Recent Advances in Hearing Devices

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Introduction

- Hearing aids (HA) have advanced greatly in the past 30 years
- Until the 1990s, hearing aids consisted of analog technology (i.e., electronic components- such as transistors, capacitors, etc.) with limited capability
- The advent of digital hearing aids in the 1990s, as well as various accompanying accessories (such as remote mics, TV adaptors, captioning apps), have enabled individuals with hearing loss to access sound in ways that could not have been imagined too long ago
- In addition, cochlear implants have also greatly advanced from when it consisted of a single electrode to its current technological state

Features That Have Changed HA Usage Demographics

Feedback Management

- Modern hearing aids have incorporated advanced feedback cancelling, so much so, that individuals with hearing loss up to a moderate-severe hearing loss can wear open domes (avoiding occlusion- that is, sounding like talking in a barrel) without any feedback (i.e., annoying whistling)

Receiver in the Canal Hearing Aids

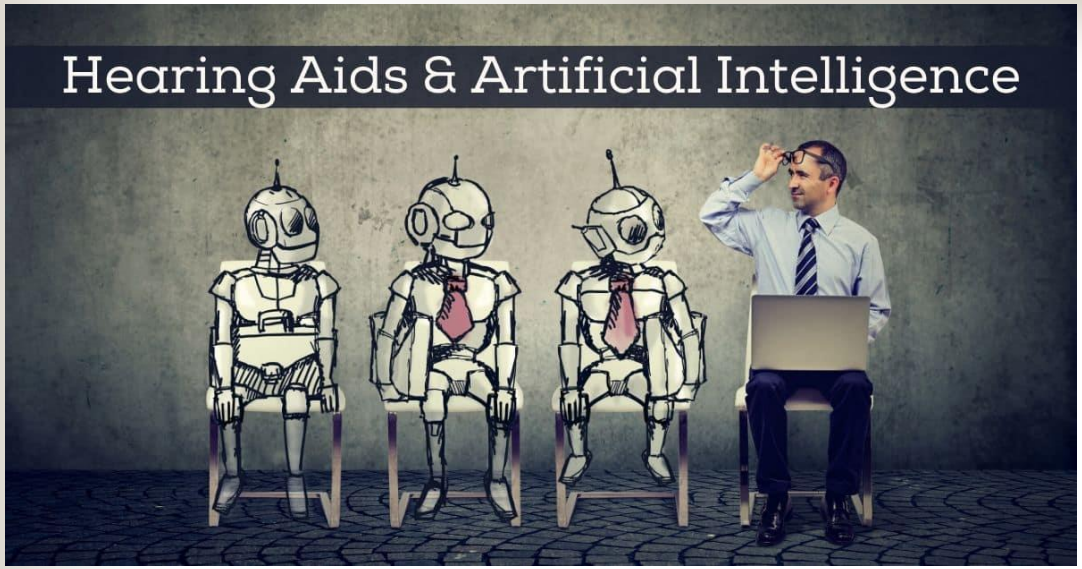
- Manufacturers have been able to relocate the receiver from hearing aid into a dome (milder losses) or earmold (for more severe hearing losses)
- This has allowed hearing aids to decrease in size and increased the receiver/mic distance (which also has helped to to decrease feedback)

Noise Reduction

- Noise Reduction: In noisy settings/no speech present, the software causes hearing aid to reduce amplification and improve listening comfort
- Wind Noise Reduction: suppresses sound of wind that used to flow over hearing aid microphones (via use of grill covers, software)
- Automatic Directional Microphones (i.e., searches environment/focuses on speech, while attentuating background noise)
  - Early on, directional mics enhanced speech in front of listener and cancelled noise from back/side
  - Recent advances allow hearing aids/CIs to determine what is speech/noise, and shift directionaility to speech source- even if on side or behind the listener

Artificial Intelligence (AI)

- AI is an umbrella term that covers technology to mimic human decision-making
  - Programmers train the hearing aid's AI chip at the factory with millions of different sounds prior to releasing hearing aids into the marketplace
  - In actual usage, hearing aids sample the acoustic environment as many as 12 billion times per second
  - In actual usage, AI builds upon initial factory/ audiologist's programming
    - AI learns from user's preferences with their devices (via adjustments) as to how they like to hear in particular environments; the settings are subsequently recalled when in a similar environment
    - Thus, HA adjust algorithms over time to improve one's ability to hear in different listening environments



HEARING AIDS

& ARTIFICIAL

INTELLIGENCE

“ARTIFICIAL
INTELLIGENCE
CHANGES
EVERYTHING“

Oticon More is trained with 12 million real-life sound scenes
A Deep Neural Network (DNN) trained with 12 million real-life sound scenes enables virtually all sounds in the world to be handled precisely and automatically.4
oticon

Split Processing

- Until recently, all processing done via a single processor
- Recently, some manufacturers have incorporated "split" processing
  - Split processing includes two different processors, each focused on processing different information (be it front/back sound sources, or speech versus noise)
  - Each processor breaks incoming sound into multiple channels (as many as 48 channels); very detailed in the analysis of sound across the frequency range, making very fine-tuned adjustments in each channel
  - The sound is processed/analyzed in parallel fashion- each processor making adjustments, then recombined into a single output:
    - This significantly enhances the speech to noise ratio, signal clarity, sound quality, etc.

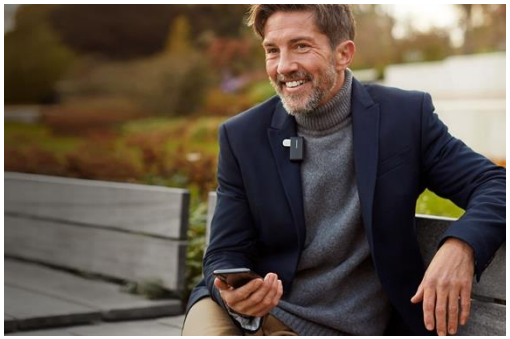
Wireless Connectivity

Wireless connectivity refers to the ability of hearing aids/cochlear implants to:

- Exchange data between devices (allowing for synchronization of both devices- such as for program or volume control changes)
- Transmit telephone signal from one hearing device to the other device, thus, allowing one to hear the talker in both ears
- Share audio streams between devices, allowing for binaural streaming
  - This allows one to hear music in stereo from cellphones, computers

Device Connectivity- cont'd

- Wireless connectivity can occur directly via Bluetooth or via an intermediary device (streamer) with external devices (such as cellphones, TV, computers, etc.)



- Hearing aids/cochlear implants can also connect wirelessly to a remote microphone (thus, allowing individuals to hear others from 30 feet away as if they were standing 6 inches away, a great benefit in noisy settings)
  - Hearing aid/CI manufacturers have their own proprietary remote mics that work with their hearing aids, though that might change with the new Bluetooth standard

Device Connectivity- cont'd

- Most hearing aids/CIs can now pair to cellphones directly (be it Apple or Android)
  - However, there are some Android models that cannot be paired directly, thus, necessitating need for an intermediary streamer
- Various hearing aids can be paired directly with Macintosh computers (select Mac computers with the M1 chip, and all Mac computers with the M2 or M3 chip)
  - For a list of supported hearing devices, see the Apple Support article **List of Made for iPhone hearing devices**
- In regards to PCs, Windows 11 will be able to pair to hearing aids that have the new BT Low Energy audio chip (more on that later)
  - In the meantime, one must use a proprietary USB dongle

Device Connectivity- cont'd

- In terms of Smart TVs, it appears at this time that only Amazon Fire TVs can be paired directly with BT hearing aids/CIs
- In absence of direct connectivity to TVs, one can stream directly from TVs via proprietary TV adapters to the hearing aids or via an intermediary hearing aid/CI streamer
- As mentioned earlier, once BT Low Energy audio is fully in place in the marketplace, TVs and computers will be able to stream directly to hearing aids/CIs

Direct HA connectivity to cellphone

Remote mic & HA streamer

https://www.youtube.com/watch?v=h7LfZl6qfMY

Hearing Aids wirelessly connected to Phonak Roger Mic

https://www.youtube.com/watch?v=dhLb5Be_eYA

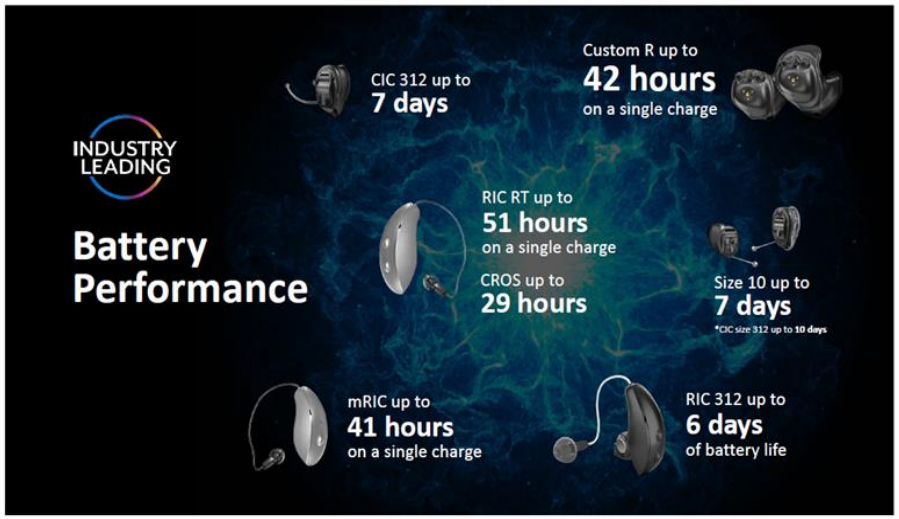
Amazon Fire TVs can stream directly to hearing implants

TV adaptor & intervening streamer

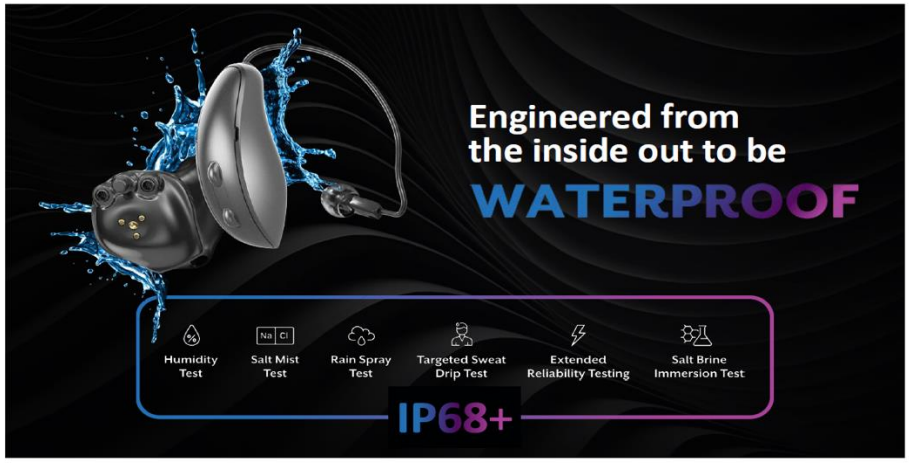
USB dongle & streamer paired with computer

Cochlear™ Wireless TV Streamer, Cochlear™ Wireless Mini Microphone 2+, and Cochlear™ Wireless Phone Clip

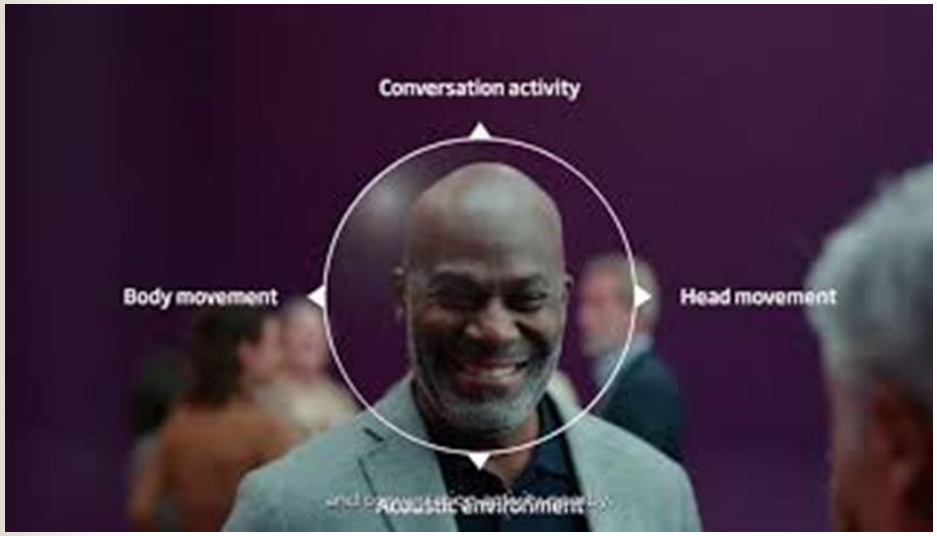
Latest Innovations



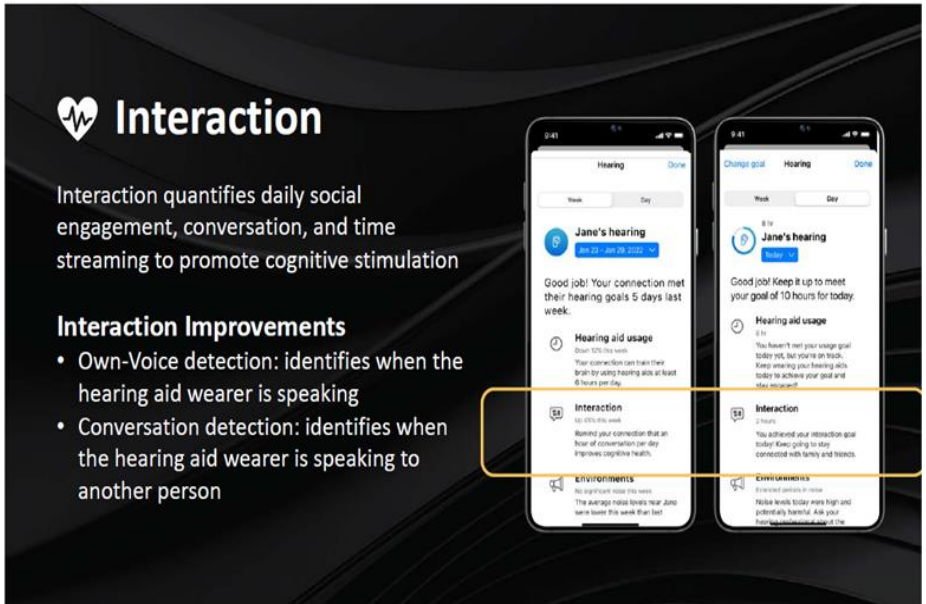
HA/CIs: long-lasting battery charge/ portable chargers; Note that streaming decreases battery life



Waterproof hearing aids/CIs: minimizes effects of sweat, allows individual to be in pool without taking aids off, such as water aerobics



Use of sensors allow hearing aids to determine listener's intent relative to acoustic environment and adjust hearing aids accordingly



As social engagement is important in decreasing risk of depression/ worsening of dementia, HA app measures interaction time

Latest Innovations- cont'd

- Because of the many advances that have occurred, hearing aids are now better classified as personal hearing systems
- Various hearing aid companies has merged amplification with what are known as "Hearable" features (i.e., sensors), including:
  - Fall detection, which, in turn, can notify either a company and/or family member
  - Fitness tracker (such as heart sensor), count number of steps/day, log how much time individual is engaged in social communication
    - In turn, you can have hearing aid share the aforementioned information with pre-selected people
- # of hearing aids can wirelessly work with Alexa, Ring, or Google Nest via Bluetooth

Tinnitus Masking

- Hearing aids often include a feature called "**tinnitus masking**", that can added as a HA program
- The hearing aids create a sound to disguise, or mask, the sound of the **tinnitus**
- The tinnitus masker is customizable to an individual's needs:
  - Type of background sound- such as noise, low-level music, pleasing environmental sounds
  - Intensity
- The goal is not to really mask the sound but to draw the listener's attention away from the tinnitus, and, in turn, decrease their emotional reactions to the tinnitus
- ** Note that sound therapy using a smartphone app can also be effective for many tinnitus patients using CIs

Remote Hearing Aid/CI Programming

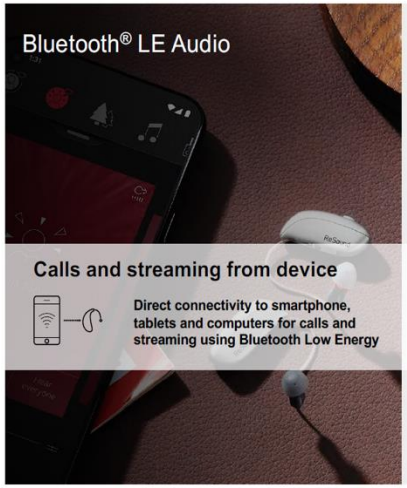
- Hearing aid/CI remote programming allows audiologist to interface with the client without the latter coming to the office, thus decreasing # of times need to go to the clinic
- Great for office visits such as:
  - Hearing aid/CI fitting follow-up visits
  - Problem-solving, allowing for programming adjustments or determination of need for repairs

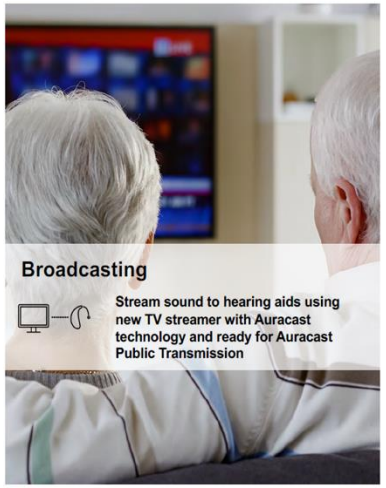
Bluetooth Low Energy Audio & Auracast

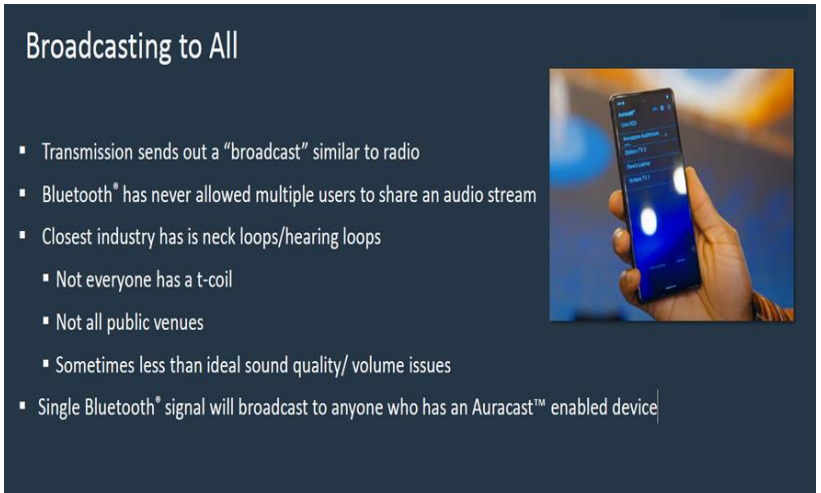
Shift from BT Classic to BT Low Energy (LE) Audio (Auracast) in the next few years will greatly change the world we live in

Conventional BT involves direct connections between two devices, while Auracast is a broadcast-style model, thus, no need to pair devices & heard by multiple receiving devices

Because audio is transmitted directly from transmitter to device, one hears it in real-time with very low latency; also at greater distance (100’ vs 30’)







Auracast will make the world more hearing friendly and accessible for everyone

Share your audio

Shared listening and watching from your personal device

Hear your best

Public address and assistive listening

Unmute your world

Public TV watching

Endless Possibilities

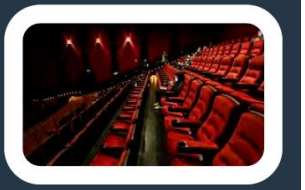
Silent screens

Lecture halls

Guided/audio tours

Multi-language support

Theater/auditorium



BT LE Audio versus Telecoil

BT LE Audio Advantages:

- Maintains frequency response of hearing aid and higher quality acoustic signal, while telecoil has more limited frequency range
- Telecoils are susceptible to electromagnetic interference
- BT LE Audio allows for stereo signal versus monaural signal of induction loops
- Will be available to all individuals (via headphones/earbuds, hearing aids, CIs), thus wider availability
- Many greater applications as mentioned earlier

** However, since will take # of years to roll out, it is recommended that HA users get both BT LE Audio chip as well as telecoil

Advances in Cochlear Implants (CI)

- Many of the advances in hearing aids have also been incorporated into CI, including:
  - Noise (wind noise) reduction
  - Directional mics (enhanced speech/noise ratios)
  - Significant improvements in miniaturization and design
  - AI (further enhancing speech recognition and speech-to-noise)
  - Wireless connectivity (including remote mics & BT)
  - Waterproofing
  - Tinnitus Masking

Recent & Future Advances for CI

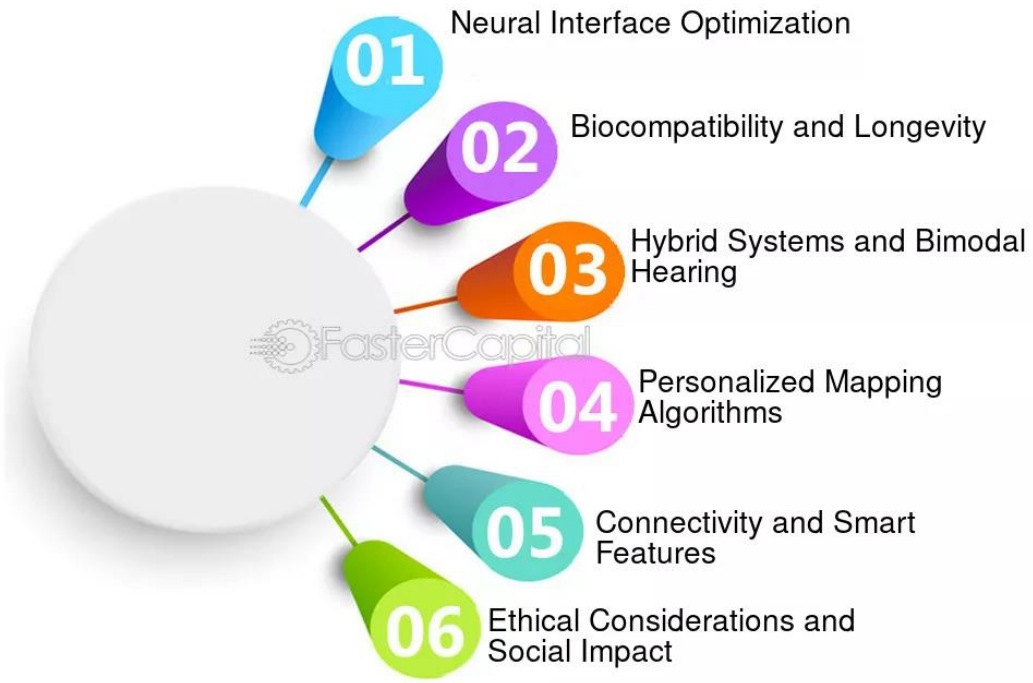
Recent Advances

- Provision of bilateral CI (simultaneous or sequential)
- Hybrid CI (hearing aid component for lower frequencies and CI for higher frequencies)
- CI for single-sided deafness

Possible Future Advances

- Improvements in surgical technique to allow even greater preservation of residual hearing
- Continued improvements in external and internal components (electrode design, # electrodes, and placement)
- Improved music/speech perception with introduction of improved coding strategies
- Fully implantable CI (mic/processor implanted as well)

The Promising Future of Cochlear Implant Technology



Summary of Key Points

- *There is so much that is now available to hearing aid and cochlear implant users*
- *Hearing aids now incorporate many advanced features, many of which go beyond just addressing audibility*
- *With the onset of BT low energy audio and Auracast, this will truly facilitate increased listening access to recreational and important life activities*
- *Hearing devices can allow us to access auditory information in certain situations where individuals with normal hearing acuity may not (e.g., muting TV and still being able to hear the TV comfortably, using remote mic to hear better in background noise or at a distance, etc.)*
- *Hopefully, the above will decrease the stigma of hearing loss*

Appendix

Automatic Speech Recognition

- As you know, when using Zoom or Google Meet, you can activate ASR and see real-time captioning
- ASR is also incorporated into various apps for in-person captioning; some of these apps are free while others include additional features and have a monthly fee
- **Apps include:**
  - Live Transcribe (Android compatible and free of charge)
  - Live Captions (iPhone and accessed via the iPhone settings)
  - Ava: Transcribe Voice to Text (for Android/IOS; tiered subscription plan;
  - Otter.ai (available for iPhones and Androids; different options, some with monthly subscription)

Real-Time Captioning Apps for Specific Settings

- The BeAware Conference Captioning app provides Deaf and Hard-of-Hearing people quick accessibility to any in-person event within 15 seconds for real-time captioning for speeches, live events, press conferences, and trade shows.

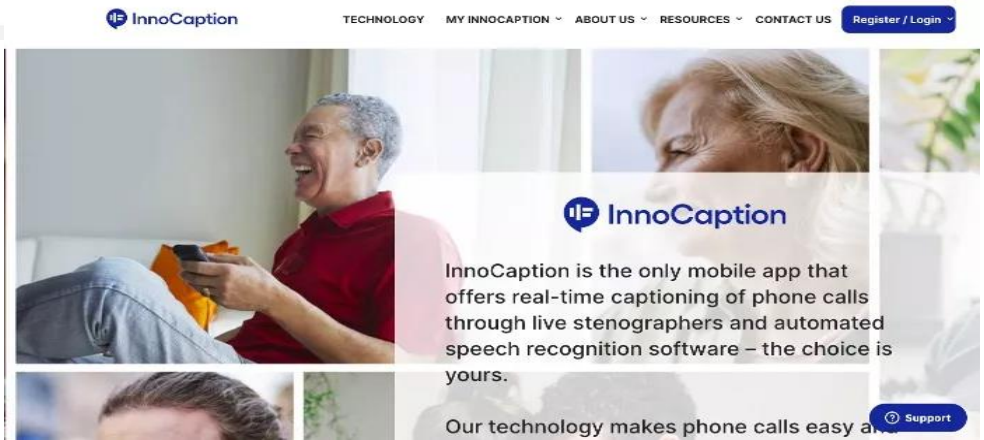
  Attendees to stream captions in real-time on their smartphones, ensuring an inclusive experience for all participants
- HealthScribe is a tool used in hospital emergency rooms to provide offline fast and privacy-safe live transcriptions for Deaf and hard-of-hearing patients

Glasses that provide real-time captions (some examples)

- XanderGlasses
- Pulse Audition

Telephone Caption Apps

- Ability to talk to other's on cellphone via use of captions and BT connectivity to hearing aids (caption program is free)



Some Useful Links re: Hearing Aids, Cochlear Implants, AI & BT,

https://www.hearingtracker.com/resources/ai-in-hearing-aids-a-review-of-brands-and-models

https://www.hearingaid.org.uk/hearing-aid-technology/how-artificial-intelligence-can-help-your-hearing

https://www.hearingaid.org.uk/hearing-aid-technology/hearing-aid-technology-2024#:~:text=The%20Latest%20Hearing%20Aid%20Technology%202024%20Predicting%20new%20developments%20in

https://news.mit.edu/2024/implantable-microphone-could-mean-fully-internal-cochlear-implants-0702

https://blog.medel.com/technology/the-future-of-cochlear-implants/