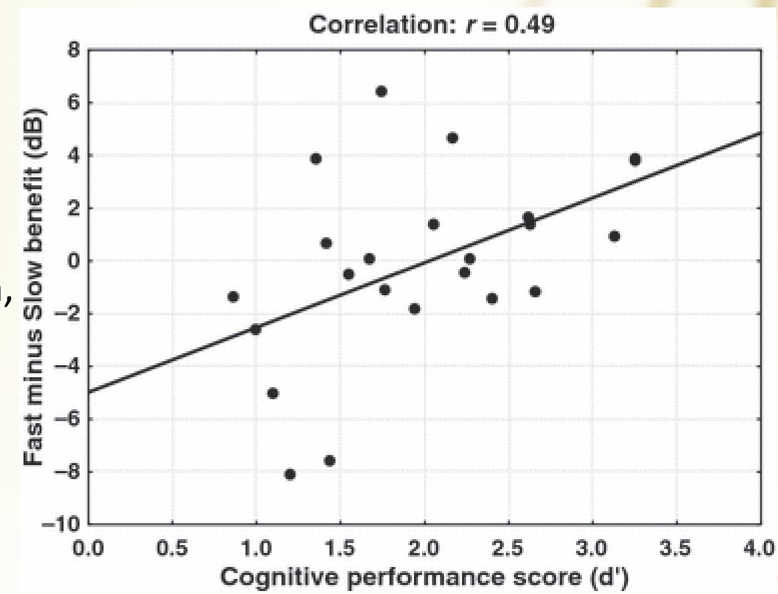
- ***Large individual differences*** in terms of how individuals with similar audiograms were able to benefit (Levitt et al 1993)

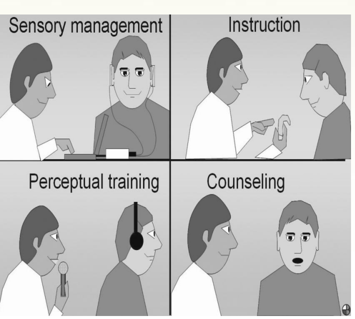


USF
UNIVERSITY OF SOUTH FLORIDA

AR and Advanced Methods of Signal Processing

- Lower ***cognitive capacity*** less able to benefit from ***compression hearing aids with short-time constants***
  - (e.g., Lunner & Sundewall-Thoren, 2007).

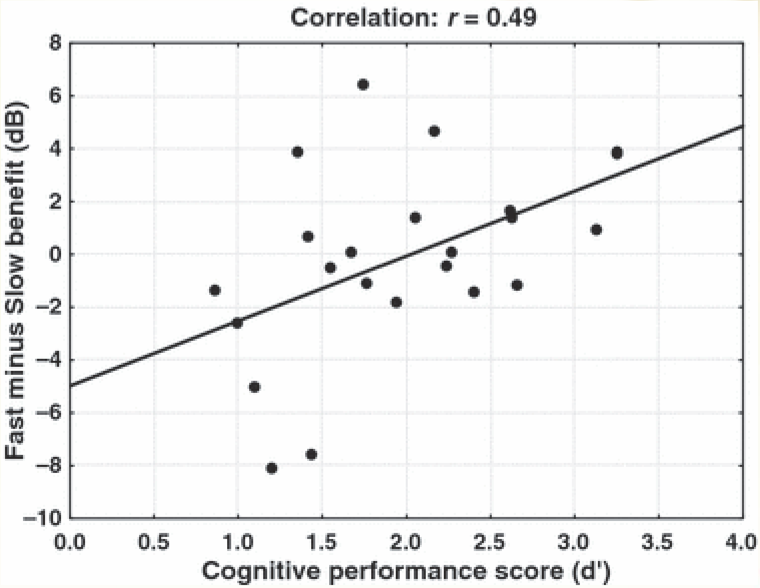


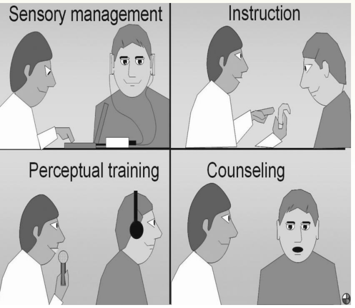


UNIVERSITY OF SOUTH FLORIDA

AR and Advanced Methods of Signal Processing

- Signal processing to increase audibility of components of speech important for understanding

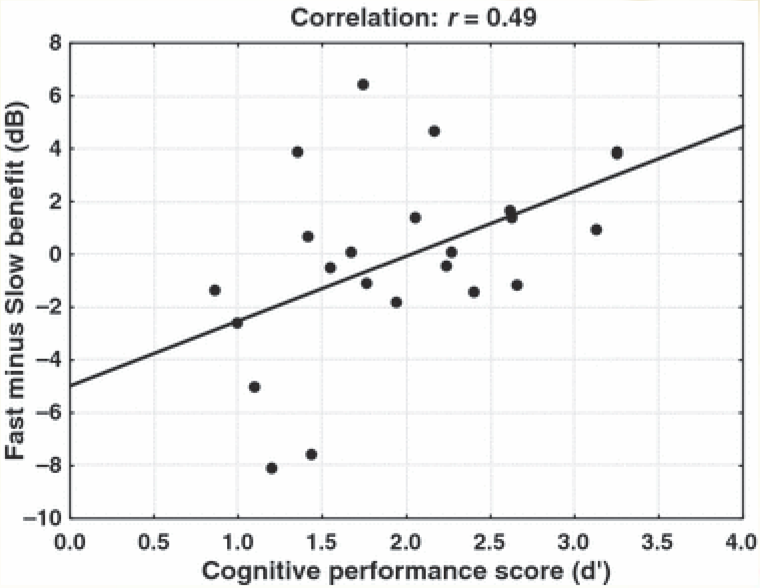


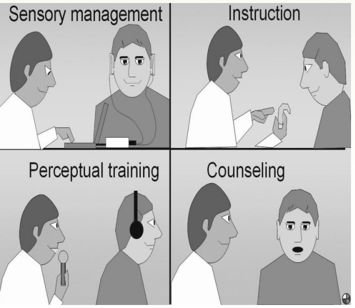


UNIVERSITY OF SOUTH FLORIDA

AR and Advanced Methods of Signal Processing

- While minimizing temporal or other distortions that could reduce intelligibility

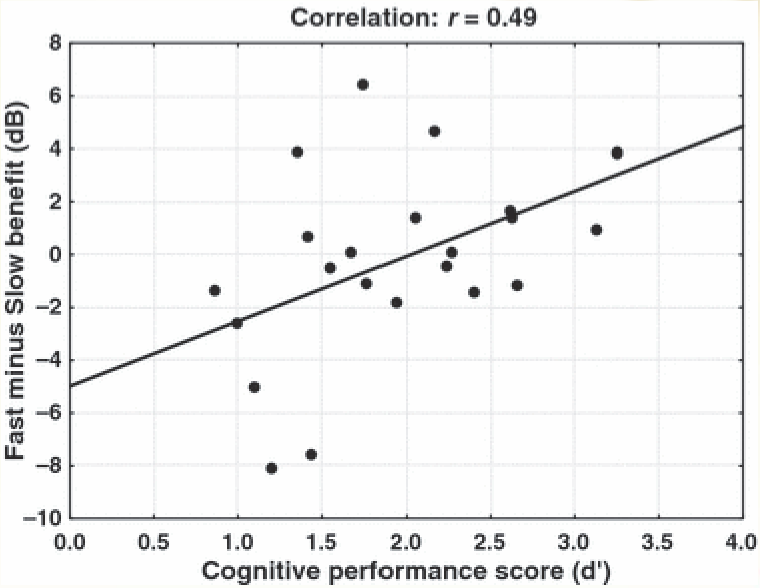


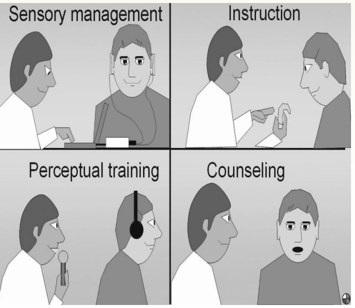


UNIVERSITY OF SOUTH FLORIDA

AR and Advanced Methods of Signal Processing

- ***Implication for Connected AR:***
  - ***Need for training programs that can help a person deal with <u>signal processing distortions</u> essential for improving <u>speech intelligibility</u>***

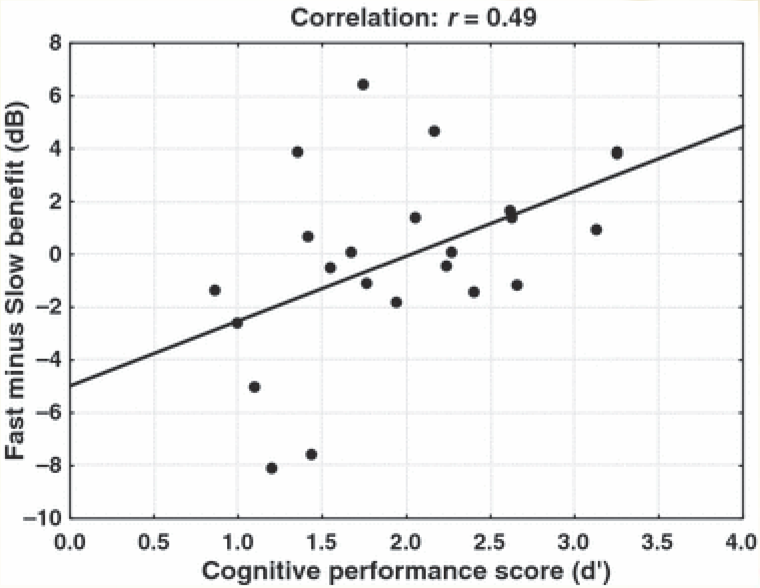


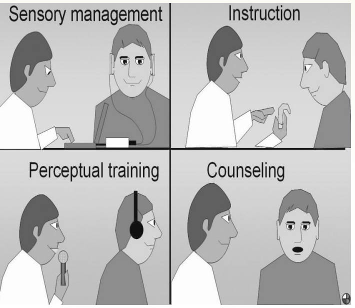


UNIVERSITY OF SOUTH FLORIDA

AR and Advanced Methods of Signal Processing

- ***Implication for Connected AR:***
  - ***Training programs include <u>cognitive</u> as well as <u>perceptual</u> components***

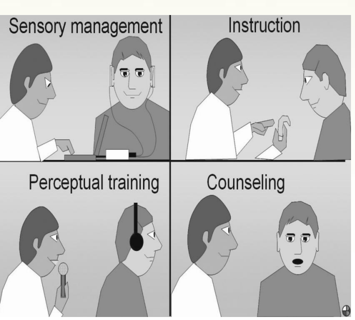




UNIVERSITY OF SOUTH FLORIDA

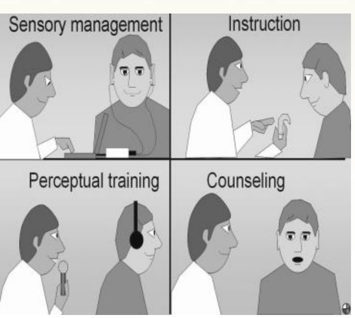
AR and Cochlear Implants

- Were not supposed to work….
- But they did!
- The innovative new biomedical technology resulted in serious rethinking by hearing scientists



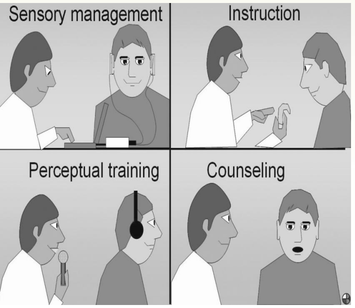
USF
UNIVERSITY OF SOUTH FLORIDA

Cochlear Implants = AR and the Digital Era



USF
UNIVERSITY OF
SOUTH FLORIDA

The Digital Era: Hearing Aids



UNIVERSITY OF SOUTH FLORIDA

The Digital Era: Hearing Aids

1980s

- Digital control of analog components

- digital hearing aids designed to do what conventional hearing aids did... only better

Second generation

- methods of signal processing

The Digital Era: Hearing Aids

1980s

- Digital control of analog components

Early 21st Century

- 1st fully digital hearing aids designed to do what conventional hearing aids did – only better

UNIVERSITY OF SOUTH FLORIDA

The Digital Era: Hearing Aids

1980s

- Digital control of analog components

Early 21st Century

- 1st fully digital hearing aids designed to do what conventional hearing aids did – only better

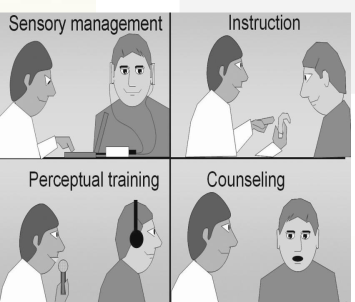
Second generation

- Innovative methods of signal processing, such as adaptive feedback cancellation

The Digital Era: Computer-Based AR: Speech Perception Training Systems

Second generation

• methods of



The Digital Era: Computer-Based AR: Speech Perception Training Systems

1980s – 1990s

- Computer-control of audio-video playback equipment

Second generation

- methods of

The Digital Era: Computer-Based AR: Speech Perception Training Systems

1980s

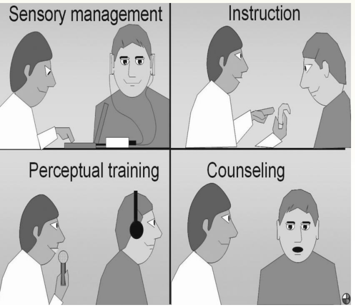
- Dynamic Audio Visual Interactive Device (DAVID; NTID)
  - Apple II computer
  - VCR
  - Monitor

Second generation

USF
UNIVERSITY OF SOUTH FLORIDA

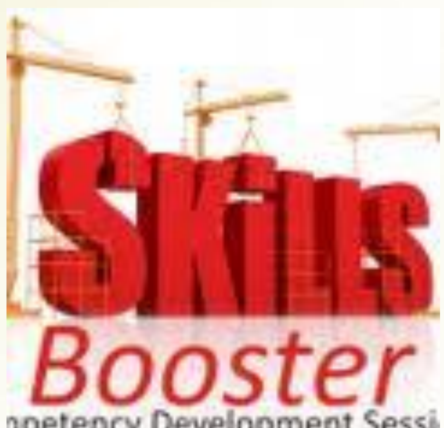
DAVID

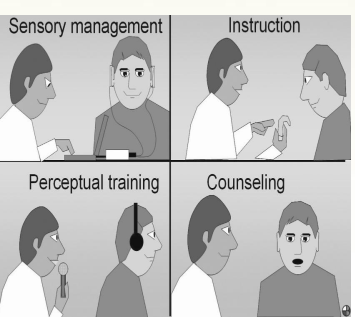
- Young deaf adults at NTID
  - Speech recognition scores of sentences improved 14.6 to 33.5% after 20 training units (Durity 1982)
  - Speechreading scores increased more than 15% (Jacobs, 1982)
- Improvements subsequently declined if after training learned skills not continuously used



DAVID

- ***Implication for Connected AR:***
  - ***Consider “booster training” in addition to “initial training”***





USF
UNIVERSITY OF SOUTH FLORIDA

The Digital Era: Computer-Based AR: Speech Perception Training Systems

1980s – 1990s

- Computer-control of audio-video playback equipment

Second generation

- Computer Assisted Speech Perception & Evaluation (CASPER; Boothroyd, 1987)
- Auditory-Visual Laser Videodisc Programs for Training Speechreading & Assertive Communication Behaviors (Tye-Murray et al., 1988)
- Computer Aided Speech Training System (CAST: Pichora-Fuller & Benguerrel, 1991)
- Computer Assisted Tracking Simulation (CATS; Dempsey et al., 1992)

USF UNIVERSITY OF SOUTH FLORIDA

The Digital Era: Computer-Based AR: Speech Perception Training Systems

1980s – 1990s

- Computer-control of audio-video playback equipment

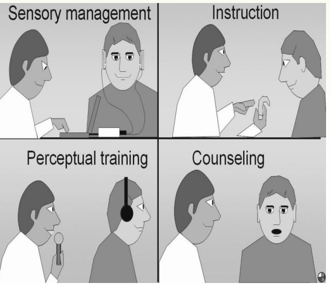
Second generation

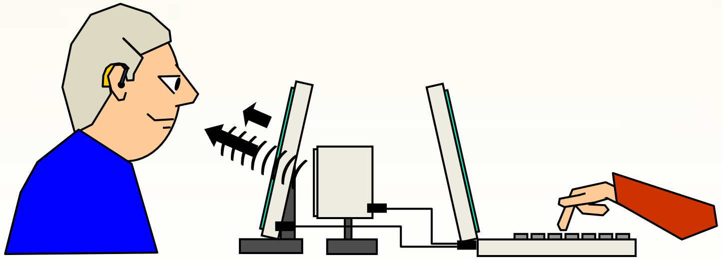
- Computer Assisted Speech Perception & Evaluation (CASPER; Boothroyd, 1987)
- Auditory-Visual Laser Videodisc Programs for Training Speechreading & Assertive Communication Behaviors (Tye-Murray et al., 1988)
- Computer Aided Speech Training System (CAST: Pichora-Fuller & Benguerrel, 1991)
- Computer Assisted Tracking Simulation (CATS; Dempsey et al., 1992)

USF UNIVERSITY OF SOUTH FLORIDA

CASPER

- Adult cochlear implant recipients
- Clinic-based system
- Hearing Alone, Speechreading Alone, Hearing + Speechreading combined
- Vowel & Consonant Analytic training
- Sentence level Synthetic training

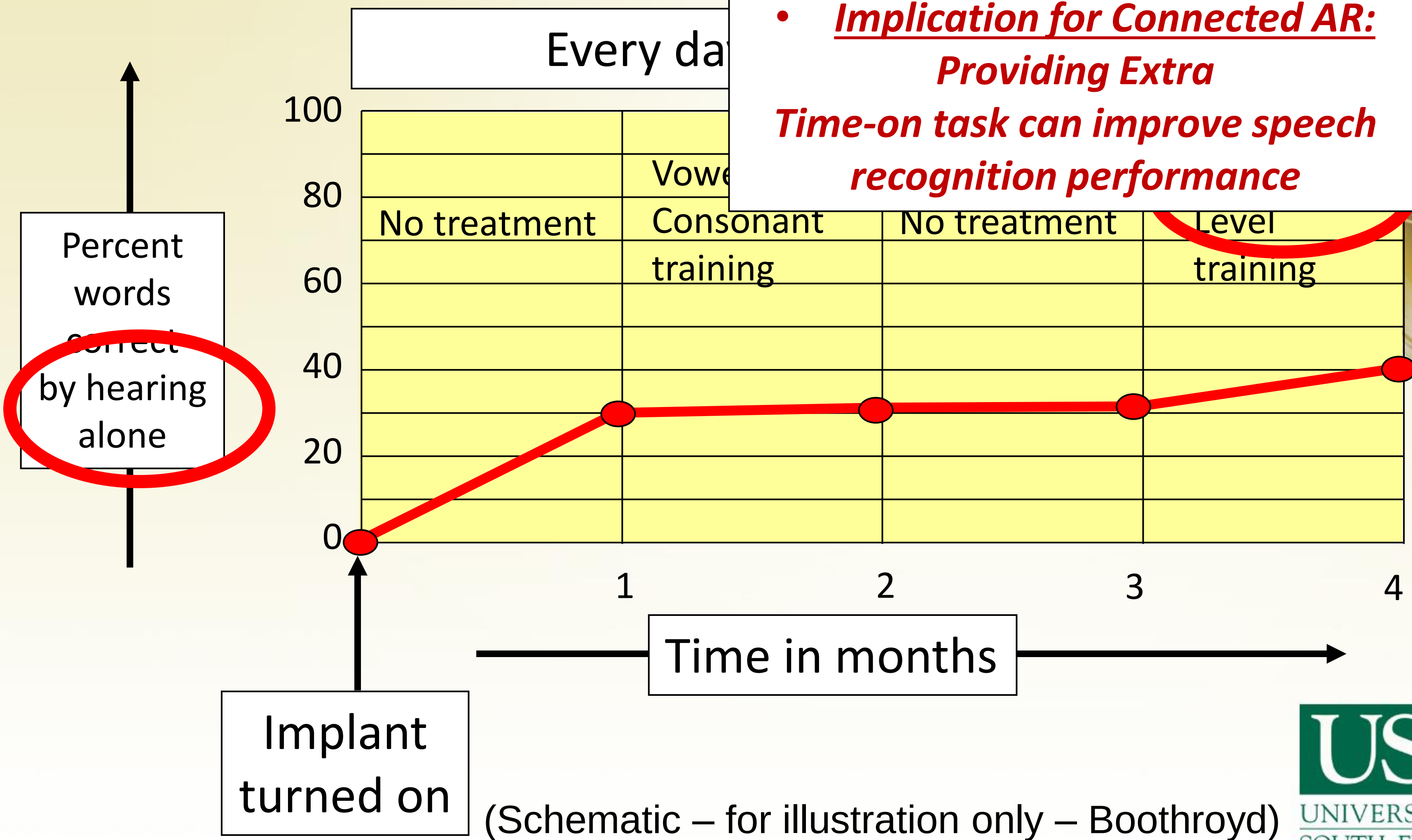




UNIVERSITY OF SOUTH FLORIDA

CASPER: Rehabilitation of adult cochlear implantees

- ***Implication for Connected AR:*** ***Providing Extra Time-on task can improve speech recognition performance***



(Schematic – for illustration only – Boothroyd)

The Digital Era: Computer-Based AR: Speech Perception Training Systems

1980s – 1990s

- Computer-control of audio-video playback equipment

Second generation

- ***Implication for Connected AR:***
  - ***Significant improvements in speech recognition outcomes***
  - ***However,***
    - ***High cost***
    - ***Lacked ease of use***
    - ***Limited by being clinic based***

The Digital Era: Computer-Based AR: Speech Perception Training Systems

1980s – 1990s

- Computer-control of audio-video playback equipment

Late 1990s-Current

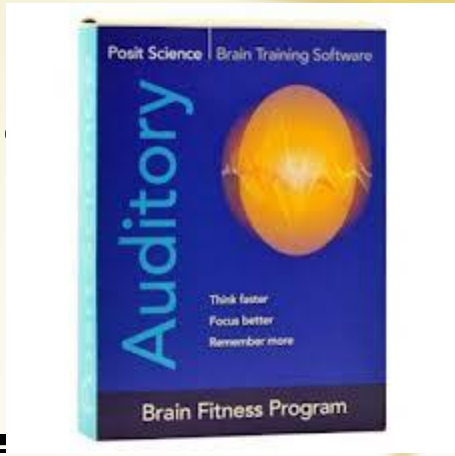
- Home-based systems using -
  - Desktops
  - Laptops
  - Tablets

Second generation

- methods of

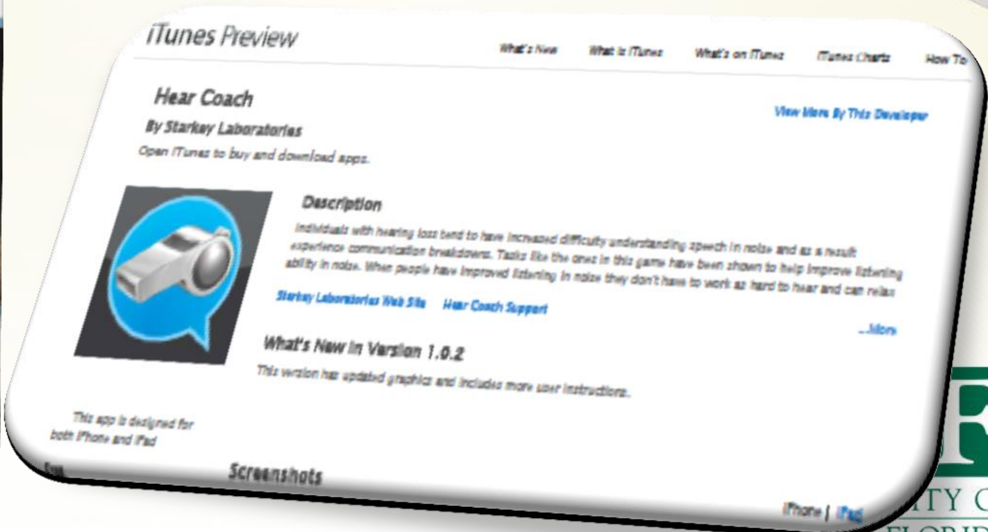
USF
UNIVERSITY OF SOUTH FLORIDA

So many choices…



ReadmyQuips™

Speech Comprehension Training System



AJA

Research Forum

Speech Comprehension Training and Auditory and Cognitive Processing in Older Adults

M. Kathleen Pichora-Fuller[a,b,c] and Harry Levitt[d]

USF
UNIVERSITY OF SOUTH FLORIDA

Table 1. Current training programs.

Program name	Source	Description
Baldi	Psyentific Mind http://psyentificmind.com/	Speechreading training is provided by means of a computer-generated talking head (Baldi) that can generate speech from text. Speed of speech production can be controlled and provides revealing views of Baldi, such as making the skin transparent to show movements of the articulators.
Computer-Assisted Speech Perception Testing and Training (CASPER)	All programs in the CASPER series can be obtained through the Rehabilitation Engineering and Research Center on Hearing Enhancement of Gallaudet University at www.hearingresearch.org or directly from the author at www.arthurboothroyd.com	A series of computer-assisted training and testing programs has been developed using the CASPER system (Boothroyd, 2010). Each of the training programs can be used in the home with or without help from a significant other (PC only). CasperCon: auditory, visual, and auditory-visual training and testing at the level of vowel and consonant contrasts. CasperSent: auditory, visual, and auditory-visual training and testing at the sentence level. AudioCasper: auditory-only training at the story level. Users can vary background noise level, talker speed, and the number of words shown in text form while listening. The goal is to improve both attention to detail and the use of story context.
Computer-Assisted Speech Training (CAST)	Tiger Speech Technology www.tigerspeech.com	The training software targets important acoustic contrasts among speech stimuli, provides auditory and visual feedback, and incorporates progressive training techniques, thereby maintaining recipients' interest during the auditory training exercises. Tiger Speech Technology offers a range of products based on CAST.
eARena	Siemens Hearing Instruments tpowers@siemens.com	eARena is an interactive audio-video training program. The program consists of a set of DVDs with "informational videos and a twenty-day curriculum containing listening exercises, 'homework', and daily tips for maximizing the benefits of their personal hearing solution."
Listening and Communication Enhancement (LACE)	Neurotone www.neurotone.com	This system focuses on auditory training for hearing aid wearers. Interactive adaptive software is used to provide instruction on using a hearing aid, lessons and training to improve listening skills and develop more effective listening strategies, and to address cognitive changes characteristic of the aging process.
Read My Quips (RMQ)	SenseSynergy www.sensesynergy.com	This system focuses on sentence comprehension in noise with contextual cues provided in a video puzzle format. The background noise is adjusted in level adaptively to match the trainee's speechreading ability.
Seeing and Hearing Speech	Sensimetrics Corporation www.sens.com/	Multimedia interactive software is used to provide instruction and training in speechreading. Video recordings of a variety of talkers are used, ranging in difficulty from easy to speechread to more difficult.
Speech Perception Assessment and Training System (SPATS)	Communication Disorders Technology www.comdistec.com	The program contains two speech comprehension and training modules: one on the sounds of speech and the other on sentence understanding.

Note. The table lists computer-based auditory training programs for adults that are currently available. The programs are listed in alphabetical order. For each entry, the first column contains the name of the training program; the second column contains the program source and the website for more information and how to obtain the program; and the third column contains a description of the program.

OPEN ACCESS Freely available online

PLOS | ONE

Efficacy of Individual Computer-Based Auditory Training for People with Hearing Loss: A Systematic Review of the Evidence

Helen Henshaw*, Melanie A. Ferguson

NIHR Nottingham Hearing Biomedical Research Unit, Nottingham, United Kingdom

USF
UNIVERSITY OF
SOUTH FLORIDA

Conclusion

- Our findings demonstrate that **published evidence** for the efficacy of individual computer-based auditory training for adults with hearing loss
- is **not robust** and therefore cannot be **reliably** used to **guide intervention** at this time.
- We **identify a need for high-quality evidence** to **further examine the efficacy** of computer-based auditory training for people with hearing loss
  - Henshaw & Ferguson (2013)

USF UNIVERSITY OF SOUTH FLORIDA

Our Work with Computer-Based Auditory Training Programs

A Tale of Two Studies

VA Merit Review Grants

The contents do not represent the views of the Department of Veterans Affairs or the United States Government

USF UNIVERSITY OF SOUTH FLORIDA

Our Work with Computer-Based Auditory Training Programs

Thanks to Harvey Abrams

UNIVERSITY OF SOUTH FLORIDA

Study #1: Supplementing Hearing Aids with Computerized Auditory Training

VA RR&D Merit Review Grant C6303R
(Chisolm & Wilson, Co-PIs)

James H. Quillen VAMC, Mt. Home, TN: Richard Wilson, Sherri Smith,

VAHC, Bay Pines, FL, U. South Florida: Terry Chisolm, Rachel McArdle,

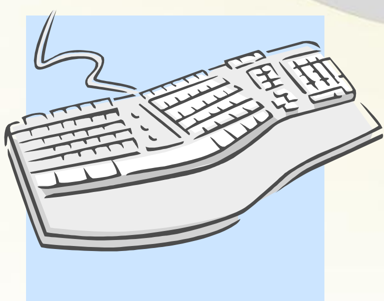
NCRAR, Portland OR
Gaby Saunders,
Melissa Frederick,
ShienPei Silverman

USF
UNIVERSITY OF SOUTH FLORIDA

All About LACE™:

- Home-based
- Adaptive training
- Progress tracked over time
- Provides motivation via feedback

- **Comprehension of Degraded Speech**
  - Speech-in-babble
  - Time-compressed speech
  - Competing speaker
- **Enhancement of Cognitive Skills**
  - Auditory working memory
  - Missing word identification using context
- **Use of Communication Strategies**
  - Helpful hints



UNIVERSITY OF SOUTH FLORIDA

Efficacy of LACE

(Sweetow & Henderson Sabes, 2006)

- Multi-site randomized controlled trial (RCT)
- *n* = 65 (mostly) experienced hearing aid users
- Ages 28-85 years old

UNIVERSITY OF SOUTH FLORIDA

Efficacy of LACE

(Sweetow & Henderson Sabes, 2006)

- Randomized to an *Immediate Treatment* or a *Control*, Delayed Treatment Group
- Positive Treatment Outcomes at the Group Level
    - Speech perception tests
    - Cognitive tests
    - Subjective measures of residual hearing difficulties and use of communication strategies

USF UNIVERSITY OF SOUTH FLORIDA

Further Examination of the Individual Data

(Henderson Sabes & Sweetow, 2007)

- Greater gains were made by Ss with:
  - Greater hearing losses
  - Poorer baseline sc
    - Recogni
    - with a Competing
  - degrees of self-perception of
    earing handicap

Considerable variability in individual outcome data

USF
UNIVERSITY OF SOUTH FLORIDA

Need for Continued Research

- Factors which might influence LACE outcomes

- **Veteran population**
  - Higher pre-fitting expectations for hearing aid use
  - More severe unaided self-report of problems associate with hearing loss
  - Poorer physical and mental health than non-veteran age equivalents (Cox et al, 2005)

UNIVERSITY OF SOUTH FLORIDA

Overview of Study

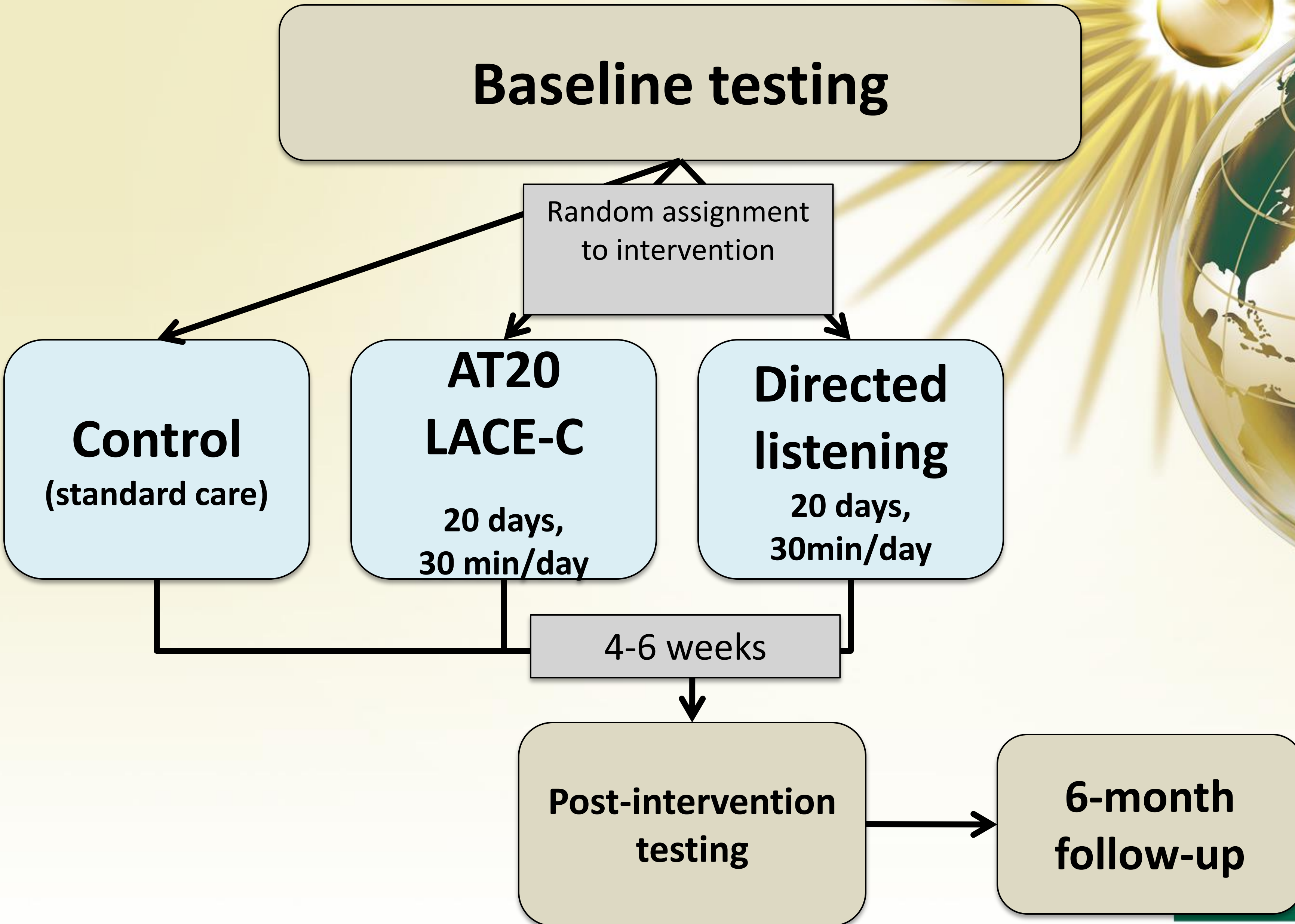
- Large scale (*n* = 279), Parallel Group Randomized Clinical Trial
- Veterans
- New and Experienced Hearing Aid Users
  - All hearing aids < 2 years old

UNIVERSITY OF SOUTH FLORIDA

➢ Interventions:

- Hearing Aid Use + Standard-of-care educational counseling
- Hearing Aid Use + LACE Computer training
- Hearing Aid Use + Directed Listening (Placebo)

Directed Listening to Books on computer for equivalent training period

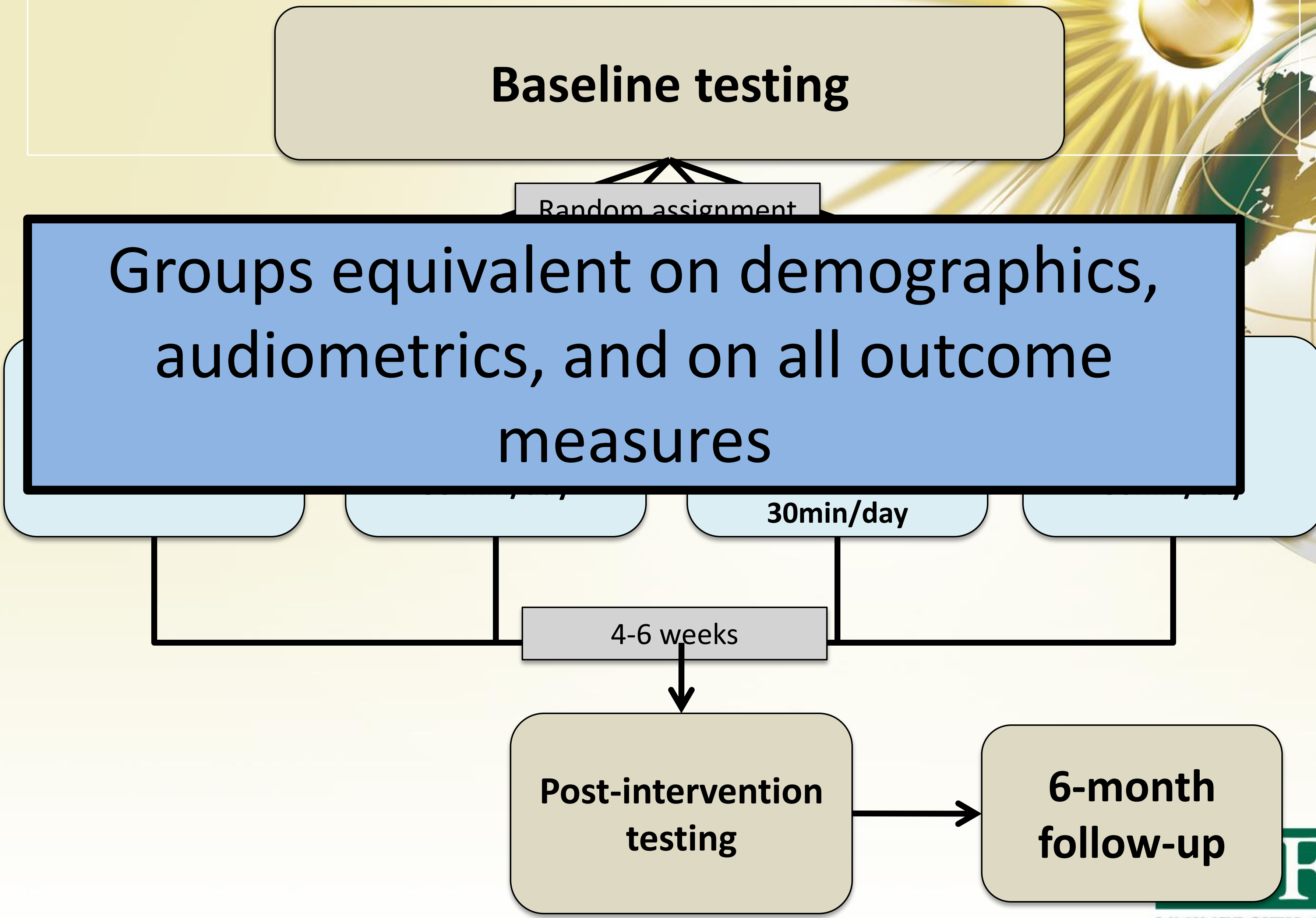


UNIVERSITY OF SOUTH FLORIDA

In addition…..

- **LACE** available in **two different modes** of administration
  - LACE-Computer
  - LACE-DVD
- Differ in recommended duration of training
  - LACE-Computer (20 sessions of training over 4 weeks)
  - LACE-DVD (10 sessions of training over 2 weeks)
    - Olsen et al. (2013) - Positive outcomes with LACE-DVD
- Compare **LACE-Computer (AT20)** to **LACE-DVD (AT10)**

USF
UNIVERSITY OF SOUTH FLORIDA


Baseline testing
Random assignment
Groups equivalent on demographics, audiometrics, and on all outcome measures
30min/day
4-6 weeks
Post-intervention testing
6-month follow-up

Outcome Measures Selected to Assess LACE^{TM} Trained Skills

LACE TASK	Outcome measure
Speech-in-babble	WIN: Identify NU-6 words presented in multi-talker babble at 7 SNRs (+24 to 0 dB), compute 50% correct SNR
Time-compressed speech	NU-6 words 45% and 65% compressed . Presented in quiet. Compute % correct .
Competing speaker	NU20: Female voice, NU20 words in carrier phase, sentence masker spoken by single male. Presented at 9 SNRs (+24 to -8 dB). Compute 50% correct SNR
Auditory working memory	Digit span: Forwards and backwards.
Missing word identification	R-SPIN-A sentences presented in multi-talker babble at 10 SNRs (+23 dB to -4 dB). Compute 50% correct SNR
Subjective ratings	HHIE/A: Social and Emotional scales APHAB: Ease of Communication , Reverberation , Background Noise , Aversiveness.

Compliance With Training

- Sweetow & Henderson Sabes (2010)
  - Compliance with LACE training by clinical patients was less than 30%

USF
UNIVERSITY OF SOUTH FLORIDA

Intervention	Assessed By	Estimate
Control		
AT10		Completed 30-100% of the 10 sessions
AT20	DTL+ Computer Logs	0-100% completed all 20 sessions
Placebo	DTL+ Computer Logs	10-100% completed all 20 sessions

USF
UNIVERSITY OF SOUTH FLORIDA

Intervention	Assessed By	Estimate
Control	No Formal Assessment	DNT HA function verified throughout study
AT10		Completed 30-100% of the 10 sessions
AT20	DTL+ Computer Logs	0-100% completed all 20 sessions
Placebo	DTL+ Computer Logs	10-100% completed all 20 sessions

Intervention	Assessed By	Estimate
Control	No Formal Assessment	DNT HA function verified throughout study
AT10	Daily Training Logs	Completed 30-100% of the 10 sessions
AT20	DTL+ Computer Logs	0-100% completed all 20 sessions
Placebo	DTL+ Computer Logs	10-100% completed all 20 sessions

USF
UNIVERSITY OF SOUTH FLORIDA

Intervention	Assessed By	Estimate
Control	No Formal Assessment	DNT HA function verified throughout study
AT10	Daily Training Logs	Completed 30-100% of the 10 sessions
AT20	DTL+ Computer Logs	Completed 0-100% of the 20 sessions
Placebo	DTL+ Computer Logs	10-100% completed all 20 sessions

USF
UNIVERSITY OF SOUTH FLORIDA

Intervention	Assessed By	...te
Control	No Formal Assessm...	...ed
AT10		...0% of ...sions
AT2...		...ompleted 0-100% of the 20 sessions
Placeb...	...puter Logs	Completed 10-100% of the 20 sessions

~ 70% of Ss completed training in each arm

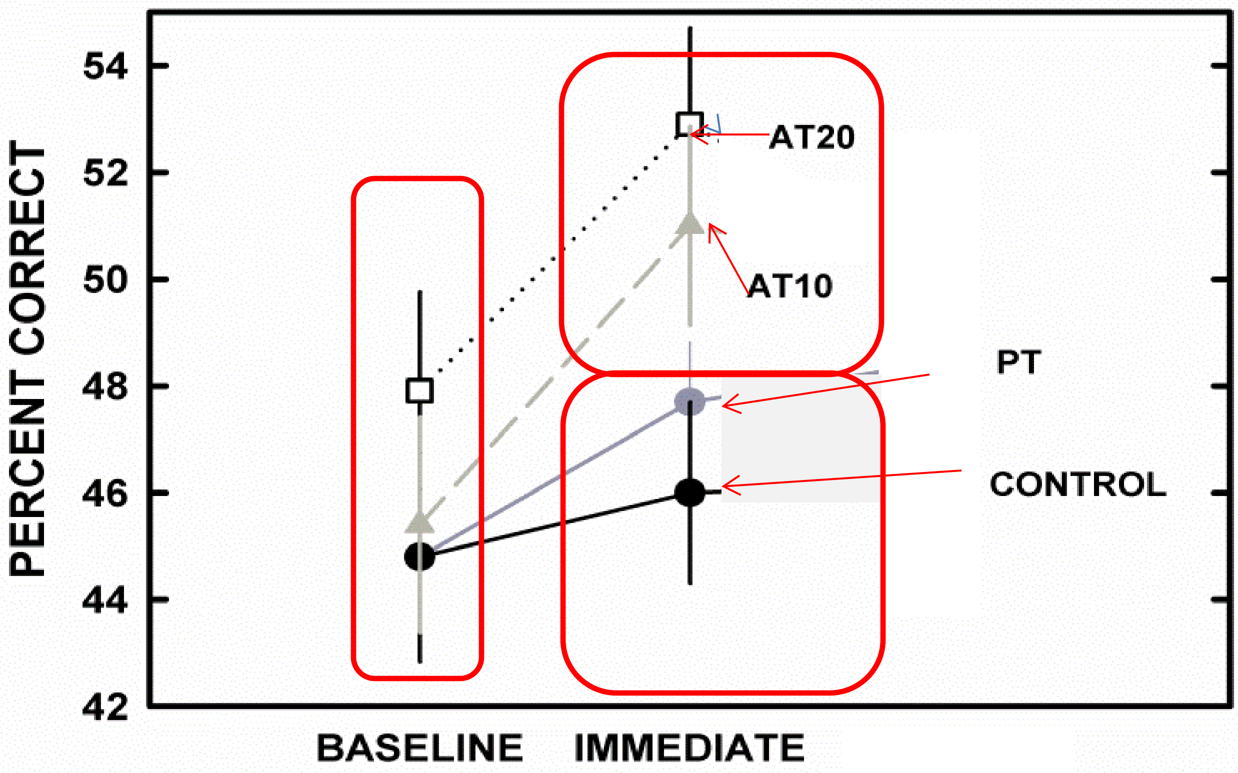
USF
UNIVERSITY OF SOUTH FLORIDA

Immediately Post-Intervention

Speech-in-babble	WIN: Identi[illegible] multi-talker babble at 7 SNRs (+24 [illegible]), compute [illegible]ect SNR
Time-compressed speech	NU-6 words 45% and 65% compressed . Presented in quiet. Compute % correct .
Competing speaker	NU20: Fema[illegible] NU20 words in [illegible]rier phase, sentence masker spoken [illegible] sented at 9 SNRs (+24 to -8 dB). Compute 50% correct SNR
Auditory working memory	Digit span: Backw[illegible] (STM)
Missing word identification	R-SPIN-A sen[illegible] presented in m[illegible]alker babble at 10 SNRs (+23 dB t[illegible] correct SNR
Subjective ratings	HHIE/A: Social and Emotional scales APHAB: Ease of Co[illegible] Reverberation , Background [illegible], Aversiveness.

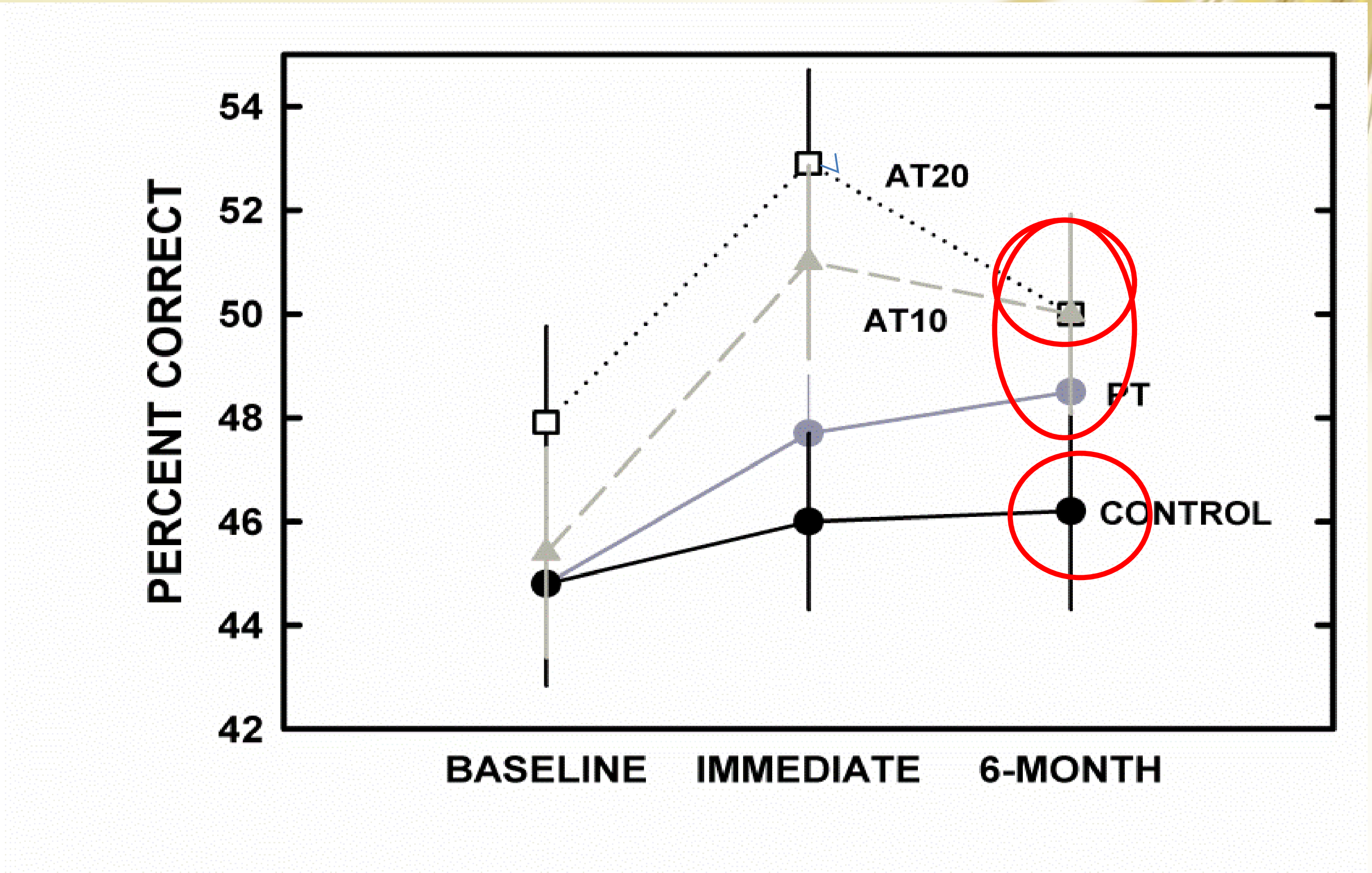
UNIVERSITY OF SOUTH FLORIDA

Compressed Speech 65% CR



USF
UNIVERSITY OF SOUTH FLORIDA

Compressed Speech 65% CR



Implication?

LACE Training might provide processing speed benefits under difficult listening conditions

Long-Term Outcomes

Benefits

Not clear that LACE training improves outcomes more than Directed Listening

UNIVERSITY OF SOUTH FLORIDA

Comparison to Published Data

- Findings not as robust as previously reported by (Sweetow & Sabes, 2006; Sweetow & Sabes, 2007)
  - Difference in design
    - Delayed Treatment Crossover
    - Between-Groups Design
  - Differences in outcome measures (e.g., QuickSIN vs. WIN)
    - Equivalence of performance established (Wilson, McArdle & Smith, 2007)
    - But some outcome measures the same (e.g., HHIE)

USF UNIVERSITY OF SOUTH FLORIDA

Differences in Participant Groups:
Non-Veterans vs. Veterans

UNIVERSITY OF SOUTH FLORIDA

Differences in Participant Groups:

Factor	Sweetow & Sabes	Present Study
Hearing Aid Experience	85% Bilateral HA users (experienced) + 9 Non Hearing Aid Users	Both New & Experienced Hearing Aid Users – All fit bilaterally
Hearing Aids		
Age		
Hearing Loss (PTA)		

Differences in Participant Groups:

Factor	Sweetow & Sabes	Present Study
Hearing Aid Experience	85% Bilateral HA users (experienced) + 9 Non Hearing Aid Users	Both New & Experienced Hearing Aid Users – All fit bilaterally
Hearing Aids		
Age		
Hearing Loss (PTA)		

Differences in Participant Groups:

Factor	Sweetow & Sabes	Present Study
Hearing Aid Experience	85% Bilateral HA users (experienced) + 9 Non Hearing Aid Users	Both New & Experienced Hearing Aid Users – All fit bilaterally
Hearing Aids	Unknown	< 2 years old
Age		
Hearing Loss (PTA)		

USF
UNIVERSITY OF SOUTH FLORIDA

Differences in Participant Groups:

Factor	Sweetow & Sabes	Present Study
Hearing Aid Experience	85% Bilateral HA users (experienced) + 9 Non Hearing Aid Users	Both New & Experienced Hearing Aid Users – All fit bilaterally
Hearing Aids	Unknown	< 2 years old
Age	28-92 years old	55-85 years old
Hearing Loss (PTA)		

USF UNIVERSITY OF SOUTH FLORIDA

Differences in Participant Groups:

Factor	Sweetow & Sabes	Present Study
Hearing Aid Experience	85% Bilateral HA users (experienced) + 9 Non Hearing Aid Users	Both New & Experienced Hearing Aid Users – All fit bilaterally
Hearing Aids	Unknown	< 2 years old
Age	28-92 years old	55-85 years old
Hearing Loss (PTA)	1.7 dB – 102 dB	5.0 dB – 57.0 dB

UNIVERSITY OF SOUTH FLORIDA

Need to Examine Individual Differences in Response to Intervention

Can Predictors be Identified?

Exploratory Forward Stepwise Linear Regression Analyses

- Baseline demographic characteristics
  - Age
  - 3-Frequency PTA (Better Ear)
  - High Frequency PTA (Better Ear)
  - Word recognition in quiet (NU-6; Binaural)
  - Word recognition in noise (Unaided)
  - Education
  - Motivation to improve hearing

USF
UNIVERSITY OF SOUTH FLORIDA

Exploratory Forward Stepwise Linear Regression Analyses

- Basic Hearing Aid Characteristics
  - Hearing Aid Experience
  - Length of time of current hearing aid use
  - Aided Audibility Index (Better Ear)
- Baseline performance for the outcome measure
- Treatment Arm
  - Control
  - AT10
  - AT20
  - Placebo

USF UNIVERSITY OF SOUTH FLORIDA

Results

- After trimming for outliers, and transforming categorical variables to similar "groupings"
- Significant models for all Outcomes
  - Not surprising given our *n*
- Account for ~ **15-40%** of the variance
- For all Outcomes, "**Baseline Performance**" strongest predictor
  - Similar to Sabes & Sweetow (2007) poorer performers at Baseline showed greatest gains

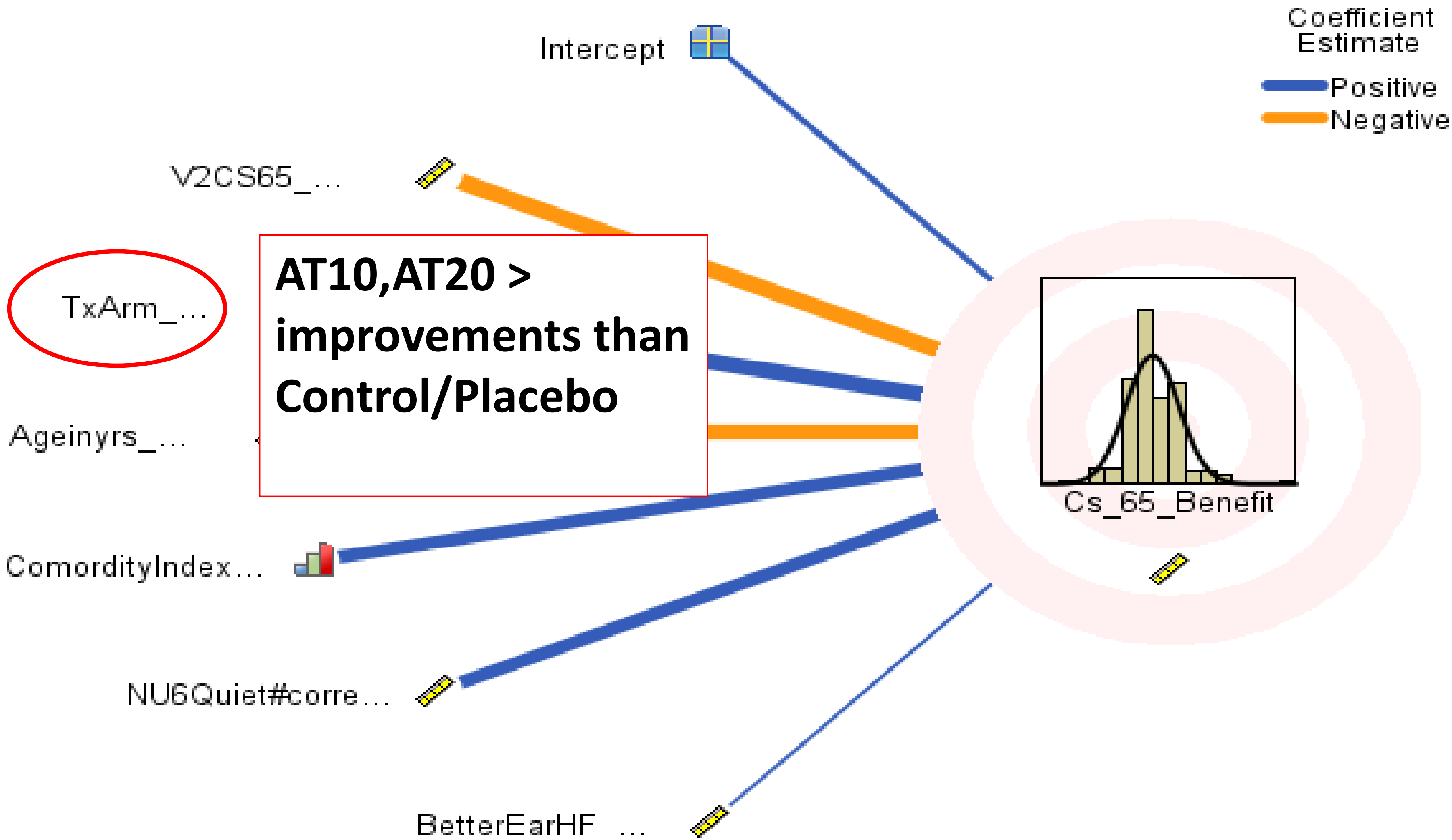
USF UNIVERSITY OF SOUTH FLORIDA

Results

- For all Outcomes, some aspect of "**hearing**" (i.e., PTA, HF-PTA, word recognition quiet, word recognition noise) was a significant predictor
  - As hearing loss increased, outcomes improved
- Depending on Outcome, other demographic and/or hearing aid related variables were significant predictors
- **Treatment Arm** significant in 3 models

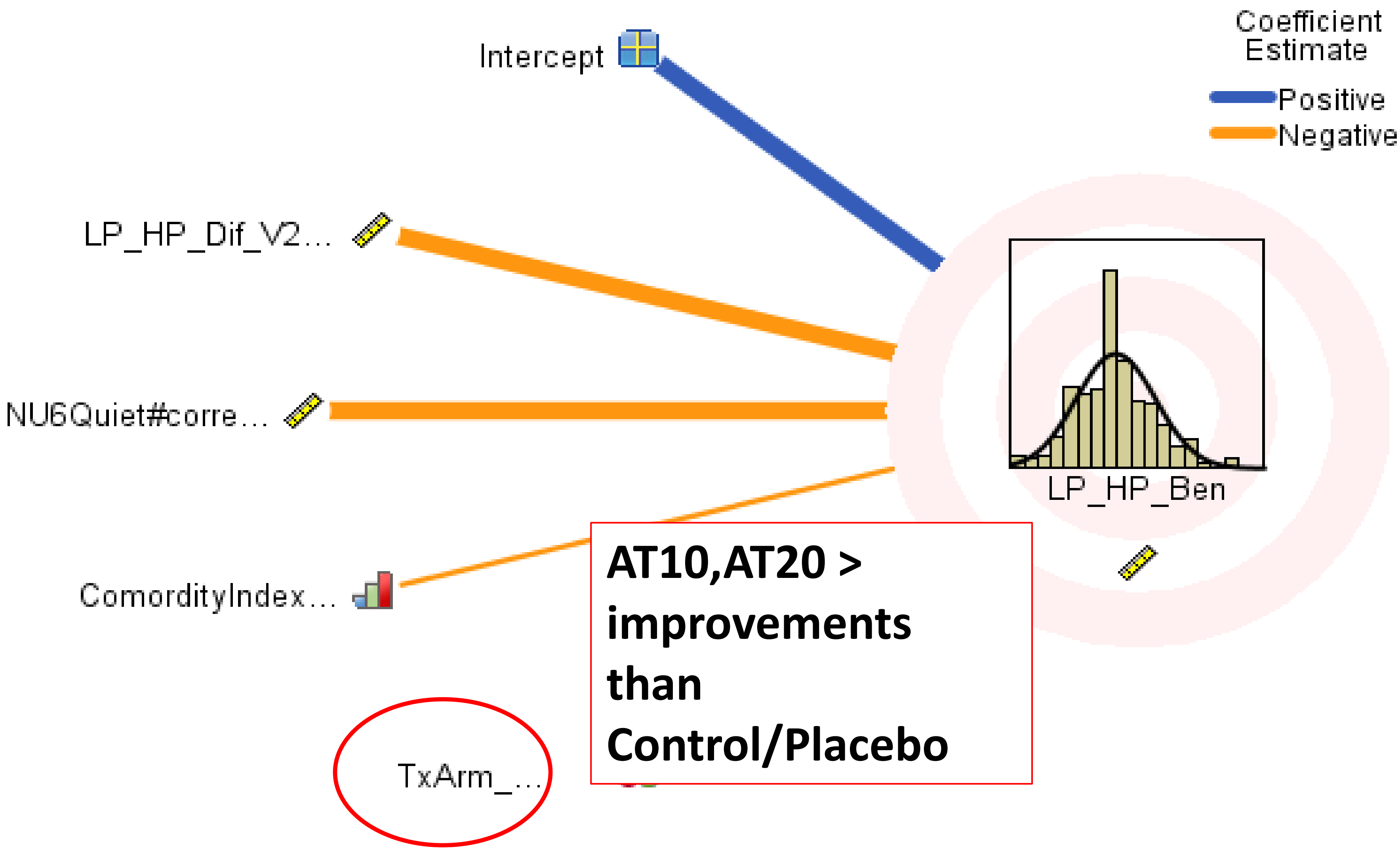
USF UNIVERSITY OF SOUTH FLORIDA

Compressed Speech 65%



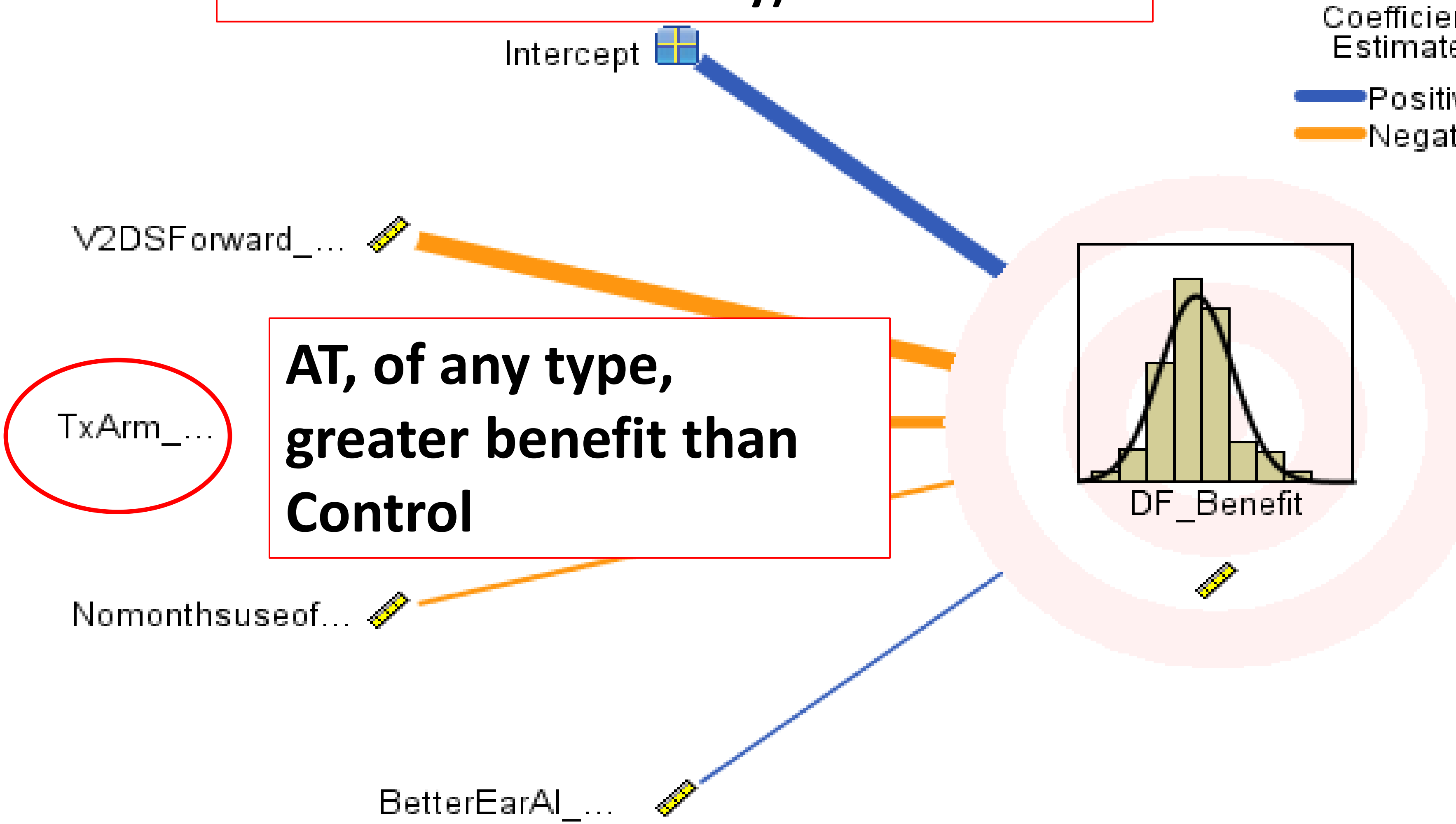
AT10,AT20 > improvements than Control/Placebo

LP – HP Difference (Context Use)



AT10,AT20 > improvements than Control/Placebo

Digit Span Forward (Short Term Memory)



AT, of any type, greater benefit than Control

Summary of 1st Study

- RCT results
  - Little benefit from LACE training
- RCTs have limitations
  - Do not take into account individual differences
- Initial exploratory analyses
  - LACE training may provide benefits **to some individuals** for:
    - Compressed Speech
    - Context Use
    - Short-term memory tasks

Implication for Connected AR:

One size doesn't fit all

UNIVERSITY OF SOUTH FLORIDA

Who will benefit from which training?

USF
UNIVERSITY OF SOUTH FLORIDA

Study #2: Evaluation of Approaches to Auditory Rehabilitation for mTBI

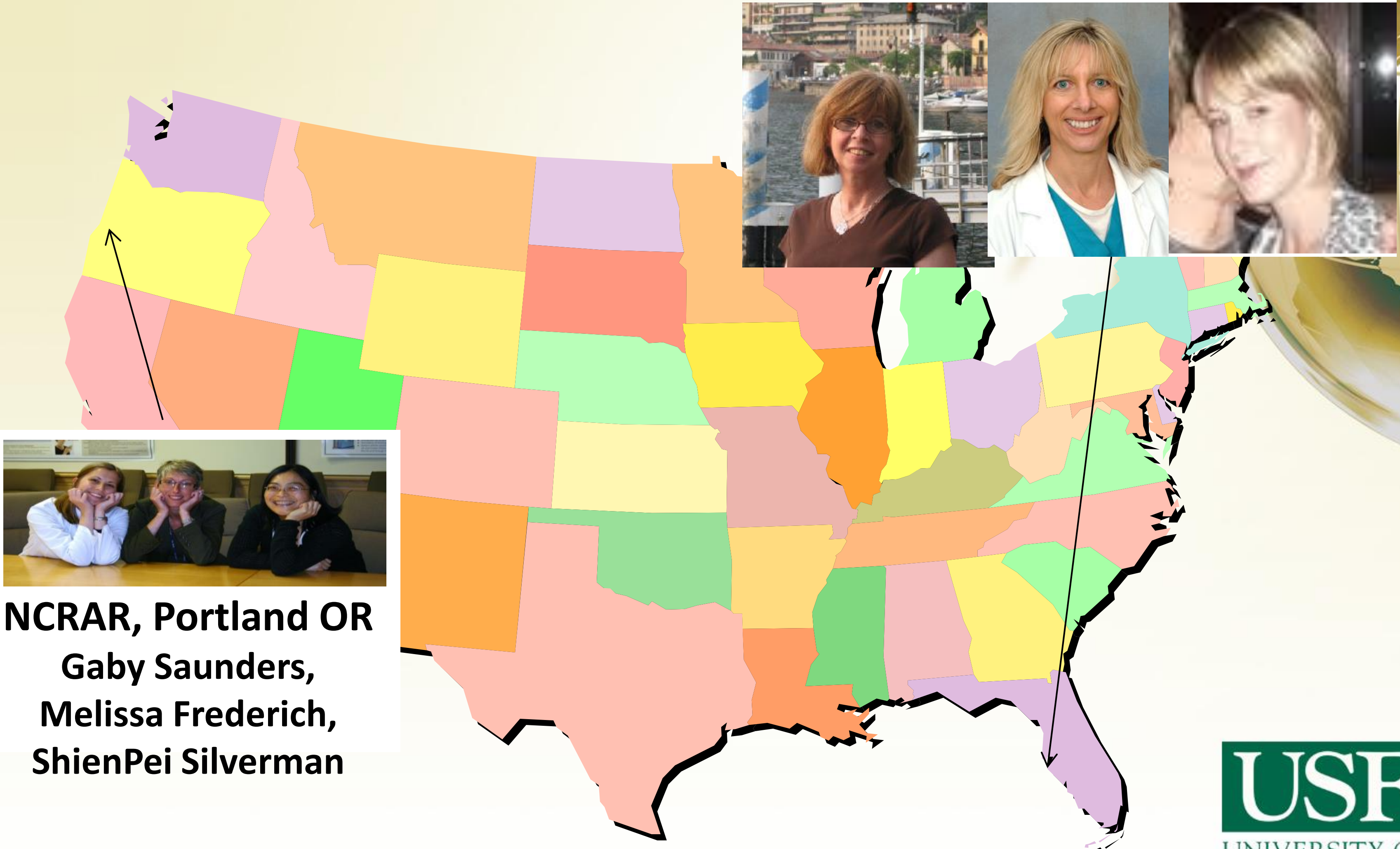
Study funded by VA RR&D grant #: C7054R

(G. Saunders, PI)

and Phonak who provided study equipment

USF
UNIVERSITY OF SOUTH FLORIDA

James A. Haley VA, Tampa, FL, U. South Florida: Terry Chisolm, Paula Myers, Michelle Arnold,



NCRAR, Portland OR
Gaby Saunders,
Melissa Frederich,
ShienPei Silverman

USF
UNIVERSITY OF SOUTH FLORIDA

Why are we interested in this?

Data show that:

- **About 300,000 Operation Enduring Freedom (OEF)/Operation Iraqi Freedom (OIF) Veterans have some form of traumatic brain injury (TBI)**
- **About 75% of wounds are due to exposure to a blast(s)**

Owens et al (2008) J Trauma., 64(2): 295-99

USF
UNIVERSITY OF SOUTH FLORIDA

66% of Veterans with deployment-related TBI and blast complained of auditory difficulties. Of these:

- **35-54% have SNHL**
- **7% conductive (ruptured TM)**
- **20% have ‘normal or almost normal’ thresholds**

Saunders & Echt (2012), JRRD, 49(7): 1043-1058 2012

USF UNIVERSITY OF SOUTH FLORIDA

Subjective impacts

- **Hearing in background noise**
- **Following rapid speech**
- **Following instructions**
- **Following long conversations**
- **Tinnitus**
- **Hyperacusis**

i.e. indicative of auditory processing problems

Reported difficulties:

- **Hearing in background noise** — **Signal-to-noise ratio (SNR)**
- **Following rapid speech** — **Temporal processing**
- **Following instructions and long conversations** — **Working memory**

Interventions

FM system

- Will be effective at improving SNR, if used correctly
- A prop rather than a 'fix'; requires an external device

Auditory Training

- Potential for sustainable change (a fix) for processing difficulties.
- Requires discipline and time commitment before any benefit may be realized.

UNIVERSITY OF SOUTH FLORIDA

Interventions

- **Phonak Zoomlink transmitter and binaural iSense receivers**

- **Brain Fitness Program - computer-based training program developed by Merzenich et al., distributed by Posit Science.**

  Designed to train:

  Temporal processing

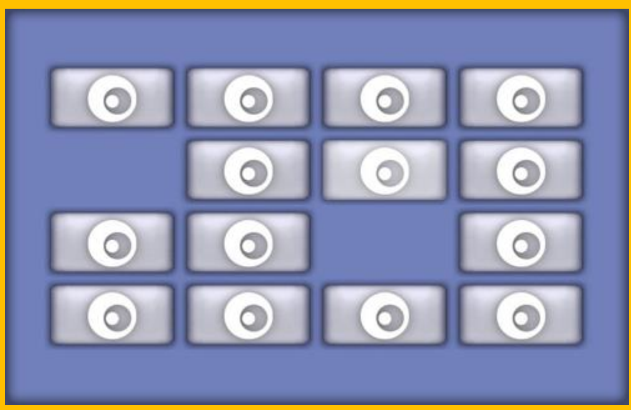
  Auditory working memory

  40 sessions, 60 min/day

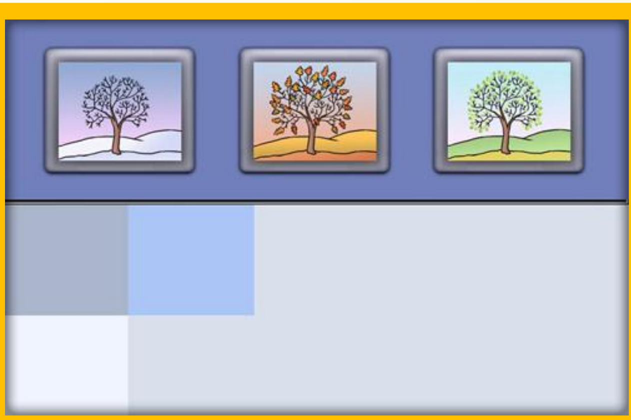
USF
UNIVERSITY OF
SOUTH FLORIDA

The Brain Fitness Program: Training Tasks

- **High or Low?**
- **Tell Us Apart**
- **Match It!**



- **Sound Replay**
- **Listen and Do**
- **Story Teller**

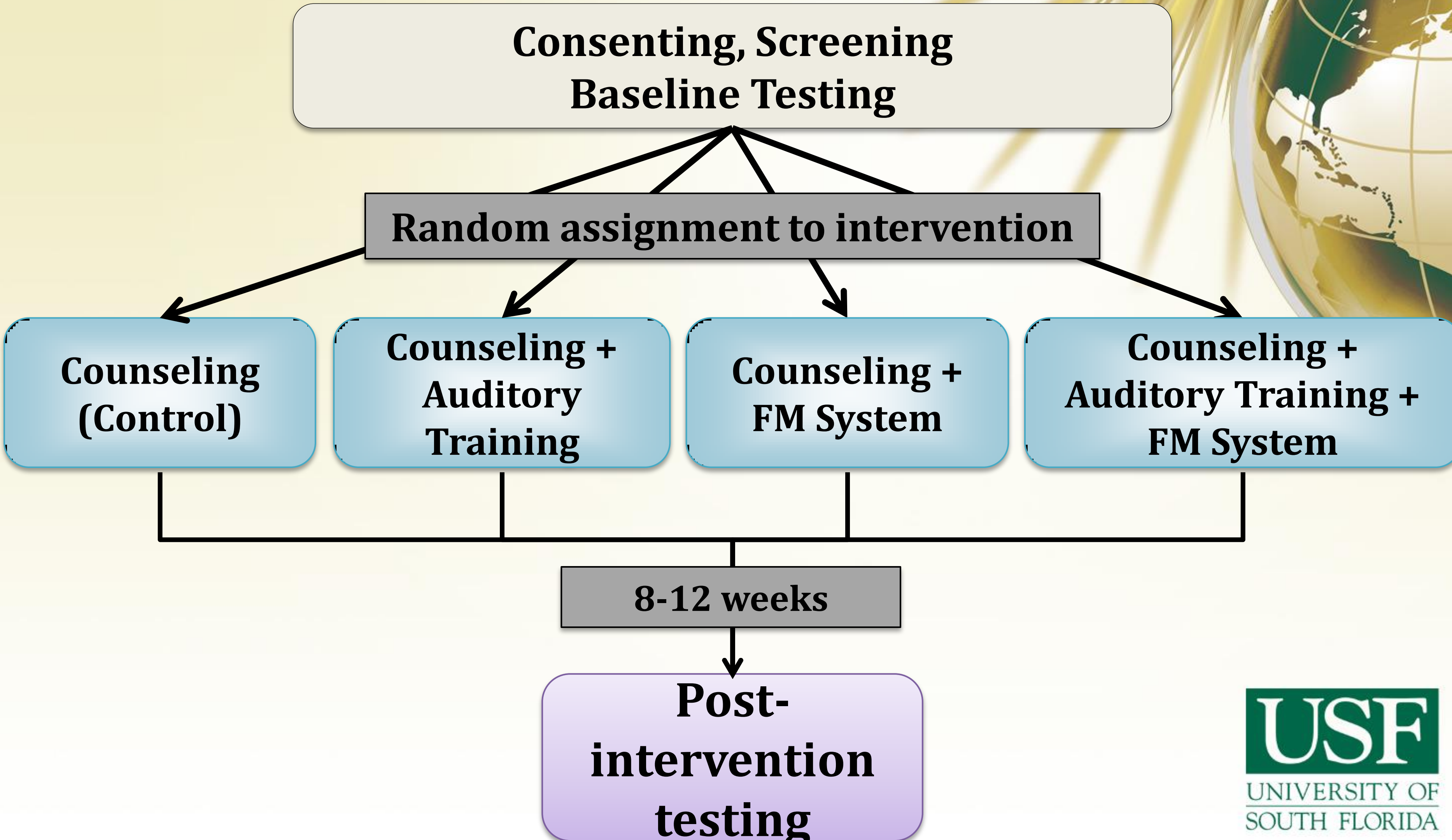


Participants

- OEF/OIF Veterans
- Normal or near normal peripheral hearing sensitivity
- Reported blast exposure during deployment
- Self-reported functional hearing difficulties

USF UNIVERSITY OF SOUTH FLORIDA

2-site RCT



USF UNIVERSITY OF SOUTH FLORIDA

Outcome Measures: Performance

Test measure	Rationale for Testing
Gap detection - Adaptive Tests of Temporal Resolution ATTR	Trained with AT
Time Compressed Speech	Trained with AT
Working memory - Digit Span Test WAIS III	Trained with AT. May improve with FM use
Dichotic - Staggered Spondaic Word test (SSW)	Indications from other studies
Attention/Interference - Stroop Color Word Test	Trained with AT. May improve with FM use
Speech-in-noise - HINT	Will improve with FM.

Self-Report Outcome Measures

Test	Rationale
Speech Spatial and Qualities Questionnaire - comparative (SSQ-C)	
Cognitive Self-Report Questionnaire (CSRQ)	
Psychosocial Impact of Assistive Devices Scale (PIADS)	

UNIVERSITY OF SOUTH FLORIDA

Self-Report Outcome Measures

Test	Rationale
Speech Spatial and Qualities Questionnaire - comparative (SSQ-C)	Likely to improve with FM; may improve with AT
Cognitive Self-Report Questionnaire (CSRQ)	
Psychosocial Impact of Assistive Devices Scale (PIADS)	

UNIVERSITY OF SOUTH FLORIDA

Self-Report Outcome Measures

Test	Rationale
Speech Spatial and Qualities Questionnaire - comparative (SSQ-C)	Likely to improve with FM; may improve with AT
Cognitive Self-Report Questionnaire (CSRQ)	Some scales likely to improve following one or both interventions
Psychosocial Impact of Assistive Devices Scale (PIADS)	

UNIVERSITY OF SOUTH FLORIDA

Self-Report Outcome Measures

Test	Rationale
Speech Spatial and Qualities Questionnaire - comparative (SSQ-C)	Likely to improve with FM; may improve with AT
Cognitive Self-Report Questionnaire (CSRQ)	Some scales likely to improve following one or both interventions
Psychosocial Impact of Assistive Devices Scale (PIADS)	May improve following either intervention

UNIVERSITY OF SOUTH FLORIDA

Results

Data collected from 86 participants.

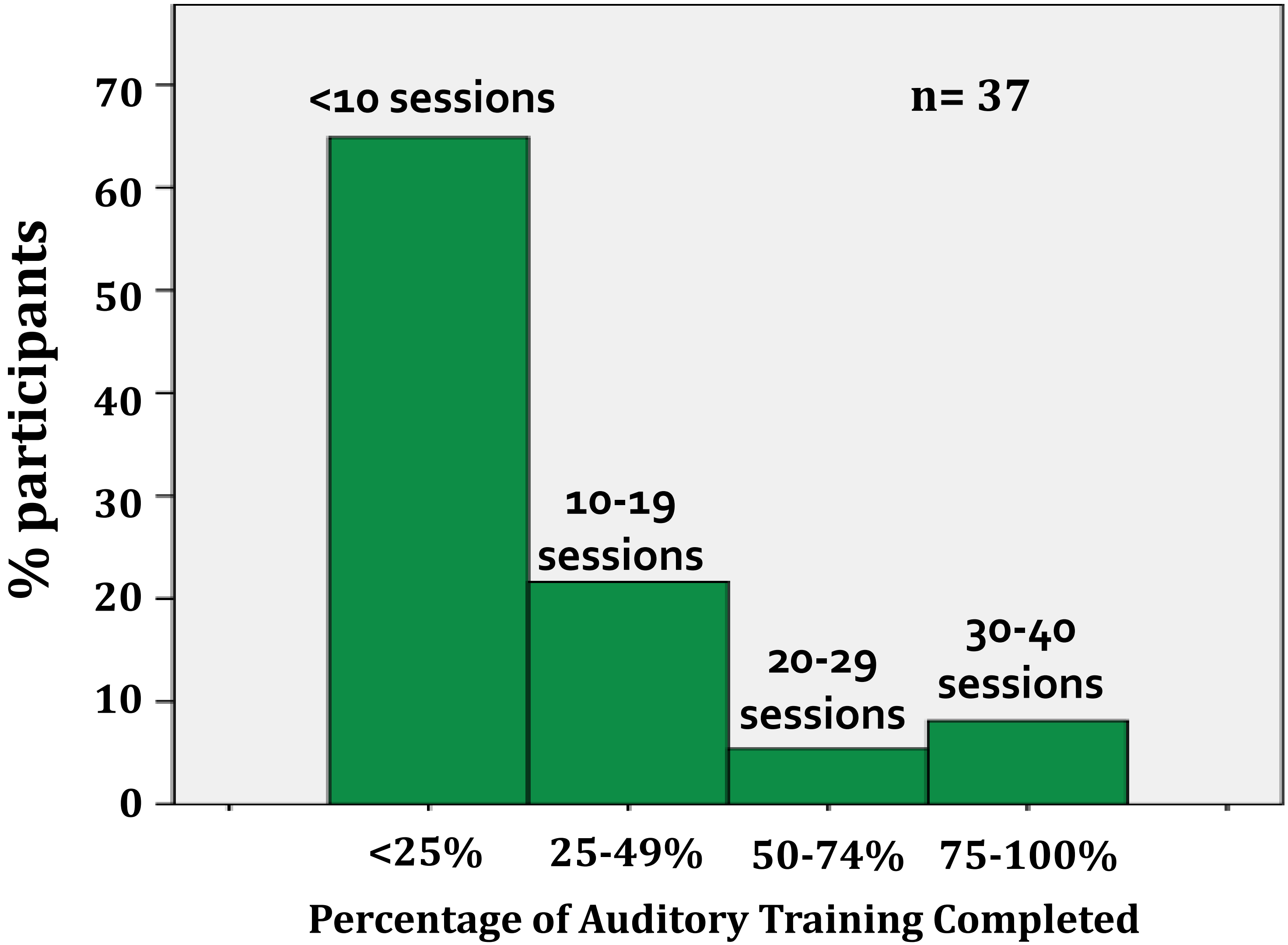
	FM+AT	AT	FM	Control
n	22	15	24	25
Age	33.1	34.8	33.9	33.7
4F-PTA	13.4	11.0	12.1	12.1
Gender	Male: 22 Female: 0	Male: 12 Female:3	Male: 19 Female: 5	Male: 22 Female:3

USF
UNIVERSITY OF SOUTH FLORIDA

Results

Did the participants use the interventions?

Compliance with intervention Auditory Training



Compliance FM System

- **1 individual did not use FM at all**
- **13 wore it hardly ever**
- **25 wore it a few times a week**
- **7 used it every day**

Average use per day = 2.9 hr, range: 0-9

USF UNIVERSITY OF SOUTH FLORIDA

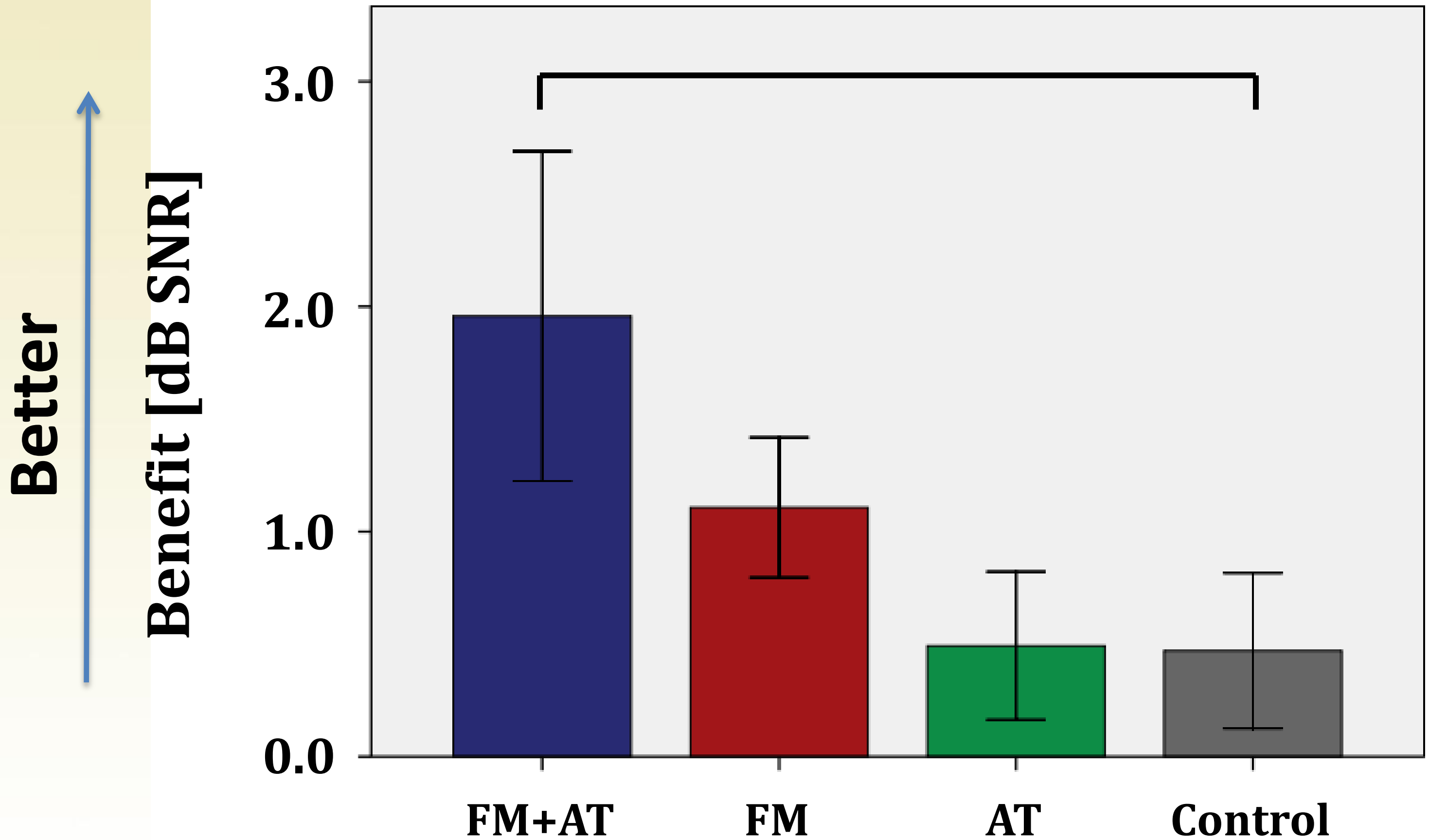
Analyses of the Preliminary Data

Test measure	Rationale for Testing
Gap detection - Adaptive Tests of Temporal Resolution ATTR	Trained with AT
Time Compressed Speech	Trained with AT
Working memory - Digit Span Test WAIS III	Trained with AT. May improve with FM use
Dichotic - Staggered Spondaic Word test (SSW)	Indications from other studies
Attention/Interference - Stroop Color Word Test	Trained with AT. May improve with FM use
Speech-in-noise - HINT	Will improve with FM.

Self-Report Outcome Measures

Test	Rationale
Speech Spatial and Qualities Questionnaire - comparative (SSQ-C)	Likely to improve with FM; may improve with AT
Cognitive Self-Report Questionnaire (CSRQ)	Some scales likely to improve following one or both interventions
Psychosocial Impact of Assistive Devices Scale (PIADS)	May improve following either intervention

Speech-in-Noise - HINT



UNIVERSITY OF SOUTH FLORIDA

Summary of Study #2

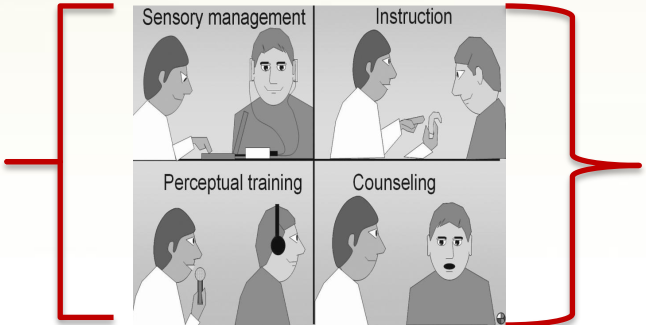
Interventions are showing some small but positive outcomes for

- ✓ temporal processing
- ✓ speech-in-noise
- ✓ Reported auditory difficulties
- ✓ Reported cognitive processing

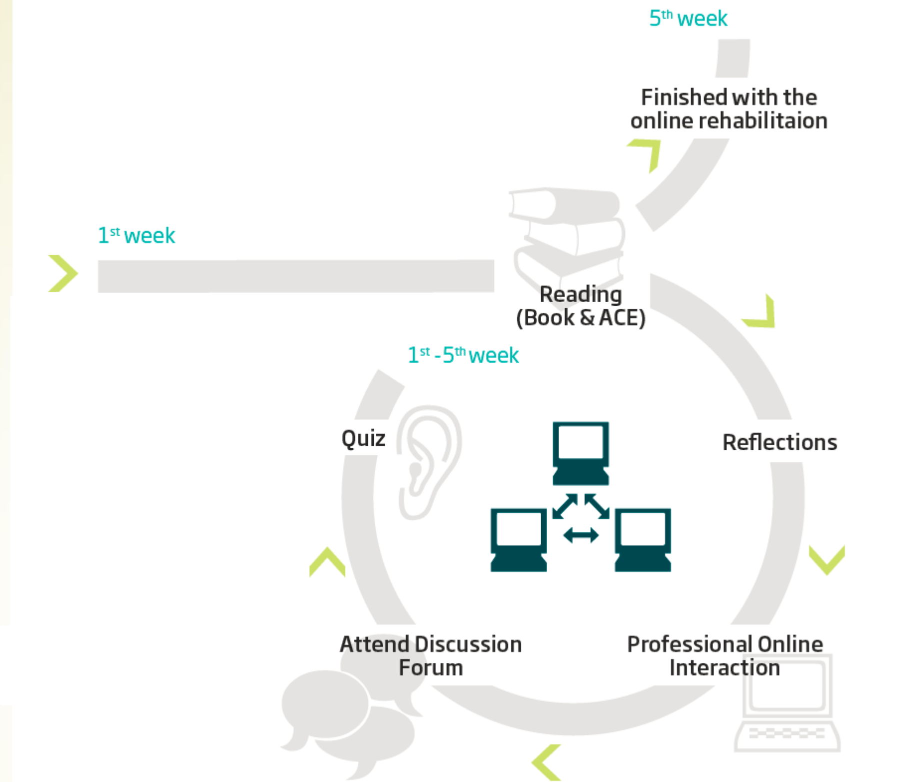
- Combination of AT and FM appears to be most effective
- There are individual differences in compliance and in outcome

Implications of Our 2 Studies for Connected AR

- Well-controlled RCTs
  - Add to the evidence-base for auditory training in adults
- Data are not overwhelming
  - But doesn't hurt and might help
- ***Are we measuring the right outcomes?***
- ***Should other aspects of AR be included?***



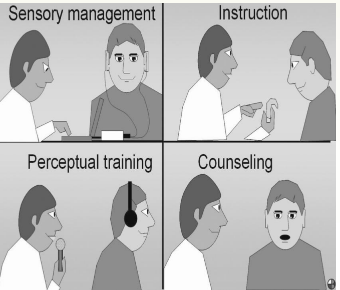
UNIVERSITY OF SOUTH FLORIDA



Poster Session

Naylor, Thoren, Andersson & Lunner

" A Randomized Controlled Trial of Professional Online Rehabilitation for Adult Hearing Aid Users"



UNIVERSITY OF SOUTH FLORIDA

The Digital Era: Computer-Based AR

1980s – 1990s

- Computer-control of audio-video playback equipment

Late 1990s-Current

- Home-based systems using -
  - Desktops
  - Laptops
  - Tablets

Future

The Digital Era: Computer-Based AR

1980s – 1990s

- Computer-control of audio-video playback equipment

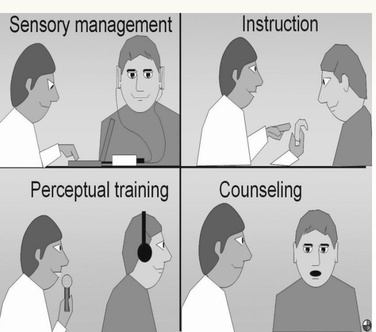
Late 1990s-Current

- Home-based systems using -
  - Desktops
  - Laptops
  - Tablets

Future

- ?

Social Networking



Warning: this is disruptive technology

Major Social Media Sites and Uses

- **Facebook:** "I ate." (social networking)
- **Youtube:** "Look at this eating!" (video)
- **Twitter:** "I need to eat." (microblog)
- **Linkedin:** "I am good at eating." (business networking)
- **Foursquare:** "This is where I ate." (location)
- Fluid and constantly changing based on new technology, websites, etc. All have mobile apps.

Glossary of Social Media Terms:
http://www.socialbrite.org/sharing-center/glossary/

USF UNIVERSITY OF SOUTH FLORIDA

Hitchhikers Guide to … Social Media?

- everything that's already in the world when you're born is just normal;
- anything that gets invented between then and before you turn thirty is incredibly exciting and creative and with any luck you can make a career out of it;
- anything that gets invented after you're thirty is against the natural order of things and the beginning of the end of civilisation as we know it
- until it's been around for about ten years when it gradually turns out to be alright really.

Douglas Adams. How to Stop Worrying and Learn to Love the Internet. 1999.
http://www.douglasadams.com/dna/19990901-00-a.html

USF UNIVERSITY OF SOUTH FLORIDA

Cloud Computing

UNIVERSITY OF SOUTH FLORIDA

Cloud Computing for Enhanced Mobile Health Applications

M.T Nkosi, F. Mekuria SM IEEE
CSIR Modelling and Digital Sciences
Mobile Computing & Security Unit
Meiring Naude Road, Pretoria 0001, South Africa
mnkosi@csir.co.za, fmekuria@csir.co.za

Figure 1: Cloud-Based Mobile Health Security Management

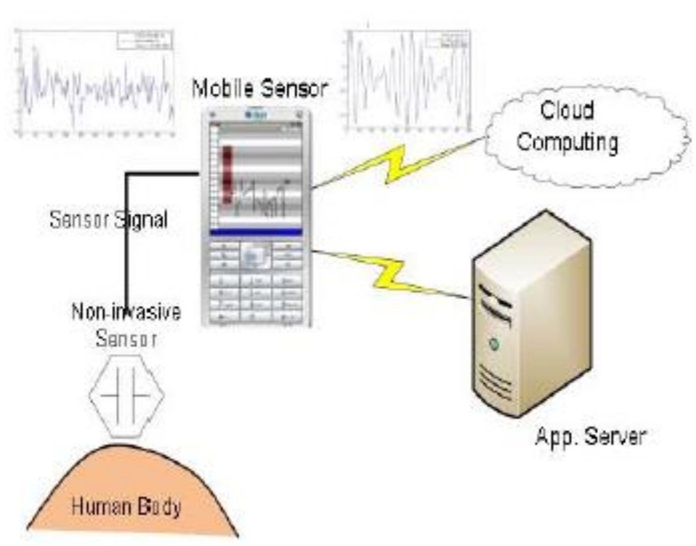


Figure 2: Sensor based Mobile Health Service

ReadmyQuips™

Speech Comprehension Training System

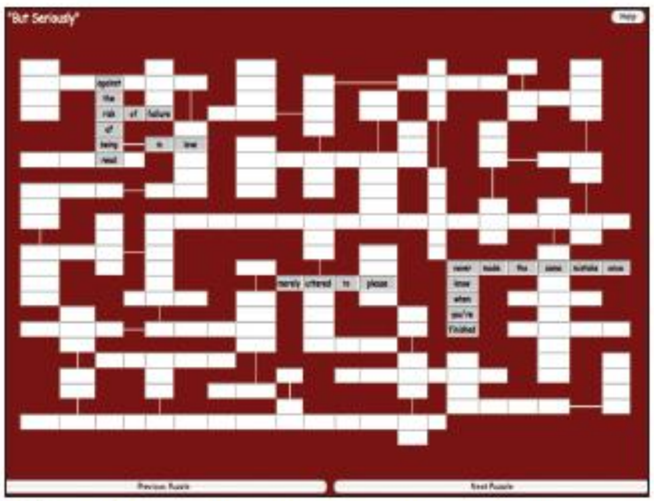


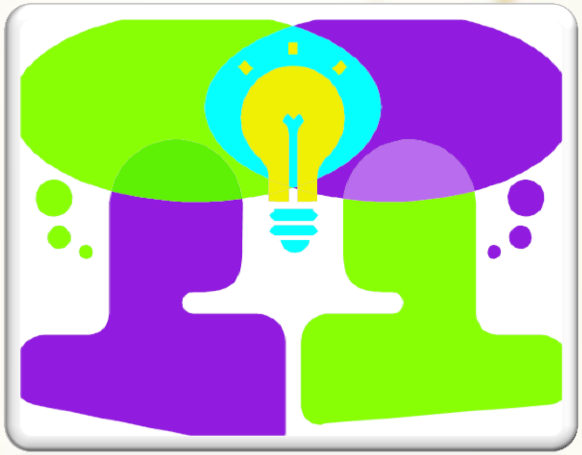
Figure 1. *Example of one of the Read My Quips puzzles.*

- **Poster Session**
  Block & Abrams
- *An Evaluation of the Efficacy of a Remotely-Delivered Auditory Training Program*

USF
UNIVERSITY OF SOUTH FLORIDA

Pattern of Technological Development

- Next leap forward results from
  - Implementation of new ideas in Rehabilitative Audiology
  - New technological advances
  - **Synergy of new ideas in both technology and audiology**



Levitt et al., 2012

USF
UNIVERSITY OF SOUTH FLORIDA

The Ida Institute

"Exploring the Human Dynamics of Hearing"

http://idainstitute.com/

About the Ida Institute

- Funded by the Oticon Foundation
- Established as an independent non-profit organization 2007
- *Foster a better understanding of the human dynamics associated with hearing loss*

USF
UNIVERSITY OF
SOUTH FLORIDA

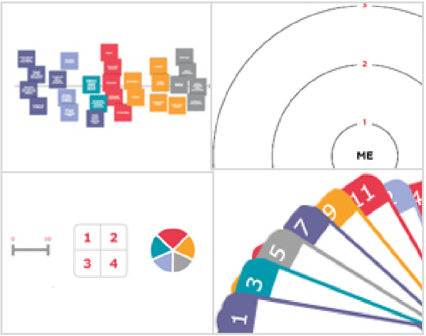
Collaborative Development Key Value and Method

- Uncovering unmet needs of hearing healthcare professionals for working with their patients
- Creating tools/methods/techniques to meet the unmet needs
- Promotes patient-centered care

USF UNIVERSITY OF SOUTH FLORIDA

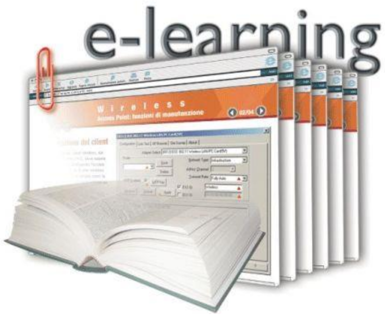
Ida World

Seminars



Tools

Workshops



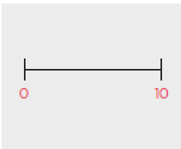
E-learning

Global Community

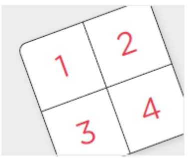
Academic Panels

Ida Tools

Patient Motivation



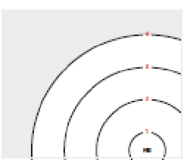
The Line



The Box

The Circle

Engaging Family and Friends

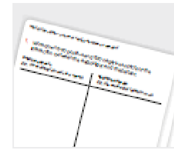


Communication Rings

Goal Sharing for Partners (GPS)

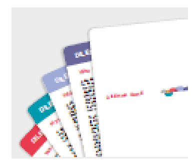
Communication Partner Journey

Self-Development in the Clinical Setting

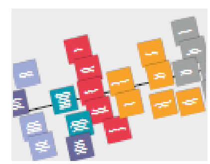


Mirror Exercises

The Reflective Journal



Dilemma Game

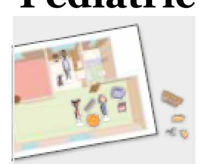


A Possible Partner Journey

Living Well with Hearing Loss

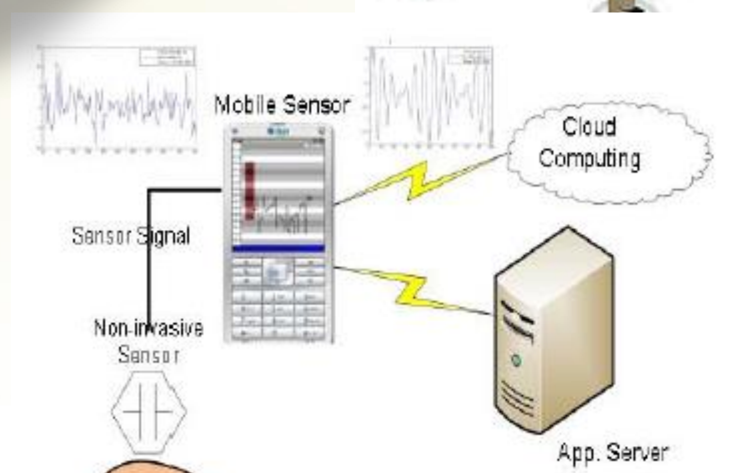
Living Well

Pediatric Audiology



My World

Integration of



USF
UNIVERSITY OF
SOUTH FLORIDA

Make the "**leap**" that will lead us further to our goal of assuring **Optimal Outcomes** for all of our Patients with Hearing Loss

UNIVERSITY OF SOUTH FLORIDA

Thank you for listening…

chisolm@usf.edu

USF
UNIVERSITY OF SOUTH FLORIDA