Signia Podcast Series: Beamforming Technology - It's Not All Created Equal!

Recorded Date: August 25, 2020

Presenter: Eric Branda, AuD, PhD; Lisa Klop, AuD

AudiologyOnline.com Course #34585
Partner: Signia

Lisa Klop: Hello everyone. And welcome to another installment of Signia's Podcast Series. I'm really excited about today's topic, which is, beamforming technology, that is not all created equal. So I think we're going to hear some really compelling information today. I am Lisa Klop, which is to remind you, I've hosted a number of our podcasts. Happy to be here today. I am part of the Clinical Education Team and I'm super excited to be joined by my friend and colleague, Dr. Eric Branda. Dr. Branda is an Audiologist and Director of Applied Audiological research for WS Audiology in the USA. For over 20 years, he's been involved in audiological, technical and research initiatives around the globe. He specializes in investigations on new product innovations at the audiology labs for optimization of hearing aids, with a really exciting acronym of aloha.

As well as with research partners, they help WSA fulfill its goal of creating advanced hearing solutions for all types and degrees of hearing loss. Dr. Brandon received his PhD from Salus University, his AUD from the Arizona School of Health Sciences, and finally his master's degree in audiology from the University of Akron. Eric, welcome. I know an area that you're really passionate about is directional technology and how we're able to use that to improve speech intelligibility and noise. We all know that this is one of the biggest challenges for hearing aid wearers. Maybe you could start us off by talking about some of these challenges.

Dr. Eric Branda: I am happy to do that and happy to be talking about, beamforming technology. And I think it's important because it does address some of those really big issues when we think about the topic of noise. At a very basic level, hearing aids can amplify both the target speech we want to hear and the competing noise in the background. And if we're amplifying both of those, then that leads into that big complaint that hearing aid wearers have always talked about, that they have trouble with speech understanding and noise. And then what can make it even more difficult is the type of noise. If you think about something like an air conditioner or traffic noise, those are pretty steady state types of noises. So they're pretty constant. But now if you look at some other noises like speech in the background, think of your cocktail party situation.

So if you look at other speech and informational types of masking, then that becomes even more difficult because now there's different words that might start to confuse you. So again, the noise situation can become very difficult. So regardless of any type of noise in the background, what becomes so critical for intelligibility is that we can improve the signal to noise ratio, that SNR. The better we can make the signal to noise ratio, that means we can suppress some of that background noise, whether it's information or non informational, and really help the hearing aid wearer focus on the target speech.

Lisa Klop: Absolutely. So you and I not to give anything away to our listeners, but we've been a part of this industry long enough to remember when directional microphones weren't used as often. I think that was maybe right around the time that completely in the canal hearing aids were so popular, but we've come full circle. And once again, we realize that directional microphones really are one of the best ways to, as you say, improve that signal to noise ratio, which is so critical. And we as clinicians then ran, not walked to embrace them again.

Dr. Eric Branda: We definitely did. And just as a slight aside, there are other technologies like remote microphones that can provide really great and improved SNRs, and those start to require other devices. So where we really see the popularity growing is in the directional technology built right into the hearing aids. And these are popular, they're used by just about every hearing aid manufacturer. And it's really where we've seen a shift away from some of those smaller instruments that go in the ear to Rick style hinge instruments, and rebirth and behind the ear in general, where we can really get those directional microphones spaced properly and to work properly. And I think there's actually a bunch of other reasons why we've seen directional microphones have this type of resurrection.

Lisa Klop: So can you expand on that a little bit for us because I know that directional microphones, when we talked about, I remember when I was a clinician having to talk about some of these other ancillary devices, it was hard to get patients to embrace them. You're absolutely right. But I think our listeners might be curious about these other reasons that you allude to.

Dr. Eric Branda: It almost becomes just a historical look on where we've come from with directional technology. Because if we look at the improvements we've seen, just in directional mic design and performance. Those early directional mics, they basically work by having two ports with a single microphone that had two ports in the diaphragm there to help work with the filter and get an internal delay. And we ended up getting a fixed type of polar pattern. So we could do maybe a cardioid type of poor pattern, make sure we focused on the front and suppressed the back. And this would be very fixed. And there were a lot of these BTE devices that, especially in the earlier times, were only directional. So you had to choose, do I want an omni-directional product or a directional product? But as we started to grow in the industry and thinking about that, finding a way to merge those became very important.

And there were some iterations on how we could do that using traditional directional microphones and combination with omni-directional microphones. But not long after we started looking at those, we also saw the introduction of digital technology with hearing aids, and that really took off. And digital technology, we can really start using algorithms to change how the directional microphones were working. So instead of looking at two ports with one microphone diaphragm, we could actually use two separate microphones and let the processing algorithms work on the external and internal delays. We had the external delay with the mic ports and the internal delay being calculated. And that let us start doing a variety of different polar patterns with the same setup. And it's actually at this point that we really should stop calling them directional microphones, because what we're really starting to talk about is a term that's probably more popular with engineers, but it's the term beamforming.

Lisa Klop: So yeah, digital technology, how that's evolved certainly has led to changes in how directional technology behaves. Can we switch gears a little bit and instead of taking a historical look, let's talk more about how modern hearing aids are using beamforming to achieve directionality.

Dr. Eric Branda: Absolutely. Because we are talking about directional microphones, but it's really omni-directional microphones working with beamforming technology, and that provides directionality. So the algorithms are pretty complicated, there's a lot of math going on there. They try to identify the target speech that's coming from the front, as well as the competing sounds from the other directions. And based on the timing of them hitting the two different microphones, the hearing aid can really start to amplify the target speech from, usually from the front and start to subtract and reduce those competing sounds. And what makes this also easy for hearing aid wearers is to really let it happen automatically. They can walk into a noisy situation, the hearing aid will detect what's going on and make a really smooth transition from omni-directional to directional or even directional back to omni-directional when appropriate and it's happening really smoothly and suddenly. So what that feeling like, they just flip the light switch on and off, but more like the dimmer switch we want to gradually get into the right mode and then gradually get out of that mode when appropriate.

Lisa Klop: Yeah. It seems when I look at how hearing aid technology has evolved that, especially in recent years, it seems to happen so quickly. So can you give us some insight on maybe what we have to look forward to in directional technology?

Dr. Eric Branda: Actually, we've already taken that next step and it's been an impressive one. So as I mentioned, there's been a lot of evolution into beamforming technology, but what's really helped that is another evolution in hearing aids that started again, not that long ago. And this is wireless communication between devices. We have two types of wireless that we work with in hearing aids generally, and these two that have been around are the 2.4 gigahertz and near-field magnetic induction. The 2.4 gigahertz is what we think about with streaming audio from phones. It's nice for transmitting long distances, not always as great for short distances and often has a bit of a higher battery drain. So it's not always as effective for streaming audio between two devices. Magnetic induction on the other hand has been shown to be very good for instrument to instrument communication. And it actually is very efficient on a battery use.

And we've also taken some approaches to even optimize that efficiency on the battery drain. And it's using this type of wireless technology, muirfield magnetic conduction, that we've been able to elevate directional technology to a higher level. So before the combination of wireless and directional technologies, when we spoke of beamforming, we were talking about unilateral or monaural beamformers. So this meant that you would have one device doing the beamforming in that device that could be worn bilaterally. So I could have a monorail beam former on the right ear and a monaural beam former on the left ear and one on each year. And they were still independent monaural beamformers. With early introduction of wireless, it was possible still to have those monaural beamformers, but ensure that they were in directional mode simultaneously. So still monaural beamformers being worn bilaterally and being synced, but they were still individual from each other. But as magnetic inductions evolved, we were able to go from not just being bilaterally worn monaural beamformers, but true binaural beamformers, where they're actually working together.

Lisa Klop: Gotcha. I can actually remember when we introduced this technology, what was it? Back in 2004, I was told something was brewing that would, "blow the industry wide open". And you know as most clinicians, when someone says that to me about hearing a technology, my imagination is going to go wild. But it really seems that the person that told me that understood just where this technology was going to take us. When you mentioned earlier that directional technology can be very different across manufacturers, this must've been what you were referring to?

Dr. Eric Branda: Yes, exactly. Because even with those monaural beamformers, there's different algorithms being used, in different ways of implementing wireless communication. So those are already two different technologies that are coming together that can be done in different ways and each of those technologies can be unique in their own implementation. So when we consider different types of wireless systems out there and how it's coming together, we can really look at differencing overall directional performance. So with binaural beamforming, which we also may hear the term referred to as bilateral beamforming, in hearing aids, we often use those for the beamforming, We use those a little synonymously. We do find that this is one of the more technically advanced approaches. So now we're able to use magnetic conduction to create the binaural beamformer and Sydney is actually one of the only manufacturers offering this type of technology, to which we refer to it as narrow directionality.

Lisa Klop: So I'm sure our listeners would really want to have you explore for them more about how this narrow directionality actually works.

Dr. Eric Branda: Yes. So I started to allude to it and to break it down a little bit more. So we have the left and the right instruments, both start out doing their jobs like monaural beamformers, but then after they've started processing the sound as two separate beamformers, they then share that information with one another. And what this lets us do is create a tighter, more direct focus on the target speech in front of the listener. It also means that many of the competing sounds that are even in the front hemisphere of the listener can also get reduced. Traditionally, with directional microphones and monaural beamforming, we would think in general terms about suppressing the rear field and amplifying the front field. With the binaural beamformer even areas of the front field can be reduced so that you can more specifically target that speaker right in front of the listener.

Lisa Klop: That was one of the aspects about this technology that excited me the most, because we don't often think of competing speech as coming from the front, but we all know personally, the way conversation is so dynamic that that's actually quite possible. Right? So the other concern though, when you describe how this is working, that this would all be well and good, as long as the speaker and the listener are frozen directly across from one another. So now I think it's important for us to talk about what happens when conversation partners, which in most dynamic conversations situations, they can potentially be located anywhere within a hearing aid wearers environment, along with other sounds and speech that are not part of what they want to hear.

Dr. Eric Branda: It would be so much easier if we just had key Mar in front of a speaker, because then they're both fixed, but that's really not how people communicate. And we really then let the algorithms prove themselves in this situation because the algorithms we're using, it's taking into account that the listener's head may naturally move and that the speaker may move as well. So we know they're not going to be fixed. The binaural beamformer is actually adaptive and now that it can continue amplifying the target speech. So as the speaker may shift to the left or the right, or maybe the listener is moving their head a little bit, leans to the side a little bit, as their head goes a little bit in one direction or another, we can adapt and compensate for that. Giving a little bit of a still narrow, but catching what's still in that front field for them. Of course, if the listener turns their head too far, intentionally, like maybe they want to talk to somebody on the side or completely on the side of them. Maybe the beamformer is not going to chase the original target speech there.

But in general communication, if we think about the target speaker being in front of the listener with some generalized movement, that's normal, the beamformer's going to keep up with them.

Lisa Klop: So when I hear us talk about direction of potential speakers, what I start to have a little bit of concern about is localization, because we know that localization is also a critical skill in being able to hear well in noisy situations. So are we worried about this technology starting to have a negative impact on localization?

Dr. Eric Branda: This is actually another case where we asked the processing to do more than just the basics of binaural beamforming. We want to take a few other measures to help with localization. First, when the information is shared between instruments, some of the key cues for localization are actually replaced back into the final signal to help the wearer with spatial adjustments. So this just helps for a more natural feeling while they're talking. So the beamformer will suppress what needs to be suppressed, amplify what needs to be amplified, but also it looks at some of those key localization cues and feeds them back into the signal. So additionally, we with speech coming from different directions can be important, a strong speech signal coming from a different direction, we may find that we even want to relax the directionality to pick up on that speech signal.

For example, I'm sitting in a noisy restaurant conversing with someone and the binaural beamformer's active. Where a server comes up from the side and wants to ask me a question, the hearing I can pick up that they're there and actually just relax the directionality so that I can hear that question, answer appropriately, and return to a stronger directionality when the situation ends.

Lisa Klop: So I think I heard you mention another method as well. Maybe we can talk about that.

Dr. Eric Branda: I guess. And this is also a very important thing. Many people seem to have a misunderstanding of binaural beamforming and seem to think it's active all the time. I've heard this for years since we introduce it, they have this feeling that we are either going to be omni-directional or in full binaural beamforming directionality. We've been doing automatic transmission and directionality for many years, and it's not really any different here. In fact, this is actually another step in automatic transitions. If it's quiet, the listener will probably be in a more omni-directional type of mode, we don't really need directionality. If it starts to get noisy, then we do want some directionality. We want the directional mics to turn on and really monaural directional microphones at lower noise levels is just fine because they can usually give us an appropriate signal to noise ratio to deal with the speech because it's a relatively lower level of noise.

When that noise level starts to get louder and the SNR really gets poor, then monaural beamforming just may not be enough. In this case, we can apply the binaural beamforming and we can help to improve that SNR as needed.

Lisa Klop: So what I hear you saying is that the hearing aid is only applying the binaural beamforming when it's necessary and still might apply omni-directional or reduce directional performance when it's most important or appropriate.

Dr. Eric Branda: Exactly, it's all about what makes sense for the listening situation, even to the extent that we now can include motion sensors in the latest devices. So if someone's walking, we can, again relax a directionality to help improve their spacial awareness, because maybe there's a lot of traffic noise and it should be directional. But if that traffic noise means that there are cars around that they should be more aware of and they're moving, we can pick up on that and relax a directionality. It's really what's appropriate for the situation.

Lisa Klop: So this really sounds great. And I know a little bit about our motion sensors, but our listeners, especially those that might be new to our technology. I know they're thinking and they may find this to be, or they may find themselves to be a little skeptical. So maybe you might want to describe how this actually works.

Dr. Eric Branda: So it all sounds very good in theory and it also means that we want to prove that it works in a laboratory situation. So when we first introduced neural directionality, we actually investigated at two different locations. We basically repeated the studies at two different sites. And the way we set this up is that we arranged eight sound speakers, evenly spaced around the listener about a meter or so away from them. And we presented the target speech directly in front of the wearer at a zero degree asthma. So target speech directly in front of the wearer. The remaining speakers, those seven speakers, again, evenly spaced around the wearer, all presented uncorrelated speech sentences with no gaps between the sentences. So never had the same signal coming out of any speaker at the same time and never really had a gap. So it was just continuous sentences, all different and all being presented at about 72 DBSPL. So pretty loud there really.

We then adjusted the target speech level and see what the signal to noise ratio would be, where the listener could get 50% of the sentences correct, or as appropriate for the test, the other side, 50% of the words correct. So this was the SRT that we were looking for. As expected omni-directional and full binaural beamforming conditions were compared and not surprisingly for us, the listeners did significantly better at both sides with the binaural beamforming. But what one might not expect is that the test was repeated again with normal hearing listeners to see what the SNR was needed for them to get 50% correct. At both sides the hearing aid wearers with binaural beamforming had some significantly lower, meaning better SRTs than the normal hearing listeners. The noise was louder in the SNR, poorer for the hearing aid wearers to still get half of the test sentences correct than for that of the normal hearing listeners. So from that we can confidently say that hearing aid wears using narrow directionality demonstrated better speech intelligibility and noise than normal hearing listeners.

Lisa Klop: That was some pretty exciting results that we saw from that study. But I'll tell you, when you describe the study set up and just thinking about all of that noise with the eight speaker set up, I would be exhausted in trying to listen in that situation. Sounds like a lot of listening effort going on there.

Dr. Eric Branda: Interestingly, that is something else we wanted to look at. Listening noise can be very effortful, it can be difficult. And if you start to look at some different patients with different aging aspects and cognitive performance and looking at what resources are being used to hearing noise, if it's more effortful then that's just a challenge we don't want our patients to have to put up with. So when you combine the challenges of hearing loss and other factors around aging, many hearing aid wearers would love to have an easier time listening in noise. What we looked at was again, using the similar eight speaker set up in a sound booth, and we wanted to measure listening effort via a EEG electroencephalogram. So the EEG measure basically gives us a relatively objective measure by placing electrodes at different points on the head, so we could really measure their listening efforts and see if the binaural beamformer help reduce that listening effort.

So again, the target speech was presented from the speaker directly in front of the listener and with the same types of uncorrelated competing speech from the other speakers. The feature assessment was conducted at a signal noise ratio that was adjusted individually to a point where the listener could just understand the target speech with the feature turned off. So with the directional mic set more to an omni-directional mode, where they just able to understand. And as the SNR we would work with for the individual participant. And the EEG measures were done in both this omni-directional condition and then with the binaural beamforming condition at the same presentation level. So these results showed significantly less effort with the narrow directionality activated for this objective EEG measurement. Also, importantly, the participants were asked to complete a rating scale of how effortful they felt each of the listening tasks. And again, you want subjective ratings participants indicated less listening effort with the neural directionality activated.

Lisa Klop: So Eric, I love talking about these study results and I think they're really very compelling, but we are almost out of time. I think we've given our listeners some really great information on how current Signia hearing aids have taken directional technology to that next level. Your explanation of how wireless technology has evolved and began to help steer directional features to provide greater patient benefit in the one area where they really need the most help is really useful. We appreciate you sharing your expertise and maybe we can do this again.

Dr. Eric Branda: Absolutely.

Lisa Klop: So on behalf of Eric and myself, we'd really like to thank you for taking time out of your day to join us for another Signia Podcast. Until next time, have a wonderful day.