Advanced Directionality with Single Microphone Hearing Aids

Presenter: Eric Branda, AuD, PhD

Now let's dive into today's course, Advanced Directional directionality with single microphone Hearing AIDS presented by Dr. Eric Branda from WS Audiology. Throughout this month, Audiology Online is showcasing groundbreaking advancements in the hearing industry with our 6th annual Industry Innovation Summit. Thank you for being here today. We encourage you to explore our course library for other compelling summit classes. And now it is my distinct pleasure to turn today's course over to Dr. Eric Branda.

Thank you very much and hello everybody. Good afternoon. Thank you guys all for joining me and hope you'll find this an interesting topic. I think this is some fun stuff. Just talking directionality over lunch to move on here after today, we'll be talking about some things, looking at impact of noise on speech intelligibility.

We'll talk about the limitations of single microphone hearing aids for directionality which also lead into how we can make that work and then looking at Those benefits for 1 mic directionality for improving speech.

So with advanced directionality in single microphones. And it's advanced because we're really, if we look where directional microphones have come over the years, there's some major improvements just in design where it's not even a directional microphone, but it's a totally different type of technology and things we've done with wireless. And it all comes down to when we think of one of the biggest challenges that we have with people with hearing loss and hearing aid wearers. And if I look at some of the market track data, noise is the big challenge. If we look at this table on the right here, this is no surprise to anybody.

But if we look at this is showing satisfaction for these scenarios for non owners of hearing aids. So we're looking at people that have a hearing loss but are not currently amplified. And the number one issue where we only see a quarter of them satisfied. There is following conversation in the presence of

noise. And I don't think that's a surprise to anybody.

That is one of the biggest issues people come in our doors with. And if we look at those other categories that are having trouble conversation in large groups, that is a noise situation when there's going to be a talker with fans and air conditioners in the background or if it's going to be other people talking, it is background noise. So the satisfaction is not much higher there. So if you look at the different noise categories, we know it's an issue and again it's what they come into the office reporting is an issue. Which then brings us to how do we solve this issue?

Because we are problem solvers in that regard. And the key way we always look at it is directional technology. And we have to think about how directional technology has evolved over the years. We go back to the earliest directional microphones. We're thinking of a microphone, single diaphragm, with two ports.

And it's the timing difference that comes into those two ports that would create some directionality to help amplify what's coming from the front and help suppress the sounds coming from the back. But that is a concept that works for us today. But that's an older technology. What we're really doing today, and we see in almost all of our hearing aids that have directionality today, is we're using two separate omnidirectional mics. So it's not one mic with two ports.

It is two microphones each with their own port. And when we look at how the directionality is happening with that, it's basically each of those mics is picking up all the information based on where it is on the head, where it is in location, to the other microphone, if it's in front, in front, or behind it. So everything around it is picking up, and the directionality is actually happening as algorithms calculating the differences between those two, because it looks at what's hitting the front mic, what's hitting the back mic, what's the delay. And they're just these really elaborate algorithms that look at how that directionality is happening and looking at how to control for the different directions of input. And this is

actually the term you can hear from this is beam forming.

So if you talk to any engineers or audio engineers, beamforming is the first term that comes to mind. But we've kind of inherited the term of directionality as we've gone through the years. But it is beam forming that we're putting in the hearing aids. And if we kind of look at that. So here we're looking at a monoral directional.

So I'm just looking at one hearing aid. So again, one hearing aid, two microphones each one of that. Each microphone is picking it up. And as it goes through the whole processing piece, you know, there is a segment of that where it's doing the directional component, where it's looking to suppress that rear noise and looking to emphasize what's coming from the frontal direction. Although in some cases, because it is an algorithm, you could flip that around and amplify what's coming from behind and focus what's coming on from front.

But the most practical approach, of course, is amplify Focus on what's in front, which is usually where our speech is coming from.

And a way we can always measure that is looking at our directional patterns here. So we see the red line indicates more of an omnidirectional pattern. You see some, since we're measuring on the left, we see some head shadow effect from the right side. But you see the farther the line is away from center is indicating that we're getting more amplification. So in the omnidirectional that red goes all the way around.

So we're picking up a lot from behind. But as soon as we go into that beam former and get that directional, that's where you see the green there. And the front is still getting that full focus. But we're getting that nice reduction on the sound that is coming in from the rear field.

And when we look at this, we have to start thinking about directional benefit. And the key thing about the directional mics because they're cutting out that background noise is that we are improving the signal to noise ratio, the snr. And by improving the SNR we can therefore improve speech intelligibility for the wearer. But this is really going to differ for each patient, how that's going to matter to them. If we look at this chart on the right, this is from Rickets 2001.

I think it's a really nice example of how two people with very similar, same hearing loss could walk in the door and have very different performance and noise. If we look at the chart on the bottom there, we see the SNR going from very poor SNR, negative SNR on the left up to a very positive signal to noise ratio on the right. So you know, much, much better hearing capabilities there. And then on a certain test we're looking at the percent correct. They get on, on the test and we got two people there, we have Lucky and Amanda.

And if we look at the two curves, you see the one, the first dark curve starts at about minus 5snr going up there. And that's Lucky. And we see the, the dotted line curve for Amanda. And if we think about how these two people would be doing in different noise situations and then how some directionality can, would impact them. And the directionality we'll look at is about a 6dB improvement on the signal to noise ratio here.

So just kind of a made up scenario here. But does it looking at the 6 decibels. So if we look at Lucky, if we look at where he is at a 0dB SNR. So my noise and my speech are the same. We see he's getting just around 50%.

If we give him that plus six boost with the directional mics, then that's taking him up to just around 85. So he's basically getting a 35% advantage there. So however he was doing that 0 DB Snr, we've just made it easier for him. 35% advantage. Now, if we look at Amanda in that same SNR level, well, at 0dB SNR, she struggles.

She's got very little intelligibility. She's getting 0% correct. And if we give her that 6dB improvement, she's actually still getting 0% correct because we've not even hit to where she is able to start hearing while in noise. Now, if we change the scenario, let's put them in a different setting where we're looking at a situation where it's a plus 10dB SNR, a very positive signal to noise ratio.

Lucky. He's already getting just over 90% there. And that 6% 6 DB improvement brings him up to already at 100%. So he only notices about a 5% benefit. He's just doing well already, so he's not noticing all that benefit from the directional mics, even though he is getting some benefit.

And then if we look at Amanda in this case, well, at 10dbnr, she was getting about 10%, but she's got a very steep slope. And that 6db improvement has just pushed her up 70% higher. So she's getting around 80% accuracy. So the directional mic has made a huge impact for her. So it didn't help her when it was very poor because of how she does in noise, but it helped her a lot in this.

And this is just bringing awareness to the individuality of our patients. But it's also important to think about when we look at these percent correct or how real world is for them, the type of signal is going to make a difference. If I'm looking at accuracy with single words, that may be a harder situation because they've got to get each phoneme accurate here. When we do a lot of the directionality tests, the two popular ones we work with are the American English matrix test, sometimes just referred to as the matrix test, and the hearing and noise test, the hint. And in both of these tests, we typically look at having directional microphone off, so being in an omnidirectional mode, and then the benefit they get in a directional mode, and we look to see where they get usually 50% accuracy.

They'll also do it sometimes for 80% accuracy. So we look at, you know, at what point are they getting in an omnidirectional, where do they hit 50%? And then when we give them that directional advantage, what's the SNR that they're now getting? That's that 50%. So how much of the SNR have we improved

for the hearing aid wearer?

And it's important to know then that what we tend to see with the matrix test, if we give them just a 1dB improvement, we usually see around a 13% improvement improvement. Whereas with the hint, a 1dB improvement in SNR usually reflects about 10% improvement in speech intelligibility. But in saying that you can already tell by looking at the curves that that's most valid for the middle of the curve, as we start to get to the tops or at the bottom where it's a little flatter, then that one DB improvement may not see a whole 10%, it may only see 5% or less. Um, so it's not that, you know, if I give them 5dB of SNR improvement, they're going to get 50% speech improvement. It's not that nice for us.

But I look at it that every little DB counts because if we think of Amanda and that's we hit her right in the middle of that slope there, you know, giving her that 10 to 15% improvement in speech with a single DB of SNR improvement. I mean that's the difference between struggling in a conversation or already being able to participate in the conversation. So I look at it that it's really important to try to help bring these benefits to the wear because every DB does make a difference. And if we look again at our market track data here, we can actually see that, yeah, what we're doing with technology primarily directional mics, is making improvements for them. If I go back to that same first area of when following conversation in the presence of noise with the non owners, they have 25% satisfaction.

Hearing aid owners are getting 72% satisfaction. And this is kind of that double edged sword that we're not going to hit 100% and we're not as close to 100% as we'd like to be. But wow, we've got a 48% improvement. 47%. I'll take that.

I mean, let's take somebody that's struggling without hearing aids and noise and find that major issue and then we can add in our directional component and we can help them. We can bring it to a much more satisfactory scenario for them. And that goes across for these other group situations and such. So we can really look at how to improve the situation in noise. And I bring up another little number that I

think is worth considering, especially think about the performance charts we just looked at.

A lot of the research shows that a noticeable difference in SNR is about 3dB, meaning that we usually need to see a 3dB improvement in the SNR for that patient to notice that. It doesn't mean that with one DB they're not getting improvement, but for them to notice it, which means we want to look at how we can really look at pushing that up for them. But we can't forget that every DB is making a difference for them and we want to help them as much as we can. Now, of course, we run into another challenge with some of our hearing aid wearers, and that comes in with stigma. So we know noise can be an issue, but there's also the aspect of stigma and the stigma, I think, with you look at hearing loss as well as hearing aids, and there's two different pieces of that.

How they see themselves perceived with having the hearing loss and physically, the visibility of the hearing aid. Because we think, first of hearing loss is that kind of invisible challenge that they may have. So somebody may not see that they have that, whereas then they see the hearing aids. And when they see the hearing aids, they look at that as a way that I've identified myself as somebody that has a challenge. So I've always gone on the route that a hearing loss is more obvious than a hearing aid, But I know that's not always how our patients look at it, because that hearing aid, there is association with ageism and associations, perceptions of the disability.

So if we look at that ageism, I mean, our patient population tends to be on the older side. So there is a natural association that if somebody has hearing aids, they must be older. Even if they're on the younger side, there is that association of ageism. There is something older about them that they may not want to be associated with. Also, when they see that hearing aid, I mean, it's kind of like you see somebody with a cast on their leg, it's obvious that they're not functioning at 100, if that's a, you know, a way to look at it, that there is something they need assistance with.

And we know the hearing aid can do a great job, but there's still that perception of it. So stigma is still a barrier for us, but on the other side, I think we're seeing improvements. Some of the data is showing that there people are rating stigma a little bit lower. We're not seeing it as much. And I think there's combinations of, you know, seeing things in the ears, but also in the sense of, you know, earbuds and stuff for listening to music.

So it's not as uncommon to see something in the ear. And some of the different hearing aids we have have very stylish looks, but we still also look at making smaller devices. As you, I'm sure most of you, if you've had that, you know, airplane or elevator conversation, what do you do? I work with hearing aids. Oh, they're making them so much smaller now.

I think we all hear that and first thing that comes to mind is the technology we have inside of those. So yes, we are making them smaller, whether it's CIC devices or the tinier RIC devices. And I think the technology that we're putting into them is also taking away from some of the stigma. So we have these different pieces working together to help reduce stigma. Although when we also look at it, if we want to use, you know, the reduction of noise to help, and that means, you know, getting to smaller devices that go in the ear.

Now we also need to consider, you know, do one microphone devices, well, they can't offer directionality if I don't have that second mic to work with. So it's a kind of a double edged sword that to make it smaller in one regard, we have to take away from some of the advantages that actually help reduce the obviousness of a hearing loss by taking away some of the directional capabilities.

Because again, if we look at how our directional microphone are typically going to work, we need those two microphones on the device and we're relying on those spatial cues and the timing between the two microphones so we can compare the signals between those two microphones. And when we look at making hearing aids smaller to help with the stigma issue, then primarily CIC devices where we only

have one microphone available on each device. So the question would come how can that deliver directionality?

So Signia with introduced one microphone directionality and we're actually on our second generation of this and by doing one mic directionality, again, that directional beam forming is happening with the algorithms in the hearing aids. So in this case, I have two microphones. They're not on the same device. They are positioned one microphone on one ear and one microphone on the other ear. But if I consider I've got those, I know the average distance of the head, I know my pinna effects, I've got all the Information there to calculate differences between two microphones.

I just need to get the information from each microphone fed into the algorithms. And this is where wireless capability comes in to help us get a directional beam with single microphone instruments.

The way we go about this is with near field magnetic induction. This is one form of wireless. The other form of wireless you'll hear about is 2.4 GHz. But we find near field magnetic is probably much more effective for the transmission we need. Because magnetic induction, it's a very short range wireless approach.

It's got a coil in each device and these coils are transmitting information back and forth. We've got the receiver transmitter function going on there. And so it's like a little magnetic field there. They work in really short range. So the transmission range is usually less than an arm's reach because it's very short range.

And they work on different frequencies. So we're working some common ones are like 13.56 MHz and 3.27 MHz. So this is totally not in our Wi Fi 2.4 GHz realm. This is a completely different area of the spectrum. But we've been doing this since 2004.

So we are. That was introduced with the Siemens Acurus when we first started doing wireless communication between devices. You can do it with something like 2.4, but 2.4 is blocked by water in the body where near field magnetic induction passes right through ear to ear. So it makes it actually very nice for synchronizing hearing aids. So it lets us focus on that bilateral synchronization.

So now my left and right devices can, can work together and talk together. We get a high quality signal transfer. Because as we're on our fourth generation of this, we've really improved the speed and the processing time so we make it much quicker. And it's such a low power drain. These devices, this, this wireless, I mean we've got our size 10 batteries.

We know that you're, you're scraping for every little milliamp you can work with there. And this is very low drain on the battery. So we can have this running continuously. So we're always getting the transmission between devices that we need. And this is what lets us have both of the instruments talk to each other and process the information from the other so that we can create that beam forming with these physically separated microphones on two different devices.

So what happens then is that if you look at this little diagram here, that I've got my hearing aid wearer in the center talking to four different people. Those three people on the outer side, that's where a natural pinna effect would help. And that's what we always traditionally have thought about with CIC devices is that the pinna effect will give me my directionality. But now that I can do this processing to give the 1 mic directionality and actually create a directional effect, we can tighten that up into more of a beam so they can hear more directly that person in front of them. So here they can actually shut down some of those other noises because they may not be talking to all four people here.

Those two people on the right may be having their own little conversation. And it's really the target speaker directly in front that we want to hear and speak with.

So the question is, does it work? How well does it work? And we've done some benchmark testing. So what you're looking at here is basically a measurement of the directivity index. And this is looking at any different cic.

I mean, it doesn't matter basically whether it's whose CIC it is. They're all getting about the same directional effect. You see very, very little happening in the lows and you get a couple db improvement in the highs on average, very little.

When I add in the speech enhancement with the binaural 1 mic directionality, we see five times that improvement because of that directional effect. So this is looking at measurements on a kemar, just standard technical measurements. So we can see five times the speech enhancement in noise by improving that, what we can do with that SNR now, what does that mean for us on real people? So this was a study we did looking at 17 participants, average age of 69, pretty even split between men and women, kind of a more mild to moderate hearing loss. And we basically tested them with the binaural one mic off and the binaural one mic on.

So the two test programs, and we use the matrix test looking for an 80% accuracy level here. And Babel Noise was presented at 45, 135, 225 and 315 degrees. So basically had the noise spread out as a babble kind of noise behind them. And again, the target speaker would of course come from the front. And as we look at the SRT50, so basically we're looking on the.

That the level at which they got, sorry, SRT 80, the 80% accuracy level, the higher up means that the SNR had to be better. So in this case, the bars, the lower the bar is, the better because that was a poorer SNR for them to get their 80% accuracy. And what we see here is going from a Omni at just about 0.3 D positive 0.3 to down to a minus 1.3 minus 1 DB on the with the directional, so a 1.3 DB advantage. So again, think about that Amanda from earlier here, we can give her almost a 15 to 20% improvement just by having these instead of other cics. So it's really a matter of, you know, every DB

counts and we can make that conversation easier.

And we see that we see a significant benefit in noise with the 1 mic directionality. And this lets us put it in a couple different hearing aid products. One where it's been very prevalent is in our Silk, which is an instant fit or I like to think more of as a ready to wear. So you don't need impressions. This could be putting a CIC style device for that again, discreet, stigma fighting look and offering them this directional enhancement with a comfortable sleeve.

And if we look at that, we've got 28 hours on a single charge. If you've tried one of these on. I remember when we first introduced these, these sleeves are surprisingly comfortable. I've actually known of patients who turn away from custom devices because they liked the comfort of the silicone sleeve on the CIC device. Also as mentioned, a rechargeable type of device, 50 gain, so very small, very discreet and has that 1 mic directionality.

Also in the NCO, IX, IIC and CIC, this is available technology in there as well. So here we're looking at custom designed products. In the IX platform we have the wireless again between both of those and looking at that, we can open up some of that conversation capability. And with that as well, again in the CIC and iic, and some of you may have heard that in Europe we have introduced a rechargeable custom CIC not available in the United States. Yet I do see a question come up.

Not Bluetooth compatible. That is correct. Because these are working on the magnetic induction, the Bluetooth capabilities. That's on a 2.4. So not putting it in these.

However, I will mention that there is a slightly larger version of the similar to the Silk called the Active and the Active Pro that does have your low energy Bluetooth, your Bluetooth audio. So not the Bluetooth Classic, because I don't think anybody's doing Bluetooth Classic in this size. These smaller devices we have Bluetooth Classic streaming in some of the larger BT and some of the RIC devices

like the Pure bct, but in these sizes, no. But in the slightly larger sizes. There's a Bluetooth low energy audio.

So I hope that answers the question that came up on the Bluetooth compatibility.

Overall we see that we can look at speech. Understanding is still an issue for people but we've got directional microphones to help improve that speech intelligibility and noise stigma is also an issue for us that we want to challenge for patient uptake. But with miniaturization and using this type of directional technology we can address those needs of stigma as well as getting them the directional benefit that we know helps them. So with that I will open it up for any other questions. Happy to field any.

Will ORACAST be introduced into these CICs?

So Oracast is based on 2.4 GHz transmission and it's a new piece of Bluetooth low energy. It's also very early in its stages. There are lots of changes. I think I shouldn't say a lot of changes but there are changes I would anticipate there's some regulatory guidance that's not due until the end of this calendar year. So I feel like it's a little early with oracast but I think it's a very interesting topic.

I would not necessarily see it in these but it's something we keep in the forefront looking at what we want to do with AuraCast.

Thank you.

So the five time. The question when you say state five time improvement in SNR and the CICS. So that was looking at. I've got to think back to the actual numbers on that study when we did the benchmark improvement on that.

I apologize for not having that right on top of my mind because it was just calculation the benefit of SNR improvement on the benchmark study. So on real people that's where we saw the 1.3 dB, the five time improvement there. I am just pulling up the. We have two papers on that. We have a white paper that has that information.

I'm just pulling up my white paper right now.

So when we looked at the it was looking at around 8 to 9 decibels at some of the frequencies. So there is an average taken in there. So some of the peak frequency saw an 8-9 dB advantage over what you would see from the Pinna effect. So that is.

And I think the average was around 7.3.

Thank you Dr. Brenda. All right. All right. With that we're going to go ahead and close down.

So. So thank you all for joining us today. I want to thank you all for joining us for the summit classes. Feel free. Be sure to check us out and see the other classes that we have available for you.

We'll be having a class later this month from Dr. Brian Taylor, also from Signia, So be on the lookout for that. And with that, have a Wonderful weekend, everybody. Dr. Brenda, thank you very much. All right. Thank you.

Have a great weekend. You, too. Bye. Bye.