WIRELESS TECHNOLOGY:

WHERE HAVE WE BEEN?
WHERE ARE WE NOW?
WHERE ARE WE GOING?

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- Principal Audiologist within Global Audiology at GN
- Primary Roles:
  1. Serve as the voice of audiology and the voice of the end user during product development.
     - Define new product requirements
     - Test that requirements have been met
       - Tests include "audiologic verification" and patient usability trials
  2. Share practical experience with professionals in the field
- Professional Passion: How to efficiently communicate hearing aid benefits to patients.
- Adjunct faculty member at Rush University

Learning Objectives

- Compare and contrast current and emerging wireless hearing aid technology in terms of functionality and end user benefits.
- Describe how these solutions can improve patient satisfaction above and beyond the use of hearing aids alone.
- Select the appropriate wireless solutions based upon end user needs

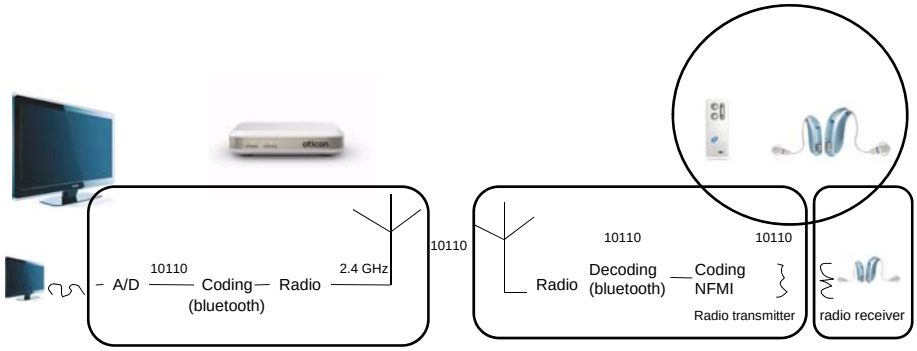
A Brief History of Wireless

- What is wireless for patients?:
  - Transmission of information for many different purposes without the use of electrical conductors (i.e. wires).
  - i.e. wireless connectivity
- Early methods of wireless transmission include:
  - Telecoils
  - Infrared Systems
  - FM Systems
- Hearing Instrument Remote Controls
- Although connectivity has been around for quite sometime, many consumers are unaware of the technology and the potential benefits

Overview of recent wireless technologies

- Near Field Magnetic Induction (NFMI)
- Bluetooth (RF)
- Proprietary radio frequency (RF)

Wireless systems based on Near Field Magnetic Induction (NFMI) combined with Bluetooth (RF)



Bluetooth radio frequency is used for communication between an accessory and a "Gateway device" and NFMI transmission is used from the "Gateway device" to the hearing instruments.

Wireless systems based on Near Field Magnetic Induction (NFMI) combined with Bluetooth (RF)

- Bluetooth radio frequency is used for communication between an accessory and a "Gateway device"
- NFMI transmission is used from the "Gateway device" to the hearing instruments
  - NFMI part of the system contains the transmission energy within a localized magnetic field. This type of transmission is referred to as "near-field transmission" (up to 1 meter).
  - The carrier frequency is generally 10-14MHz.
- "Gateway device" is typically worn around the neck as the hearing instruments/user needs to be within the NFMI field/little bubble to pick up the signal.

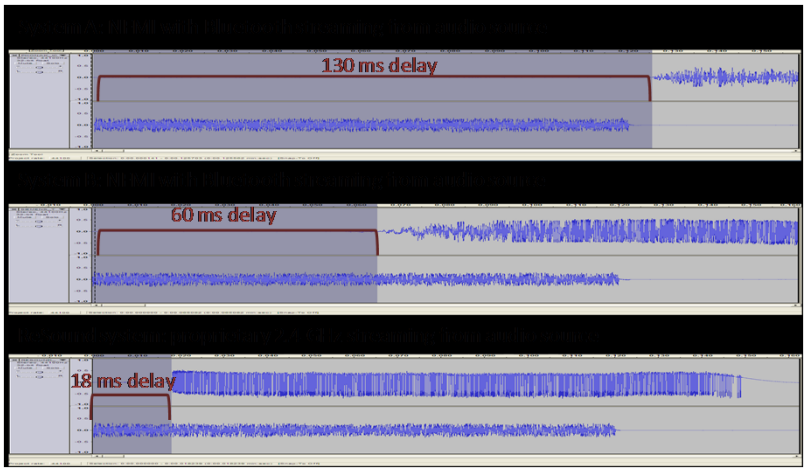
Overview Of Wireless Technology (Bluetooth)

- Bluetooth
- An open standard for wireless communication
- Currently there are nearly 12,000 different products using Bluetooth
  - Communication protocols for Bluetooth must be broad and flexible enough to accommodate many uses.
    - Bluetooth uses 79 frequencies
  - Bluetooth uses more computational and power resources to operate than a design for an application such as hearing instruments
  - Bluetooth is simply not feasible for direct implementation in hearing instruments.

Overview of Wireless Technology (Bluetooth)

- Using Bluetooth for audio streaming introduces a delay that is likely to be unacceptable for television viewing
- Bluetooth-based systems that stream audio use Advanced Audio Distribution Profile (A2DP)
- The latency for this protocol exceeds 40 milliseconds, and is commonly up to 125 milliseconds depending on the audio compression technique that is used
- Combinations of the streamed sound with amplified sound or direct sound of this magnitude are perceptible as echoes and even lip synch issues when watching television
- Even small delays, though not consciously perceived, will cause a mismatch between audio and visual signals has a significant negative impact on the television viewing experience (Reeves & Voelker, 1993).

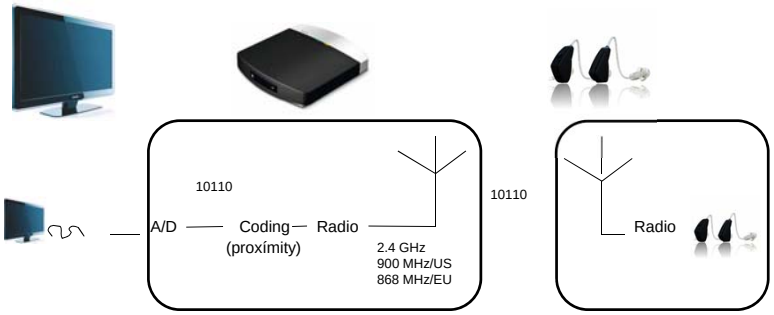
BLUETOOTH AUDIO DELAY



Wireless systems based on Near Field Magnetic Induction (NFMI) combined with Bluetooth (RF)

- Advantages:
  - Ease of implementation due to existing Radio Frequency (RF) chips
  - Longer battery life due to low current drain on hearing instruments
- Drawbacks:
  - Short transmission distance (max 1 meter)
  - Need to wear "Gateway device"/streaming device around the neck
  - Sound quality is affected by orientation of the gateway device and HA receiver coil and any delay introduced by relay between components

Wireless systems based on Proprietary radio frequency (RF)



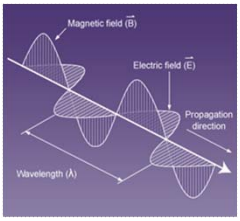
In wireless systems based on proprietary radio frequency the radio frequency is used for direct communication between the accessory and hearing instruments.

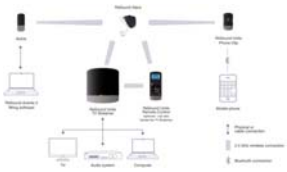
Radio Transmission

- AM, FM and pulse width radios all work on this principle
- Radio/cell towers and antennae are a given size to cover a given area
- The antennae is an important component to keep in mind for HIs

Wireless systems based on Proprietary radio frequency (RF)

- The proprietary radio frequency system uses a radio to generate an electrical wave and an antenna to send the information. In these types of systems all of the transmission energy is designed to radiate into free space. This type of transmission is referred to as "far-field".
- The electrical wave carries the information and it can be done by using different frequencies.
- Uses ISM bands - Industrial, Scientific and Medical Frequency Band
  - 900 MHz (US, Greenland, & some eastern Pacific Islands).
  - 868 MHz (EU).
  - 2.4 GHz
- The radio frequency is used for direct communication between the TV streamer/accessory and hearing instruments. Hearing instruments are turned into small wireless head phones





Wireless systems based on Proprietary radio frequency (RF)

- Uses ISM bands - Industrial, Scientific and Medical Frequency Band
- Frequency bands that are internationally reserved for these applications
  - Most common-Microwave ovens
- This reserved bandwidth was originally not designed for communication devices
- Communication devices must be error tolerant, or….
- …Implement methods to avoid interference

ISM Bandwidths

ISM bandwidth is defined by the ITU-R (International Telecommunications Union) for radio communication.

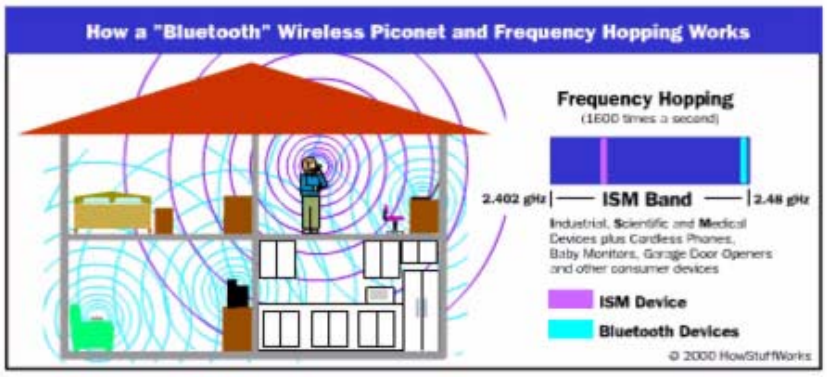
Higher frequency transmission allows for greater data transmission.
A trade off exists between amount of data transferred and current consumption.

Frequency range [Hz]	Center frequency [Hz]	Availability
6.765–6.795 MHz	6.780 MHz	Subject to local acceptance
13.553–13.567 MHz	13.560 MHz	
26.957–27.283 MHz	27.120 MHz	
40.66–40.70 MHz	40.68 MHz	
433.05–434.79 MHz	433.92 MHz	
902–928 MHz	915 MHz	Region 2 only
2.400–2.500 GHz	2.450 GHz	
5.725–5.875 GHz	5.800 GHz	
24–24.25 GHz	24.125 GHz	
61–61.5 GHz	61.25 GHz	Subject to local acceptance
122–123 GHz	122.5 GHz	Subject to local acceptance
244–246 GHz	245 GHz	Subject to local acceptance

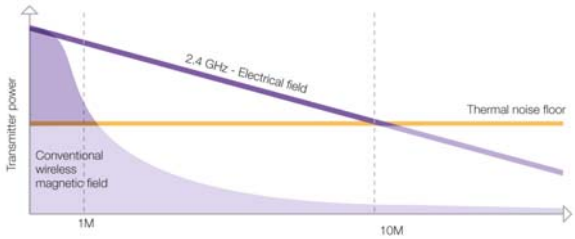
ISM Transmission

- ISM bands tend to be congested both for audio applications as well as ISM applications
- How is data transferred reliably
  - Spread Spectrum Frequency Hopping
  - Point to point data transmission

Spread Spectrum Frequency Hopping



2.4 GHz transmission range



Conventional wireless transmission hits the thermal noise floor at 1 meter. 2.4 GHz transmits as far as 10 meters before it hits the thermal noise floor.

Bluetooth Smart (Low Energy)

- Bluetooth 4.0, Smart, LE are all synonymous terms
- Typically "Sensor" type devices
- Sending data is less "power hungry" than streaming audio

Bluetooth in the News

News Feed Item

New Global Standard for Hearing Aids With Bluetooth Connectivity

BY PR NEWSWIRE ARTICLE RATING:
MARCH 6, 2014 03:30 AM EST READS: 289

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COPENHAGEN, March 6, 2014 /PRNewswire/ --

The European Hearing Instrument Manufacturers Association (EHIMA) announced a new partnership with the Bluetooth Special Interest Group (SIG). The cooperation aims to develop a new Bluetooth standard for hearing aids, while improving existing features, and creating new ones such as stereo audio from a mobile device or media gateway with Bluetooth wireless technology. EHIMA represents the six major European hearing instrument manufacturers, producing up to 90% of hearing aids made in Europe.

Bluetooth technology is crucial to transforming the hearing-impaired user's experience. Extending existing profiles and developing a new hearing aid profile that allows streaming of audio sources at mono speech or stereo music quality is only the first step. Several use cases will be supported, including calling with a mobile phone, enjoying stereo audio from multi-media devices (music players, radio, television, etc.) and receiving broadcast audio information from public address and announcement systems. This new hearing aid profile will be developed to meet the challenging power requirements of hearing aids, which have to operate with sub-miniature batteries.

The Future of Wireless Connectivity

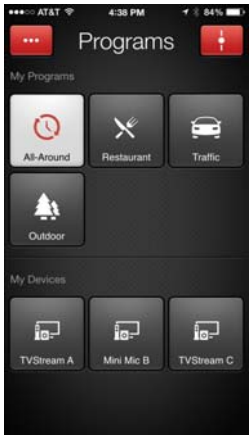
Direct Connectivity, Apps, & Services

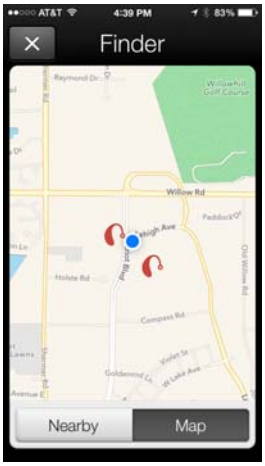
22

Made for iPhone

Made for iPod iPhone

- **Direct audio streaming** from iPhone, iPad, and iPod Touch to the user's **"wireless stereo headphones"** that just happens to be their **hearing aids**





- Find My Hearing aid
- Geo Tagging
- Personalization

Wireless Fitting

- Wireless transmission is not limited to streaming
- Data transmission is also quite common
  - Remote Control
  - Wireless fitting
- Similar constraints exits
  - Antennae size
  - Speed of the data transfer
  - Distance of data transfer that can be acheived

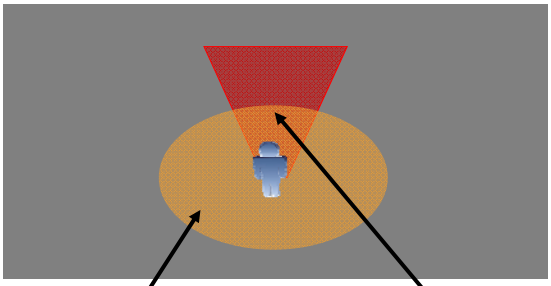
Wireless Ear-to-Ear Signal Processing

- The communication between the ears is being used for new signal processing.
  - Directionality – Hearing in Noise
  - Localization
  - Feedback Cancelation
  - Phone Usage

Directionality

- Synchronizing the settings at the two ears
- Narrowing beam widths
- Steering the directional beam
- Changing the microphone configurations
- Streaming of sound from one aid to the other

Asymmetrical Changes



Monitor Ear: omnidirectional

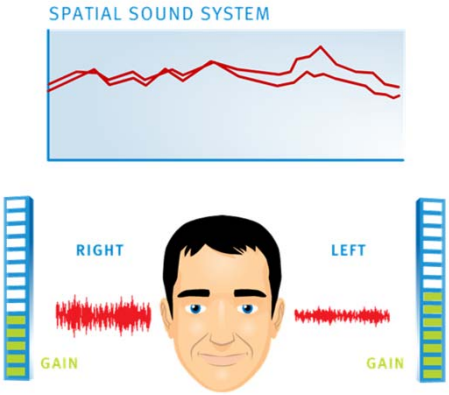
Spatial Awareness

Focus Ear: Fixed directional

Directional benefit

Localization

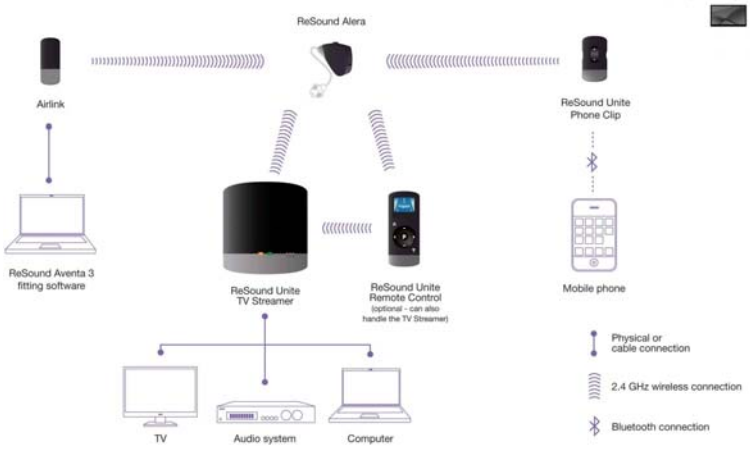
- Maximizing interaural intensity differences



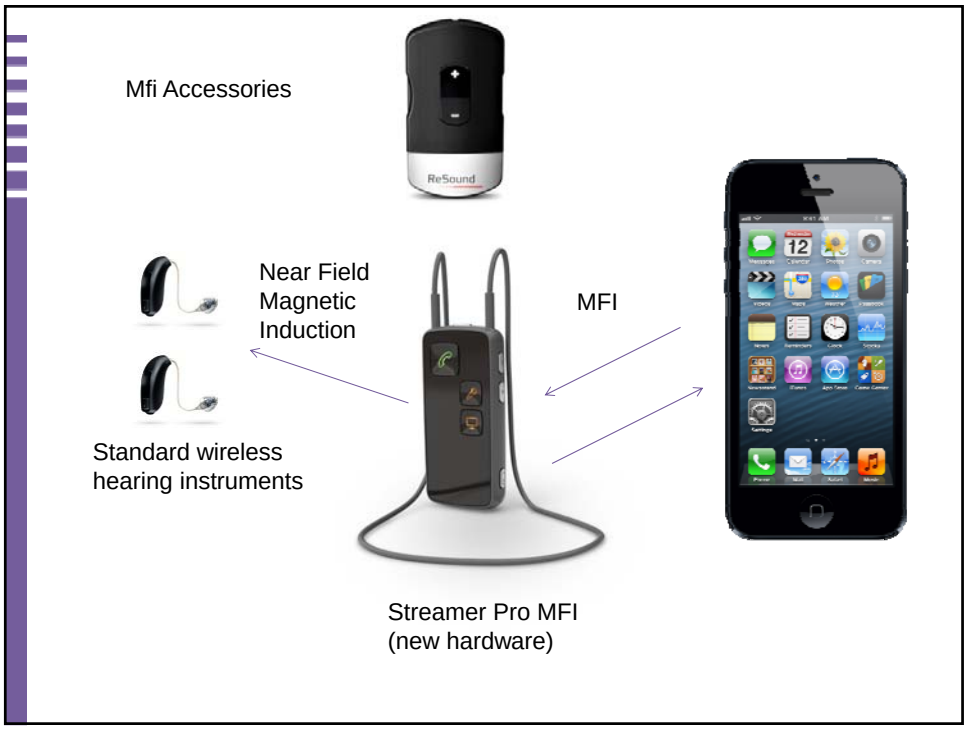
Phone Communication

- Streaming
- Attenuation of opposite ear

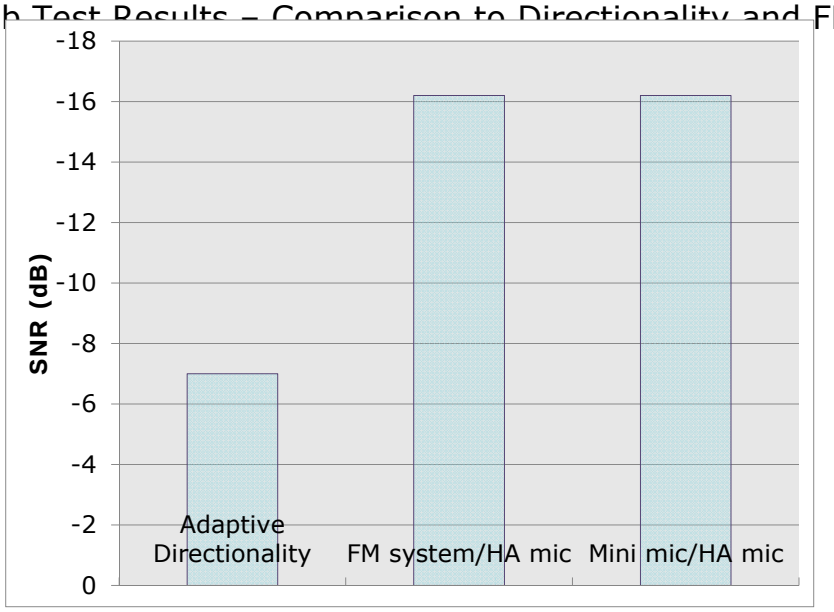
THINK SYSTEM




ReSound
ReSound
ReSound
ReSound
Basic


Mfi Accessories
ReSound
Near Field
Magnetic
Induction
MFI
Standard wireless
hearing instruments
Streamer Pro MFI
(new hardware)

Lab Test Results – Comparison to Directionality and FM

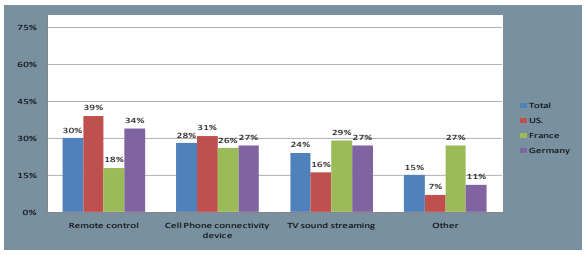


Two Fundamental Questions

- Are these technologies making any kind of a difference?
- Why do we think these technologies will make a difference?

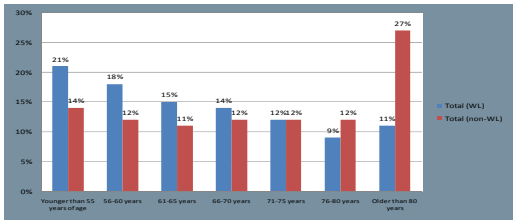
Before 2.4 GHz: Accessories with Wireless Fittings

Accessories were included in less than 30% of fittings of HI with wireless features



Before 2.4 GHz: Age of Clients

Wireless hearing instruments are generally fit to younger patients than non-wireless hearing instruments



Conclusions of Market Research 2010 (pre 2.4 Ghz)

GOOD:

Accessories overcome distance, background noise, poor room acoustics

BAD:

Previous competitive accessories are perceived as immature technologies with unstable connectivity and complicated set up.

UGLY:

Hearing care practitioners include accessories only when end-users demonstrate familiarity with technology or reported hearing difficulties when watching TV.

Clinical Note International Journal of Audiology 2014; Early Online: 1–4 International Journal of Audiology

The benefits of using bluetooth accessories with hearing aids

Pauline Smith*,† & Adrian Davis†

*University Hospitals of Leicester NHS Trust, Leicester, UK, and †Public Health England, London, UK

Abstract

Objective: To investigate the benefits in reported outcomes after providing bluetooth accessories for established hearing aid users. *Design:* Prospective observational study using validated quantitative outcome measures and detailed patient narrative before and two months after patients were provided with bluetooth accessories. *Study sample:* Twelve patients with bilateral NHS hearing aids participated. They had a wide range of ages and hearing loss. *Results:* After two months, 10 patients reported substantial additional benefit and kept the accessories; two returned them for various reasons. Statistically significant changes were seen in two validated outcome measures: the Glasgow Hearing Aid Benefit Profile and the International Outcome Inventory – Hearing Aids, but not in the Speech, Spatial and Qualities of Hearing Scale. Two notable benefits were reported: some described hearing the emotion and mood in a voice for the first time; others were amazed to report an improved ability to hear film or to hold conversations over the telephone. *Conclusions:* The provision of bluetooth accessories can give additional reported benefit for some patients – we need better knowledge about who benefits, and whether further support/training to individuals would make a difference.

Key Words: Bluetooth; accessories; hearing aids; outcomes; benefit

Smith 2014: Benefit results

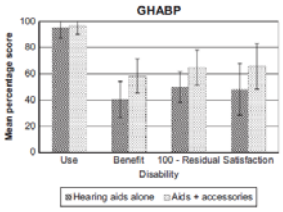


Figure 1. Mean GHABP percentage scores before and after use of bluetooth accessories (excluding the remote microphone).

Smith et al, 2014: Summary

- Effects of age and hearing loss:
  - Significant positive correlation between age and GHABP
    - Older patients reported greater benefit
  - Significant negative correlation of HTL and GHABP and IOI-HA
    - Patients with less loss reporting more benefit
- Usability:
  - Subjective reports: "Quite easy to use"

Smith et al 2014 Summary

" It is clear that patients using hearing aids report additional benefits from using Bluetooth accessories"

Researchers highlight the need for training and that it is difficult to predict who will benefit from accessory technologies

Rhetorical Question

- *What can be done to bring the "think system" mentality into your daily routine?*
- *Suggestions:*
  - *Investigate the "Liveability" of the technology for yourself*
  - *Augment your intake forms to include questions about technology attitudes and opportunities for situational use*
  - *Use demonstration to illustrate the concept*
  - *Use contextual training to make the use relevant*

Apple iDevice Pre-Fitting Expectations Questionnaire

1.) You are receiving a pair of hearing aids that connect directly to your iphone. How do you think you will use the iphone with your hearing aids? :

_____

_____

2.) What iphone or ipad functions or features have you been using prior to receiving these hearing aids?: (Please X any used)

_____Make and Receive Phone Calls

_____Make and Receive Face Time Calls

_____Listen to Music

_____Texting

_____Emails

_____GPS (Google Maps, Mapquest etc.)

_____Siri

_____Searching the Web

_____Other Apps

Please list some of the apps you commonly use:

_____

_____

3.) How do you think any of the functions or features you marked above, will work with the hearing aids?:

_____

_____

Additional Intake Questions: Dexterity

- Medical History: indicators for dexterity options:
  - Do you have arthritis? Where? and rate the severity?
  - Do you have numbness and/or tingling in the hands, fingers or other extremities?

Additional Intake Questions: Entertainment

- A common question: Do you have problems on the TV?
- A revised approach:
  - Check the following that apply to you:
  - Family/neighbors report the TV too loud
  - Listen to music through a smartphone/mp3 player
  - Use headsets for work or video gaming systems?

Preparation is Key

- #1 Question--When should accessories be presented/discussed?
- Improved engagement can be achieved via "touch points" through out the journey
- The answer, create the opportunities for a discussion on Apps and Accessory technology whenever possible.

Summary

- Quickly/easily find and demonstrate various app features
- Identify patient needs that can be addressed through apps or accessories
- Begin to develop a "clinical narrative" to ensure the benefits provided by these technologies are communicated *throughout* the hearing care journey

Questions?

- THANK YOU!
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