Telepractice for Cochlear Implants

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Disclosures

- Financial:
  - Michelle Hughes and Sara Robinson are employed by Boys Town National Research Hospital.
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- Non-Financial:
  - Michelle Hughes is a member of the Ear & Hearing editorial board, member of AAS, AAA, ASHA, and ASA.
  - Sara Robinson is a member of the Hearing Loss Association of America.

Learner Objectives

Following this course, learners will be able to:

- Describe the factors that underlie the need for remote clinical services for speech-perception testing and aural rehabilitation with cochlear implant recipients.
- Explain how speech-perception scores obtained remotely using direct-connect compare to those obtained in person in a south booth.
- Describe important components of adult aural rehabilitation for cochlear implant recipients.

Overview

- Background: The Big Picture
- Study 1: Speech-perception testing in CI recipients (Michelle Hughes)
- Study 2: Aural rehabilitation with adult CI recipients (Sara Robinson)

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Background

- Why is telepractice needed for CI recipients?

Reason #1: Lots of visits!

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Background

- Why is telepractice needed for CI recipients?
  - Audiology/Programming:
    - 6-8 visits in first year (more for kids)
    - 1-2 visits yearly thereafter
    - Additional visits for problems or upgrades
  - Speech/language/listening therapy:
    - Number of sessions depends on recipient needs & resources
  - Medical follow-up:
    - Typically just one visit prior to IS; more if complications

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Background

- Why is telepractice needed for CI recipients?

Reason #2: CI centers are not on every corner!

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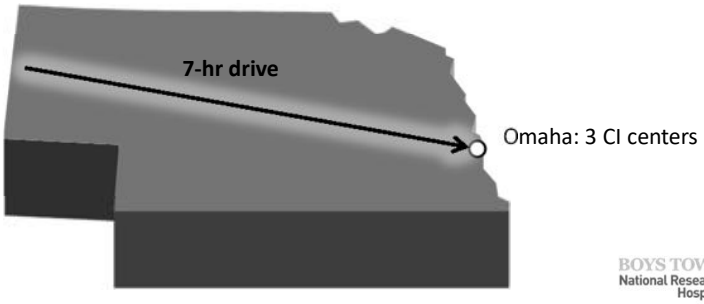
Background

- Why is telepractice needed for CI recipients?

Reason #2: CI centers are not on every corner!



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Background

- Options for those who live far from the center:
  - Travel a LOT
    - Costs time (missed work/school) and money
  - Forego or minimize services
    - Suboptimal outcomes
  - Telepractice!

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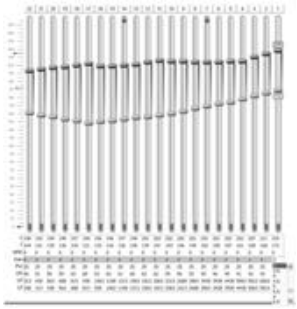
Background

- Previous studies with CIs: focus on remote processor mapping with adults
  - Ramos et al. (2009)
  - McElveen et al. (2010)
  - Wesarg et al. (2010)
  - Eikelboom et al. (2014)
  - Hughes et al. (2012)



- Outcomes: it can be done!

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Background

- But what about everything else?
  - Speech perception testing
  - Troubleshooting equipment
  - Sound-field thresholds
  - Aural rehabilitation (adults)
  - Pediatric CI programming
  - Aural habilitation (children)

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Background

- Our current studies are focusing on:
  - Speech perception testing – Study 1
  - Troubleshooting equipment
  - Sound-field thresholds
  - Aural rehabilitation (adults) – Study 2
  - Pediatric CI programming
  - Aural habilitation (children)

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Background

- Our current studies are focusing on:
  - Speech perception testing – Study 1
  - Troubleshooting equipment
  - Sound-field thresholds
  - Aural rehabilitation (adults) – Study 2
  - Pediatric CI programming – *Goehring & Hughes (2017) JSLHR*
  - Aural habilitation (children)

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Study 1: Remote Speech-Perception Testing for Cochlear Implant Recipients

Michelle L. Hughes, Ph.D., CCC-A
Joshua Sevier, Au.D.
Sangsook Choi, Ph.D.
Daniel Valente, Ph.D.

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Introduction

- *Hughes et al. (2012) JSLHR* – First comprehensive study on telepractice with CIs
- Remote vs. in-person outcomes for a battery of measures:
  - Electrode impedance
  - Map levels (T & C/M)
  - ECAP thresholds
  - Psychophysical thresholds (3IFC, research software)
  - Speech perception

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Introduction

- *Hughes et al. (2012) JSLHR* – First comprehensive study on telepractice with CIs
- Remote vs. in-person outcomes for a battery of measures:
  - Electrode impedance
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  - ECAP thresholds
  - Psychophysical thresholds (3IFC, research software)
  - Speech perception

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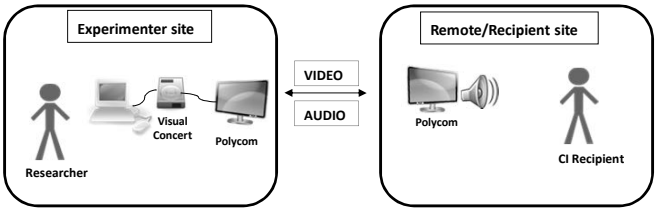
Introduction

- *Hughes et al. (2012) JSLHR*
- Methods for speech-perception testing:
  - 29 CI recipients (adults & older kids)
  - 3 visits, ABA design (A: in-person in booth, B: remote in room)
  - 2 sets of measures at each visit



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Introduction

- *Hughes et al. (2012) JSLHR*
- Polycom system with visual concert:
  - Two-way audio/video
  - Transmits recorded speech stimuli from tester's computer to recipient/remote site

Introduction

- *Hughes et al. (2012) JSLHR*

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Introduction

- *Hughes et al. (2012) JSLHR*
- Speech-perception outcome measures:
  - CNCs (words & phonemes)
  - HINT sentences in quiet
  - BKB-SIN (SNR for 50% correct)

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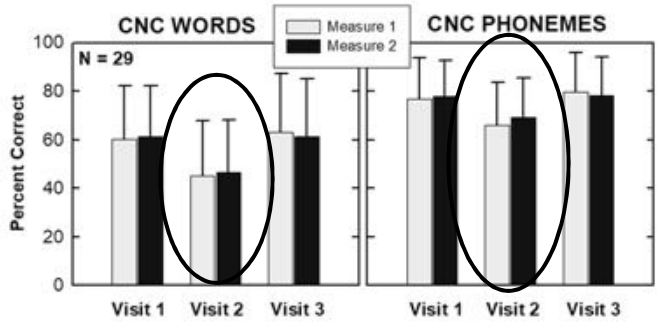
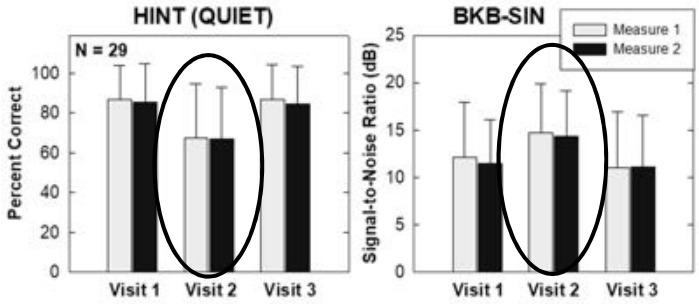
Introduction

- *Hughes et al. (2012) JSLHR*
- Results:
  - Remote (visit 2) poorer
  - 14% worse for words, 10% worse for phonemes



Introduction

- *Hughes et al. (2012) JSLHR*
- Results:
  - Remote (visit 2) poorer
  - 19% worse for HINT, 3.1 dB worse for BKB-SIN



Introduction

- Delivery of speech testing materials via videoconferencing yields reduced scores
  - Acoustic environments differ (booth vs. room)
  - Background noise, reverberation
  - Possible compression/distortion of signal being sent over the internet *(Goehring et al. 2012, JSLHR)*

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Introduction

- Alternatives to sound-booth testing for remote service delivery:
  - Direct-connect (DAI)
  - Develop correction factors for combinations of noise/reverberation times

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Introduction

- Alternatives to sound-booth testing for remote service delivery:
  - Direct-connect (DAI)
  - Develop correction factors for combinations of noise/reverberation times

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Introduction

- Can direct audio input (DAI) be used for telepractice as a reasonable alternative to sound-booth speech-perception testing?

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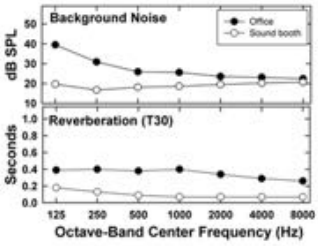
Introduction

- Booth has better acoustical characteristics than a quiet room
- Reverberation: T30 is time for signal to decay by 30 dB



Hughes et al. (2012) JSLHR

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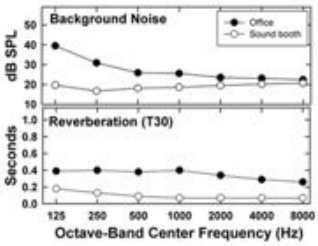
Introduction

- Reverberation results in substantial decrements in speech understanding (Kokkinakis et al. 2011)
  - 30% decrement in speech understanding for T_{60} = 0.3 sec
- But DAI might more closely resemble an anechoic setting



Hughes et al. (2012) JSLHR

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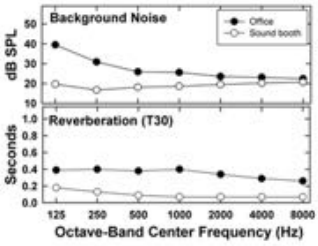
Introduction

- Hypothesis:
  - Scores for remote DAI will not differ significantly from scores for in-person testing in the booth
  - Alternatively, it is possible that DAI could produce *superior* results due to elimination of reverberation.



Hughes et al. (2012) JSLHR

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Methods

- Split-half study design
  - Half of subjects tested remote DAI first, then in person
  - Other half tested in person first, then DAI
  - Groups randomly assigned

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Methods

- Participants
  - Goal: 32 adult/teen CI recipients
  - Currently: 18 CI recipients (16 AB, 2 Cochlear)
  - Proficient in spoken English
  - At least 6 months CI use
  - Testing in monaural condition (if bilateral users)

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Methods

- Stimuli
  - CNC (words, phonemes)
    - 50 & 60 dB SPL
    - Quiet
  - HINT, AzBio sentences
    - 50 & 60 dB SPL
    - Quiet, +10, and +5 SNR
  - Noise was 4-talker babble

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Methods

- Stimuli – presented via ListPlayer (Advanced Bionics)

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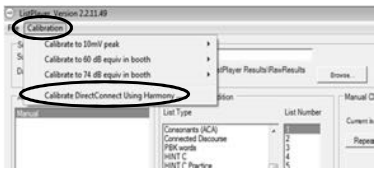
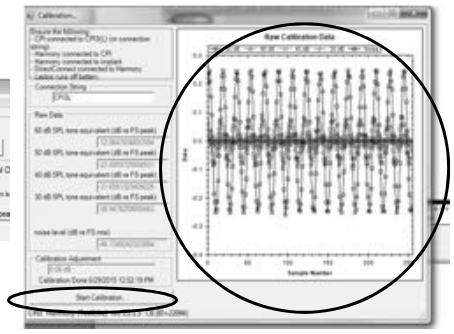
Methods

- Calibration: Advanced Bionics devices
  - Calibration for Harmony is incorporated into the ListPlayer software





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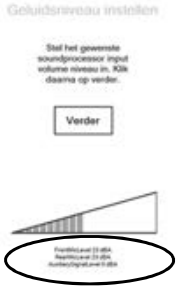
Methods

- Calibration: Cochlear devices
  - Initial complications with earlier technology
  - N6 has internal SLMs
  - Calibration with proprietary software from Cochlear (*de Graaff et al. 2016*), and ListPlayer software as input stimulus



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Methods

- Procedure
  - Everyday map loaded onto lab processor
    - Harmony* for Advanced Bionics
    - CP910 (“N6”) for Cochlear
  - For DAI, setting is Aux Only
    - Cochlear automatically switches to DAI
    - Advanced Bionics requires manual switch to Aux Only program
  - All other front-end processing intact
  - No change in volume within experiment

**Excludes front-end processing not back-compatible from Naida*

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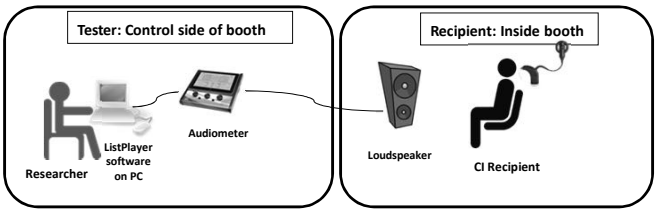
Methods

- Procedure for in-person sound-booth presentation:
  - Calibration tone from ListPlayer to zero VU meter
  - SLM to calibrate to 60 dB in soundfield



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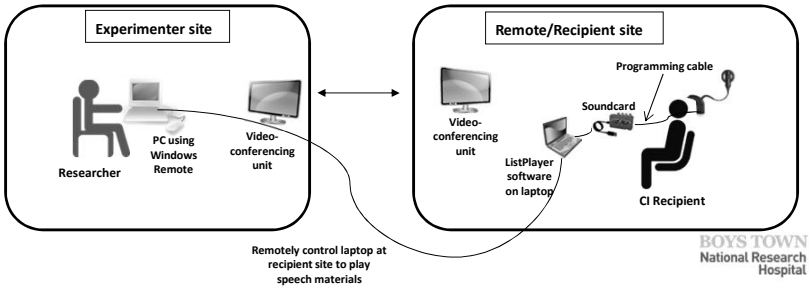
Methods

- Procedure for remote DAI presentation
  - Remote location was within same building
  - Experimenter remotely controls laptop→USB sound card→programming cable→processor
  - Speech materials on computer at recipient site to avoid potential compression/bandwidth issues



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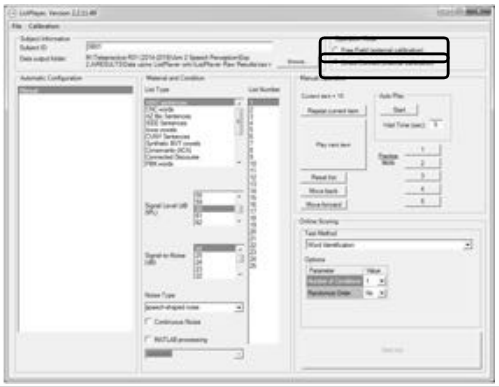
Methods

- Procedure for remote DAI presentation
  - Advanced Bionics: choose “direct connect”
  - Cochlear: choose “free field”



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Methods

- Analysis
  - RM ANOVA
  - Factors for CNC:
    - Location (Remote, In Person)
    - Level (50, 60 dB) – to assess Location x Level interaction
  - Factors for HINT and AzBio:
    - Location (Remote, In Person)
    - Level (50, 60 dB)
    - SNR (Quiet, +10, +5)
    - Interactions with location

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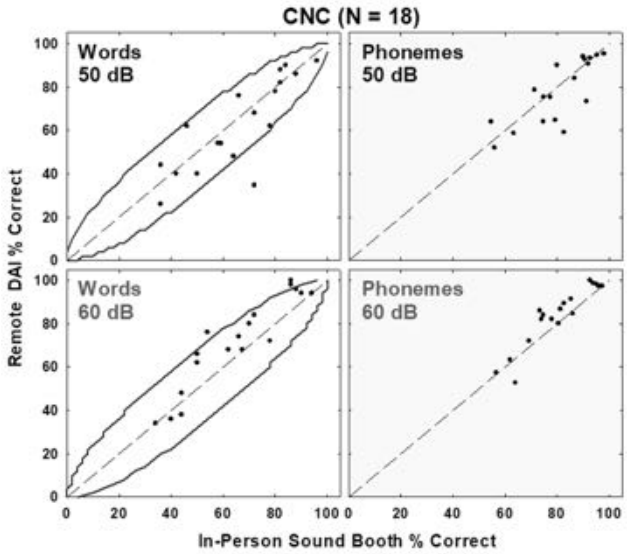
Results: CNC Words & Phonemes

- Location, NS
- Level, $p < 0.05$*
  - 60 dB > 50 dB
- Loc x Lev, $p < 0.03$*
  - Larger level differences for remote DAI

Cond.	Remote	In-Person
W50	62.5%	66.2%
W60	71.6%	65.3%
Ph50	77.7%	80.6%
Ph60	83.5%	80.2%

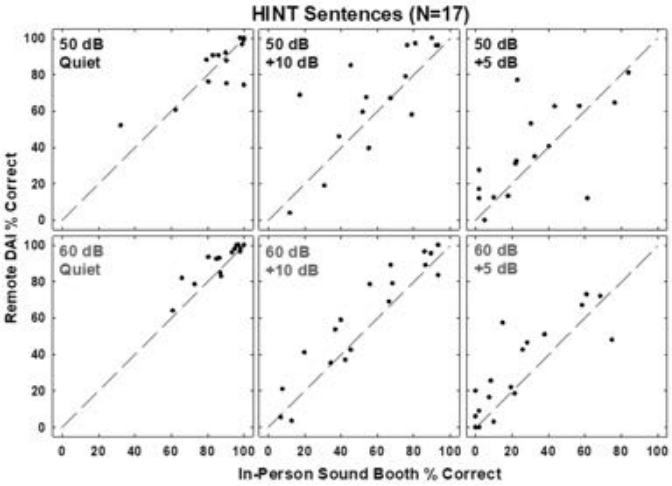


(Thornton & Raffin, 1978)

Results: HINT Sentences

- Location, NS
- Level, NS
- SNR, $p < 0.001$*
  - Q > +10 > +5
- Location interactions NS

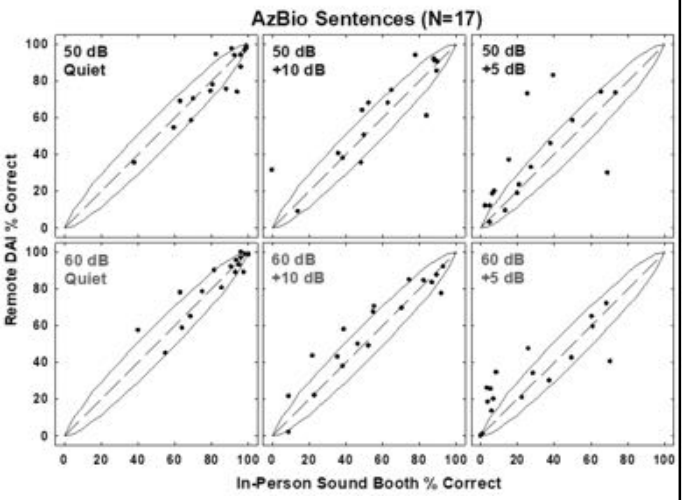
Cond.	Remote	In-Person
50Q	88.6%	88.8%
50+10	63.4%	56.6%
50+5	36.6%	31.2%
60Q	93.0%	90.1%
60+10	61.0%	55.0%
60+5	33.5%	25.9%



Results: AzBio Sentences

- Location, NS
- Level, NS
- SNR, $p < 0.001$*
  - Q > +10 > +5
- Location interactions NS

Cond.	Remote	In-Person
50Q	81.8%	83.8%
50+10	58.5%	55.0%
50+5	35.7%	28.1%
60Q	84.7%	83.7%
60+10	58.9%	56.0%
60+5	31.3%	26.8%



(Spahr et al. 2012)

Discussion

- Scores not significantly different between traditional in-person testing in a sound booth vs. remotely via DAI.
- Results suggest remote speech-perception testing is feasible.

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Discussion

- No significant effects of level for sentences (60 dB vs. 50 dB), in contrast to Firszt et al. (2004).
- However, front-end processing in today's technology incorporates adaptive processing that was not present then.

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Challenges

- Calibration
  - Internal SLMs in processors & access is critical
- Commercial availability of necessary tools
- Communication with recipient when in DAI mode
  - No "talkover" button in ListPlayer software

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Challenges

- DAI does not assess microphone functionality
- No binaural/bimodal testing

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Coming up next…

Study 2: Aural Rehabilitation with Adult Cochlear Implant Recipients

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Aural Rehabilitation Studies

- There is a shortage of audiologists and SLPs working with cochlear implant recipients in aural rehabilitation (AR)
- Also a shortage of well controlled scientific studies examining AR services delivered via telepractice for adults with CIs

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Existing Studies: AR

- Cullington, H., et. al. (2016). Have cochlear implant, won't have to travel: Introducing telemedicine to people using cochlear implants, AJA, 25, 299-302.
  - Describes a planned project, results are not yet available
  - Remote care includes self-monitoring (online speech in noise test), self-adjustment of the device, and online support (includes equipment information, troubleshooting, goal setting, rehabilitation, help with music and telephone)
  - Remote care is not individually tailored to the recipient and is not clinician directed

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Existing Studies: AR

- Sundewall Thorén, E., Hefting Pedersen, J. & Ove Jørnæs, N. (2016). Usability and online audiological rehabilitation. AJA, 25, 284-287.
  - Examined the use of an online training program with a virtual coach
  - Participants were hearing aid users
  - Pre-set curriculum, not tailored to individual user needs
  - Small sample size (pilot study) of 4 participants

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Existing Studies: AR

- Studies on the benefit of AR and auditory training (AT) for adult HA recipients:
  - Casserly & Barney, 2017; Barcroft, et. al., 2016; Smith et. al., 2016; Tye-Murray et. al., 2016
- Studies on CI recipients mainly focus on the use of auditory training
  - Miller, Zhang & Nelson, 2016; Shafiro, et. al., 2015; Zhang, et. al., 2014

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Study 2: Adult Aural Rehabilitation

- Ideally, adult AR services for CI recipients should consist of both auditory training and counseling/coaching.

- The missing link: patient centered care (PCC)
  - Addresses the whole person by eliciting narratives, engaging them in shared decision making and ensuring self-efficacy.

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Study 2: Adult Aural Rehabilitation

- The primary goal of this study is to determine if clinician-directed AR conducted via telepractice is as effective as that conducted in the traditional in-person condition and superior to self-administered AT.

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Study 2: Adult Aural Rehabilitation

- 4 study groups:
  - Group A: traditional clinician-directed, in-person therapy
  - Group B: clinician-directed, remote therapy
  - Group C: self-directed therapy at home
  - Control group: receives no therapy

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Study 2: Adult Aural Rehabilitation

- Question 1: Are the in-person (Group A) and remote (Group B) conditions similar?
  - Hypothesis 1: Test scores will improve following intervention for all groups, and the differences between pre- and post-intervention scores will be statistically equivalent for Groups A and B.
- Question 2: Is clinician-directed therapy (Groups A & B) superior to self-directed therapy (Group C)?
  - Hypothesis 2: Groups A and B will demonstrate significantly more improvement than group C because both involve a comprehensive approach that is facilitated by a clinician.

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Methods

- Enrollment Criteria:
  - Post lingually deafened
  - Native English speaker
  - Oral communicator
  - Groups matched on duration of CI use, duration of deafness, baseline performance level (CNC words)
  - Score of 18-30 on cognitive screening test: Montreal Cognitive Assessment (MoCA)
    - 26-30 is passing
    - 18-25 possible mild cognitive impairment

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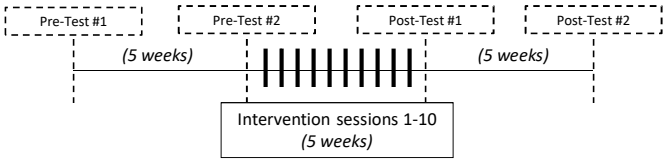
Methods

- Experimental design:
  - 4 groups (16 subjects per group):
    - Group A: In-person, clinician-directed therapy
    - Group B: Remote, clinician-directed therapy
    - Group C: At-home, self-directed therapy
    - Control Group: Receives test visits only, no therapy
  - Pre-test phase, intervention, post-test phase



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Methods

- Subject demographics

	Avg. Age	Avg. Duration of CI Use	Avg. Duration of Deafness	Avg. Baseline CNC-Word Score	Avg. MoCA Score
Group A (n=16)	65.69	8.21	9.75	64%	25.44
Group B (n=16)	60.94	7.53	8.81	62%	25.81
Group C (n=16)	64.56	7.37	8.93	63%	27

- No significant difference between any of the groups on these categories

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Methods

- Pre- and post-test measures:
  - Nijmegen Cochlear Implant Questionnaire (NCIQ)
    - Designed specifically for CI recipients
    - 60 questions, 3 domains (physical, psychological, social)
  - Communication Profile for the Hearing Impaired (CPHI)
    - 4 areas related to coping
    - 163 questions, rated 1 (substantial problem) to 5 (no issues)

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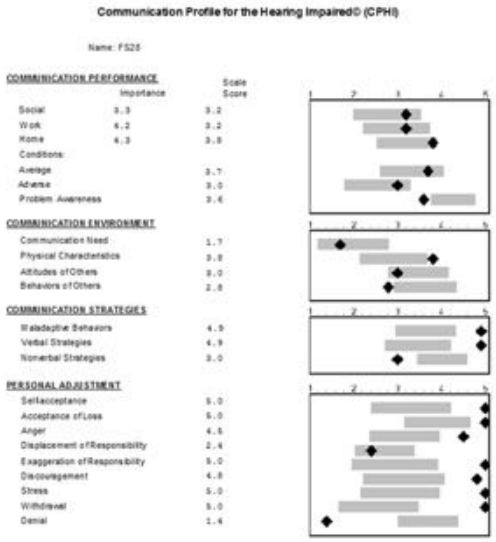
Methods



Communication Profile for the Hearing Impaired© (CPHI)

Name: FS28

COMMUNICATION PERFORMANCE	Importance	Scale Score
Social	3.3	3.2
Work	4.2	3.2
Home	4.3	3.8
Conditions:		
Average		3.7
Adverse		3.0
Problem Awareness		3.6
COMMUNICATION ENVIRONMENT		
Communication Need		1.7
Physical Characteristics		3.8
Attitudes of Others		3.0
Behaviors of Others		2.8
COMMUNICATION STRATEGIES		
Maladaptive Behaviors		4.9
Verbal Strategies		4.9
Nonverbal Strategies		3.0
PERSONAL ADJUSTMENT		
Selfacceptance		5.0
Acceptance of Loss		5.0
Anger		4.6
Displacement of Responsibility		2.4
Exaggeration of Responsibility		5.0
Discouragement		4.8
Stress		5.0
Withdrawal		5.0
Denial		1.4

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Methods

- Pre- and post-test measures:
  - Testing portion of Angel Sound™ software
    - Free auditory training tool http://angelsound.emilyfufoundation.org/
    - Testing and training portions
    - Environmental Sounds, Vowel Recognition, Consonant Recognition, Word Discrimination, Everyday Sentences, Music Instruments, Music Melody
  - Speech perception
    - CNC words
    - AzBio sentences
    - BKB-SIN

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Methods

- Intervention

Group A (In Person)	• 30 minutes: counseling/coaching • 30 minutes: Angel Sound™ training
Group B (Remote)	• 30 minutes: counseling/coaching • 30 minutes: Angel Sound™ training
Group C (At Home)	• 30 minutes: AR reading resources • 30 minutes: Angel Sound™ training

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Methods

- Remote set-up uses a Polycom system with the participant and clinician in separate rooms.

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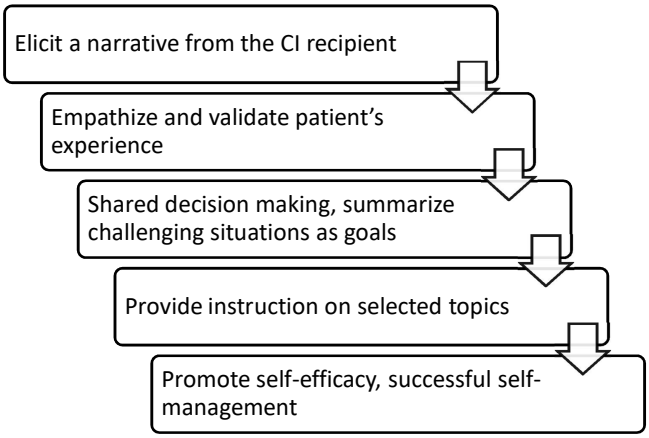
Methods

- Scripted patient-centered counseling process



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Methods

Aural Rehabilitation Resources	
1. Understanding Hearing Loss	9. Lip Reading
2. Hearing Loss and Emotions	10. Listening Strategies
3. Listening in Noise	11. Communication Tips for Families
4. Communication Strategies	12. Assertiveness
5. Using the Telephone	13. Environmental Considerations
6. How do CI's and HA's Work?	14. Assistive Listening Devices
7. Listening to Music	15. Tinnitus
8. Workplace Challenges	16. Inspirational Stories

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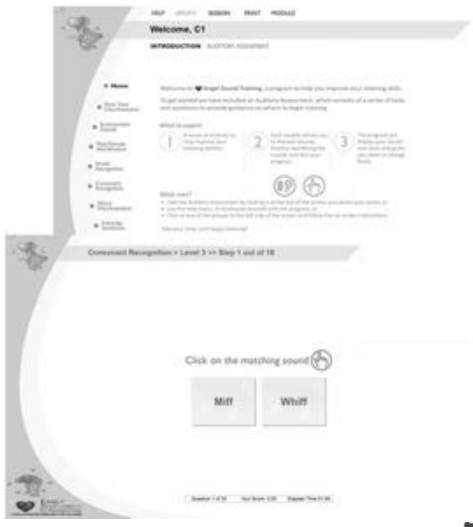
Methods

- Intervention:
  - Auditory training with Angel Sound Basic Module
    - Environmental sounds
    - Music
    - Vowels
    - Consonants
    - Words
    - Sentences



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Example of Remote Session

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Example of In-Person Session

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Example of Auditory Training

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Results

- Results to date:
  - 48 participants completed (4 in progress)
    - N=16 Group A
    - N=16 Group B
    - N=16 Group C
    - N=4 Control Group (in progress)

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Results

- Angel Sound

Subtest	Baseline – Post	Group Effect?
Environmental Sounds	*	A=B=C
Instrument Recognition	*	A=B=C
Melody Recognition	*	A=B=C
Vowels	*	A=B=C
Consonants	*	A=B=C
Word Discrimination	*	A=B=C
Sentences	*	A=B=C

* indicates significant improvement, = indicates no significant difference

A = In Person B = Remote C = At Home

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Results

- Speech Perception

	Baseline – Post	Group Effect?
CNC-Words	*	A=B=C
CNC-Phonemes	*	A=B=C
AzBios	*	A=B=C
BKB-SIN	B=P	A=B=C

* indicates significant improvement, = indicates no significant difference

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Results

- NCIQ

	Baseline – Post	Group Effects
Basic Sound Perception	B=P	A=B=C
Advanced Sound Perception	*	A=B=C
Speech Production	B=P	A=B=C
Self-Esteem	*	A=B=C
Activity Limitations	*	* B > A,C
Social Interactions	B=P	A=B=C

* indicates significant improvement, = indicates no significant difference

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Results

- CPHI Communication Performance

	Baseline – Post	Group Effects?
Social	B=P	* B > A,C
Work	B=P	A=B=C
Home	*	* B > A,C
Social Importance	*	A=B=C
Work Importance	B=P	A=B=C
Home Importance	*	A=B=C
Average	B=P	* B > A,C
Adverse	B=P	* B > A,C
Problem Awareness	*	A=B=C

* indicates significant improvement, = indicates no significant difference

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Results

- CPHI Communication Environment

	Baseline – Post	Group Effects?
Communication Need	B=P	A=B=C
Physical Characteristics	B=P	A=B=C
Attitudes of Others	*	A=B=C
Behaviors of Others	*	A=B=C

* indicates significant improvement, = indicates no significant difference

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Results

- CPHI Communication Strategies

	Baseline – Post	Group Effects?
Maladaptive Behaviors	*	A=B=C
Verbal Strategies	B=P	A=B=C
Nonverbal Strategies	*	A=B=C

* indicates significant improvement, = indicates no significant difference

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Results

- CPHI Personal Adjustment

	Baseline – Post	Group Effects?
Self-Acceptance	*	A=B=C
Acceptance of Loss	B=P	A=B=C
Anger	*	A=B=C
Displacement of Responsibility	B=P	A=B=C
Exaggeration of Responsibility	*	A=B=C
Discouragement	*	A=B=C
Stress	*	A=B=C
Withdrawal	*	A=B=C
Denial	*	A=B=C

* indicates significant improvement, = indicates no significant difference

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Discussion

- Overall, each group (A, B, C) demonstrated improvement on most measures (supports hypothesis 1)
- Group A was equivalent to Group B for most measures (supports hypothesis 1)
- Overall there was no significant difference between the groups (A=B=C) (did not support hypothesis 2)

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Discussion

- Group C may have demonstrated more improvement than expected due to the higher motivation of being paid to participate in a research study
- Group C also spent time reading AR resources, which is not typically part of standard care (i.e. not included in computer-based AT programs)
- Some participants in Group C spent more time on Angel Sound than instructed

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Feedback From Subjects

- What did you like the most about the way you received your therapy?

In-Person (A)	Remote (B)	At-Home (C)
The opportunity to interact.	The way she listened and seemed to really care about my needs.	Liked the flexibility of the at-home program.
I liked doing it with a person as it was scheduled and not easy to miss.	Personable still, even though not in the same room.	Could be done at my convenience and comfort.
As we progressed section to section I was able to ask questions.	Frankly, it was as if the clinician was right there in the room with me, it didn't present any difficulties.	Being able to do different computer programs at home. Could do one I felt good about when frustrated with others.

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Feedback From Subjects

- Did participating in this study change your perceptions about aural rehabilitation?
  - It helped me better understand some of my frustrations and be able to talk about them.
  - It made me think more about actual word structures and sounds I miss.
  - I learned to be assertive.
  - I wish I would have had this training when I first received my cochlear implant!
  - I'd never heard of it, found it to be a "missing link" to hearing better.

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