Hearing is Believing: Demonstrating the Benefits of Hearing Assistive Technology

Presenter: Justin Burwinkel

- [Anna] All right, this is Anna from Audiology Online and I'm gonna go ahead and get us started with the webinar FAQs. Justin, if you wanna go ahead and advance us to the first slide, that'd be great. Okay, if you would like to ask a question today, please do so by clicking on the Q and A box at the bottom of the Zoom window. If you would like a handout for today, I am sending that in the chat, so you can go ahead and click on that link to download the handout. If you go to the next slide, if you would like to earn a CEU for today, please stay logged in for the entire session. And if you're a member of Audiology Online's Unlimited CEU Access Membership, you can earn that CEU by going back and taking and passing the five choice multiple choice question.

You have seven days to do that. If you have any technical issues or problems today, please send me a note in the Q and A, or you can call Audiology Online at 1 800-753-2160. And the last thing we're gonna do before I turn this over to Justin, is running through our learner outcomes. So the learner outcomes for today are as follows, understand the efficacy of wireless assistive listening technology and improving speech recognition SNR for individuals with hearing loss. After this course, you'll be able to describe the impact of counseling and in-office demonstrations on patient awareness, information retention, and motivation for using hearing assistive technologies. And lastly, after this course, you guys will be able to discuss the analysis of real world recordings that were used to estimate speech intelligibility improvements and ecological listening environments.

And now I'm gonna turn this over to Justin.

- All right, good day everyone. Thank you for attending this presentation, "Hearing is Believing." As a research audiologist working in industry, I welcome opportunities like this because I recognize it's not enough for us just to develop great hearing aids with a variety of wireless audio input options. We need well-informed audiologists to actually introduce these wireless audio functionality to their patients. And I'm reminded of a

quote from Walt Disney. He said, "You can design and create and build the most wonderful place in the world, but it takes people to make the dream a reality." And the fact that you're here today, you're my kind of people and I'm so grateful for that. So without further ado, let's begin.

In this presentation, I plan to discuss the observations and implications of several research studies on this topic. But before we delve into those details, I wanna take a moment to just acknowledge the contributions of individuals that you see in your screen here. This research is a product of a brilliant group of engineers, audiologists, and several research collaborations. And if I take the 30,000 foot view from all of these studies, the key research questions really boil down to these three: What is the actual SNR benefit from using wireless assistive hearing technology in both laboratory environments and real world situations? How does the use of direct audio input into hearing aids affect the patient's perceived listening effort? And finally, what's the most efficient way to counsel on these types of features for optimal information retention and use?

And in other words, how can you make the most of your patient interactions and increase the likelihood that your patients will understand what this means and actually be able to benefit from it? Well, let's take another step back here and ask why should we even be concerned with our patients' use of assistive listening technology, to even begin with? Because on one hand it might seem like a silly question, right? We know that hearing in the presence of background noise is frequently the primary complaint that leads our patients to seek our help as hearing healthcare providers. That's obvious to us. But a fundamental acoustics perspective would say, assistive listening technology allows us to pick up that target signal captured close to its source, which means it's further away from picking up potentially competing background noises, and it transmits it over a distance while maintaining that advantageous signal to noise ratio.

And in the case of our patients who might attend lectures or religious services, this can mean the elimination of those extraneous noises around them, or the ill effects of reverberation. And certainly as we saw during the pandemic, the use of physical barriers and PPE can make listening, even for those of us with typical hearing sensitivity, all the more challenging. But looking even further beyond that, we ultimately need to be recommending assistive listening technology to help our patients to live the lifestyle that they'd like to enjoy. And while I'm not going to focus on health or mental health and the cognitive implications of withdrawing from social interactions, I do think we can all appreciate that supporting our patients to communicate better in public venues is a very important element of what we can provide as hearing healthcare providers.

So let's take a moment to take a look at these studies and see how much patients might realistically benefit from using them. In this first study, we chose to emulate a realistic scenario where even close distance communication can be difficult. Think about the information desks at a busy museum center or at an airport. Imagine the crowds and distractions around that. Then a pandemic comes along and the world is using plexiglass barriers and facial masks that not only reduce speech audibility, but also deprive our patients of those important visual cues that they would use to supplement their ability to understand them. Well, we created this type of environment in our lab, which allowed us to efficiently compare patient performance when using the hearing aid microphone as an audio input, versus using a telecoil with an induction loop system that might be found at one of those types of desks.

Since it would've been wholly impractical for us to constantly be setting up and removing physical barriers during a lab study, we chose to systematically re-record QuickSIN test stimuli to instead reflect those different conditions acoustically. Like the original QuickSIN test, we progressively decreased the signal of noise ratio by five DB for each successive sentence of the test, ranging from positive 25 DB SNR, down to

zero DB SNR. For those re-recordings, we presented the original QuickSIN test stimuli using a talking research mannequin, which actually has a loudspeaker that's ported through its mouth. And that allowed us to use the mannequin in a way that it accurately reflected how facial masks filter speech. Then while the mannequin was speaking, we rerecorded the speech from a podium microphone that you can see near the mouthpiece of that mannequin and that signal we eventually routed through a hearing loop while human subjects were listening, and an ambient microphone just on the opposite side of that plexiglass barrier, which we used to present the speech signal for sound field testing where the hearing aids would pick up using their microphone.

Then once we had our rerecorded testimony, we tested the performance of 20 hearing aid users. And what we found was that the hearing loop and telecoil listening conditions significantly improved speech recognition for all three test scenarios. Now, a quick note here, the results you see are the percentage of words correct across six signal to noise ratio conditions. So that plus 25, plus twenty, plus fifteen, et cetera, on down to zero db. So naturally, performance seems quite low as a percentage, particularly with that microphone condition, because we were testing out all those SNR ratios and that's what you're seeing in those tan bars here. And you can also see the effect of going from the unobstructed test condition where there was no plexiglass barrier and the mannequin was not wearing a mask, compared to the mask and barrier conditions respectively.

You can see there was a notable decrease in performance. However, if we look at the blue bars, which represent the hearing impaired listeners' performance in those same conditions. When listening to that podium microphone signal being routed through their hearing aids telecoil, we saw a significant improvement that remained very high across all of those scenarios. In fact, the only scenario where we saw a small dip in the telecoil performance was when the mannequin was wearing a mask, which makes sense because the mask would still be attenuating some of that acoustic energy before its

picked up by that podium microphone, and that would not be the case obviously, with the unobstructed or barrier conditions. Now our second study sort of piggybacks off that first, but it goes so much further towards relating those laboratory results to real world benefit.

For the second study, we developed a research firmware that allowed our Genesis RIC RT hearing aids to collect real world recordings from both their microphone and telecoil inputs, while a listener was listening in various places where our hearing loop would be available. And the research firmware basically allowed us to stream synchronous microphone and telecoil input recordings to a smartphone for storage. Now, traditionally, hearing aid manufacturers might compare recordings made with and without a noise reduction strategy being applied, to objectively provide a result of what that benefit would be. However, those types of recordings are generally made in a lab where there can be a perfectly clean reference signal separated from the noise signal, so that we know what's noise and what's target.

Obviously that would not be feasible in a real world situation, like the ones that we wanted to characterize in that study. So instead, we collected these recordings from various types of venues and then we processed those recordings through Google Speech to text AI recognition software, which automatically generated text transcripts of what it believed it had heard. And then we compared those to the ones created by normal hearing listeners. And we used the normal hearing listeners' transcripts as a ground truth and then reported the accuracy of the Google AI for each of the microphone input and telecoil input transcripts. So in a moment I'll share these recordings with you and those results. But before I do, I want to show you how the Google AI performed compared to hearing impaired subjects from that first study at each SNR step level.

So we collected the same hearing aid microphone and telecoil input recordings while wearing those research hearing aids in that lab setup that we used for the first study. And we did this to help us relate that AI's performance to human performance at known SNR levels. And what you see here, going across the top in that red line on the graph, that is the Google AI speech-text recognizer's performance in terms of percentage of words correct when processing the original QuickSIN tests perfectly clean speech-only stimuli. Below that, you see the dark blue line. This is the performance of the AI when processing the recordings we made from the telecoil input of the hearing aid wearer listening in that lab set up.

And we see only a minimal degradation performance compared to that perfectly clean original QuickSIN speech stimuli. Slightly below that is the lighter blue dash line. This is the average performance of our 20 hearing impaired subjects. You see relatively consistent performance across the SNR step levels, though with these human subjects, we do see at the most extreme SNR levels, there was some degradation. And this was likely because unlike the AI when it was making its transcripts, it's only hearing what's in that telecoil recording. However, the human subjects could also hear background noise that could be leaking in through their ear molds or earbuds, particularly if they had an open fitting. So, that finding makes a lot of sense still.

Now to take a look at those dotted lines representing the performance with the standard hearing aid microphone inputs. Here, where it becomes more difficult, we see human performance was better than the speech to text recognizer. However, they both followed the same pattern of poor performance at that SNR, lower SNR levels, and both showed poor performance than what was achieved when listening through the telecoil input. So with that explanation as a framework, I wanna share with you a few of the recordings that we collected from actual real world use cases. And this first one was collected from the departures hall of the Minneapolis St. Paul International Airport. And in the first sample here, you'll hear the recording from the hearing aid microphone

input, and then the second half will be from the hearing aid's telecoil input as it picks up a public broadcast through the hearing loop that was installed throughout that portion of the airport.

So, here we go.

- [PA] Paging the party who recently lost a cell phone rescue in the mall area. see the information representative Paging the party who recently lost a cell phone in the family restroom in the mall area. Please see the information representative,

- Hopefully you were able to hear that demonstration and the differences that listening through the telecoil could make there. But if you couldn't, here's a visual representation that might help you see the differences. These are spectrograms, which show the amount of acoustic energy at each frequency over time. And in the spectrogram at the top of the slide, you see speech with well-defined speech formants in the lower frequencies, and you can also see these cooler greens and blue colors across the spectrum, particularly in the gaps between speech utterances. This shows the reduction in background noise level and the clarity of speech that can be heard through the hearing loop. And if you look at the spectrogram on the bottom, you see a lot more of that red and yellow where there's just a lot of acoustic energy in the key speech regions of the signal.

And this is because there are many other conversations occurring in this public space. And you can still see that there are still some of the speech formants emerging from the target talker, but they are definitely less clearly defined and somewhat masked by that background noise. Now if we look at how the Google speech to text AI performed with these two recordings, we see market differences. With the microphone signal, the AI showed zero understanding of the target talker. There were just too many other competing voices for it to really lock onto that one voice we were interested in.

Whereas a correctly recognized 92% of the words for the telecoil recordings. So going from zero to 92%, I mean, that's huge, right?

And if you put this in the context of what was actually said in that overhead announcement, it can be even more profound. I feel for our patients who might be in the situation where they're traveling with their children, where they're under a lot of stress trying to get their family through the airport, only to become separated from their cell phone. So they have hearing loss, they're in a strange place, they're likely frustrated and clearly scattered all over the place. And their most reliable source for non-auditory information, has gone missing. Think of how much of a difference actually being able to hear that overhead announcement would be to that person. Losing your cell phone could easily make or break your vacation.

Now, I think the next example is also a very good one. And this one, the hearing aid user is standing at baggage claim at that same airport. There's a lot of machine noise generated by the conveyor belts, so you're gonna have to listen carefully because you might not even know that an overhead announcement is occurring, but here we go. Again, in this example, the differences are evident in the spectrograms that we can visually inspect. Look at the spectrogram on the bottom for the hearing aid microphone input. There's just so much noise present here. It's almost impossible to spot speech formants of the target talker or even the gaps between the utterances. And in the telecoil spectrogram above that, you can see where the utterances begin and end, you see those speech formants, and the speech to text AI correctly identified 96% of the words using the hearing loop in that baggage claim area.

And that's compared to the 11.5% that it was able to recognize from the microphone recording. So based on these last two examples, that appears that the speech to text AI handles machine noise better than multi talker babble, but in either case, there was significant improvement when using the telecoil input versus the hearing aid

microphone input. And in this final set of recordings that I wanna share with you today, I wanna shift your attention to the effects of reverberation. I think we can inherently appreciate the difficulty that even normal hearing listeners can have in noisy situations, but reverberation might outwardly seem more benign. Because by definition, reverberation is just echoes or duplicates of the original signal that are a little bit quieter and a little bit delayed.

However, there are a couple of major problems with that for our hearing impaired patients. First, hearing aids amplify using nonlinear compression. This means that softer sounds tend to receive greater amounts of gain, which can make those echos sound almost as loud as the original version of that sound. Secondly, our patients can really be hampered by reductions in their auditory system's spectral and temporal resolution capabilities and degradations thereof. So our patients have difficulty in large spaces, as well as small chapels like this one.

- [Anna] Hey Justin, I think something went wrong with the sound. I'm not hearing anything now. I know we checked it earlier. Do you wanna just double check?

- Sure, or maybe have the participants turn their volume up. I am hearing it on my end. I'll go back a slide.

- [Anna] Okay. It could just be me. We'll just let it go, I'm not getting any complaints.

- Okay, well again, if they're not able to hear it, hopefully they're able to see it. And the spectrograms for this recording are very revealing as well. The telecoil spectrogram up top looks beautiful. It has a very wide bandwidth and great contrast between the signal and the noise. Very, very clearly defined speech formants. Whereas the microphone recordings look as if someone took the one from up top and just smeared it sideways to the right. And reverberation is effectively a temporal smearing of the signal of

interest, and this is just such a vivid example of that. And when we look at the AI's performance in this situation, we did see a little bit lower performance with the telecoil input, about 85% accurate, but still quite good.

I think the AI struggled a little bit with some of the uncommon vernacular of biblical readings and chanting, but again, still good performance there; especially in comparison to the microphone recordings, which yielded only 30% accuracy. And thinking back to the differences we observed between the AI and hearing impaired subjects at known SNR levels, we've been able to estimate that hearing loops and telecoil is fairly consistently provided equivalent SNR benefits of ten, 15, and in some cases like the airport examples that I shared, even up to 25 DB of SNR improvement. And just to reiterate this point, we observed this in real world use cases where we just showed up, and we passively collected the recordings. So I don't think it becomes any more ecologically valid than that, to just collect the recordings passively.

Now for the third study, it's comprised of three different parts that I wanna walk through. The first was that we provided differential hearing aid fitting appointments, in terms of how the participants were counseled. Secondly, we conducted additional laboratory testing to compare the telecoil performance specifically to remote microphone performance. And again, we made more ecologically valid observations related to utilization. And for this study, we involved, actually, 28 participants with hearing loss, all of which were experienced hearing aid users. Half of them were fit with Evolv AI CIC hearing aids. And for our testing we had them use the remote microphone plus accessory to access its telecoil functionality. And the other 14 participants used the Evolv AI Power Plus BTE hearing aids, which of course has an onboard telecoil built in.

As you'd expect, the CIC users had more mild to moderately severe hearing loss, while the power plus BTE users had more moderately severe, to severe and profound hearing

loss. We randomly split those BTE users into two subgroups. We had what was we referred to as the no demo group. They were given a telecoil program to access hearing loops and were instructed on how and when they might access them, which included showing them the universal hearing accessibility signage with the T symbol on it. The second group was our demo group. And in addition to receiving that verbal counseling, we allowed them to practice accessing the loop and to listen to a hearing loop during their fitting session.

They were also given a list of venues in the Twin Cities metro area where public hearing loops could be found, and in total we spent about five to 10 minutes between explaining and demonstrating that with them; so not an exorbitant amount of time by any means. And then about a month later, they came back for their followup session and the participants were asked, do you recall talking about the telecoil feature at your fitting? We asked 'em if they could explain to us what their hearing loop program would be for, and we had them reteach it to us. We had them demonstrate for us how they would actually access that program. So after about a month, all of the participants in that demonstration group reported that they did remember talking about the telecoil feature and five of the seven participants from the no demo group remembered talking about it.

So a high percentage from these groups at least remembered having these conversations. When asked, do you recall what the loop program does? All seven participants who received the live demonstration recalled what the telecoil is for. Out of the seven participants who did not get the demo, only two remember what the telecoil could actually do for them. As for remembering how to access it and use it, there was one from the demo group who forgot, but still six of the seven who received the loop demonstration at their first visit were able to reteach us how to access the loop program, one month later. And that's compared to the total of two from the no demo group who were able to do the same.

So we saw a clear effect on knowledge retention, all from taking just a few extra minutes to demonstrate this in the office. And although this is a small number of participants, I think it's a powerful insight that could extend beyond just that feature. So keeping this background in mind, let's talk about the next phases of the same study. The second part of the study was to evaluate speech understanding in the lab with the hearing aids alone, compared to with a loop system and separately with a 2.4 gigahertz wireless remote microphone accessory. This study was done in a simulated looped conference room environment with very high reverberation. AZBio speech simul were presented at a distance of 10 feet, which in this reverberant room was actually beyond the critical distance, basically meaning that the sound reflecting off the walls was reaching the listener at the same level as the direct sound was coming from the talking mannequin.

So this was, by all accounts, a challenging listening environment. But we were really, the goal here was to determine the maximal benefit of wireless audio systems. So we had, again, those three test conditions, hearing aid alone, remote microphone, traditional acoustic audio streaming, and telecoil listening. And here are the results, separated for those BTE and CIC participants. And the first bar on the left there for each group is performance in terms of words correct with the hearing aid alone test condition, which again, you can see how difficult that listening scenario was that we had created. But if we look at what happened as the participants used the remote microphone and telecoil, we saw a significant improvement over using just the hearing aid microphone alone.

And I think it's worth noting that there was not a statistical difference between the telecoil and remote microphone conditions. We observe the same dramatic effect, whether using the telecoils or the remote microphone technology. And the degree of that potential improvement that someone can get when they're struggling in an

environment as difficult as this, is absolutely remarkable; even for the patients with more mild degree of hearing loss. Now, fast forward another month into the study, so now we're at the two month mark, and that's when we brought in all these participants for a simulated movie theater experience. In this phase of the study, we designed it to help us understand more about the real life usage of telecoils and to continue following the ability of our participants to remember that information about telecoil, with those two different counseling approaches that I described earlier.

We wanted this to be as lifelike as possible. So before, when we were scheduling them to come into this, we were telling the participants to think of the event as if they were going to a movie theater on their own. We encouraged them to use whatever settings that they felt would allow them to hear their best that day. So when the participants arrived to our theater, they were greeted as if we were to take tickets from them. And just beyond that greeter was the standard ADA signage that indicated that there would be an active hearing loop inside that theater. But no one was calling the participant's attention to that signage. It was just there and if they walked by it and saw it passively, great.

But once everyone was seated, we began the film. And again, in the spirit of making it an authentic movie going experience, we began it by playing the same type of movie previews and trailers that everyone is accustomed to seeing when they arrive at a movie theater. And then once the actual film began, we were monitoring those BTE users to see if any of them were activating their loop program on their own. And here's what we saw: The blue bars indicate the number of participants from the Telecoil Demo group and the tan color bars represent the no demo group. And on the left we see how many participants self-initiated their loop program, a total of three; two from that demo group and just one from that no demo group.

Then we interrupted the film to administer a survey. One of the questions was about whether or not that hearing loop signage was outside the door as they had walked in. So asking them to recall and remember if they saw it or not, or if they even looked for it at all. And interesting, a greater number of participants indicated that signage was visible outside the room, and then there were more of them that noticed that than who actually activated the loop program during the first five minutes of the film. Most of the participants, however, reported not remembering to even look for the signage to begin with. And I think these findings are are interesting, so we're gonna talk more about that in a moment.

But after that initial survey, we conducted paired comparisons to determine listening preference based on a variety of movie scenes, which captured a variety of talkers and music genres, as well as having someone in front of them with a speaker, speaking to them with a microphone rather, speaking to them live. And you know, I wanna point out that this was all done, all these comparative listening was all done in a professionally sound engineered auditorium. So this was unlike our previous experimentation, a very favorable listening environment. And even still, when we look at the results of these pair comparisons, we see that in that auditorium environment, the participants overwhelmingly prefer the loop program over their everyday normal program, as shown by the bars on the left side of this page.

And the trend was a bit stronger for BTE users than the CIC users, which I think still makes sense based on what we consider a normal or general candidacy criteria for when we recommend loop systems. When we look at perceived listening effort, we can see a similar trend there, too, as well, that there was a large percentage of participants who reported less listening effort with the telecoil than with their acoustic everyday listening program. In fact, 96% of the BTE users reported less effort with telecoil than their microphone, and still, 70% among those CIC users. So this shows even a large

percentage of those CIC users with those more mild degrees of hearing loss perceived overall less listening effort with the telecoil than that normal program.

And again, this was data based on a favorable listening environment. You can see that the participants were also almost all either somewhat likely or very likely to seek out hearing aids with hearing loop compatibility in the future, based on their experience during that study. But if that were the case, why hadn't these same participants switched to the Loop program at the start of the film, right? Especially the participants who apparently saw the signage as they walked in. Well, I think we learned a couple of key things from these studies. First, yes, demonstrations absolutely do help with awareness and knowledge retention. Yes, audio inputs provide a more favorable listening experience. And in many situations, it's not even close.

But finally, for things to really stick, the rubber needs to meet the road. Our patients have to go out and prove it to themselves. They have to experience remote microphones and hearing loops for themselves in scenarios that are meaningful to them. So what can we do with this information? We can teach our patients about these technologies, we can demonstrate it with them, help them practice it, but perhaps most importantly, we can encourage them to go out and use it in the real world; have them report back on how it went, ask them about it at their follow-up visits. And if they tell you that they didn't try it, really challenge them to do so. And it's okay to send them to places that they might not otherwise go, because the benefits are clear.

But they need to internalize those benefits before they'll have this lasting behavior change. And I know I went a little over today, so many thanks for attending today's presentation. I hope you found our data and these demonstrations compelling. It'll take all of us doing our part to make the dream of having a truly hearing accessible and inclusive society become a reality. You can use this QR code to access our white paper and our research posters on this topic. We have additional real world demonstrations

that you can listen to. Feel free to download those, share 'em with your patients, or any facility managers in your community who you think might be considering installing hearing accessibility systems. And finally, please also know that you can reach out to me directly.

I'd love to help support you in this important cause. So you don't have to stay for this next part, but if you do have questions, I'd love to field them.

- [Anna] Justin, it looks like we've got one question. What is the most accessible and accepted method of direct audio?

- In public places, I think the most preferred, which might not necessarily be the most widely used, but the most preferred by hearing aid users would be hearing loop systems, for a variety of reasons. They don't have to go fetch a listening device at the front desk, which may or or may not be charged or have been cleaned since the last user. They don't have to wear that conspicuous device, and they can take benefit from the fact that the hearing aids will do that individual enhancement of the speech for them, based on their audiogram, right? The hearing aids are gonna amplify the sound best to meet that person's needs. That being said, probably the most widely used system are either infrared or FM systems, which do require those handheld boxes to be worn with headsets.

But users can use those in combination with what's called a neck loop, where then they could benefit from their hearing aid, again, processing that sound for them. There are ADA requirements, in the US at least, that say a certain percentage of those FM or infrared receivers need to have neck loops, for specifically to provide hearing aid compatibility. I have found that they are not, many venues don't live up to those requirements, so that is another role that we can play as audiologists, as advocates for

our patients in our communities, is to make sure that those are available for our patients when they go to use them. Great question.

- [Anna] And just a point of clarification as far as the exam question goes, there's a question about what is the most universally accessible method for providing direct audio, and that is telecoil; just in case anyone was not a hundred percent sure, I'm giving you a clue for the answer. That was our only question, though, so I believe we are at the end of our time.

- All right, well thank you again, everyone. Appreciate it, gave a good rest of your day.

- [Anna] Thanks.