Deep-Diving into the Next Era of Hearing: The Research Behind ReSound Nexia

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- Welcome to today's course, Deep Diving into the Next Era of Hearing, the Research Behind ReSound Nexia presented by Dr. Tamara Stender. This month on Audiology Online, we're celebrating innovation in the hearing industry with our fourth Industry Innovation Summit. Thank you for joining today. And as we hope to see you in other courses real soon. We would like to thank our title sponsor, CareCredit and all of the companies who are participating in this year's Industry Innovations Summit. And now it is my great pleasure to turn the microphone over to Dr. Stender.

- Thank you, Melissa. And thank you for tuning in everyone. I'm really excited today to be here to really do a deep dive into some research. If you're like me, you have a lot of questions about the technology that is introduced by any hearing aid manufacturer. And you may not always have time to read all of the white papers. And so today, what I'm hoping to accomplish is to take you through some of the studies that we have done when we developed the ReSound Nexia and to give you a better understanding of how this technology works, but more importantly, how to apply it to get the best outcomes for your patients. So again, thank you so much for joining me today.

I'm very happy to be here. I am an audiologist in Chicago, Illinois, working for GN ReSound. And I hope someday to meet you not just virtually, but in person sometime as well. So let's start with our learning objectives. We have three learning objectives. The first one is to be able to discuss how ReSound directional technology helps hearing aid users achieve better outcomes in real world environments. We know that we do a ton of research in the lab when we develop products, but what's most important is what your patient walks out the door with and how they perceive it and the satisfaction that they gain for it. The second learning objective is to be able to show what the first time user onboarding setting, how it was developed, why it was developed, and most importantly, how it was validated.

When we make different settings for profiles, it's nice to know the kinds of research and thought process that went into them because we know that gains are some of the most important things that you set for your patient to personalize the fitting to them. And this is something that will make a big difference when you're trying to onboard someone who's maybe brand new to amplification. And finally, we're gonna talk a little bit about this new Bluetooth low energy audio and ARACAST technology that has been included in the ReSound Nexia products. What is most important about that is not necessarily the interesting technology, but how it opens the world to our patients. We're becoming a much more inclusive society by allowing more accessibility to these most difficult listening situations, which are difficult for everyone, but especially difficult, of course, for our patients.

So let's just get started with a deep dive into directionality. If you are familiar with ReSound, you know that we talk about hearing a noise a lot. So directionality is one of my favorite areas to really dive into because there's so much that we can do to analyze it, to measure it, and to think about ways to make it better in the future. So let's follow the little penguins and deep dive into this. The reason why ReSound talks so much about hearing a noise is because despite the amazing advances that have been made across the industry in this area, it is still the biggest challenge that we face. And I'm not telling you anything you don't know.

If you've been out there fitting, you know that it's very common for you to hear that people are not having problems hearing you in the fitting suite. They are having problems hearing their loved ones, their friends in a noisier conversation, noisier situation. And that's the main reason why they come in to purchase hearing aids for the first time, especially if they're in that mild to moderate hearing loss segment. Hearing a noise, if we are able to achieve good satisfaction is the number one driver of that satisfaction. But at the same time, it is the biggest unmet need. So what does that mean? We've just displayed a paradox there. It means that if we can get it right for

helping people hear better in noise, then that is going to drive their satisfaction more than anything else after they purchase the hearing aids.

But if we don't meet it, it will be the glaring reason why they might not be wearing their hearing aids more often. So that is how important it is for us to get it right as an industry, for us to get it right as a manufacturer, and for us to know how to fit it to our individual patient's needs. And then finally, nearly one in three hearing aid users are unsatisfied with their ability to hear conversations in noise. So this is a significant portion and definitely not something that we would be proud of. We want to make that a lower number, in fact, we'd love everyone to be satisfied with their ability to hear conversations in noise because that is actually why they came to get the hearing aids in the first place.

So as an audiologist, I know this is not anything new to you, but this is something that we are going to focus on with our research and development because we know what a big impact it makes. But before we can even apply any directional features, we need to think about how the hearing aid knows when to apply that directionality. And that goes into the environmental classification of the sound scene in real time. So environmental classifiers are used in hearing aids to provide input to decide how and when to apply different features. And that includes directionality, but it also includes noise reduction, impulse noise reduction, and the like. And so there's three different ways that this is accomplished.

First, there's acoustic feature extraction, and that's looking at the overall level of the environmental noise sound. The spectral shape, what does it look like? Does it look like white noise? Does it look like there's some speech in there? Is it just music? The signal to noise ratio is taken to account. How much does the loudness modulate? What are the temporal patterns? Are they speech-like? Are they different? And what's the spectro-temporal profile? Those are just a sampling of some of the things that go into

this environmental classifier when it is gathering data from the environment in real time to make decisions later on. When it has all this data, it classifies it and estimates what kinds of proportions each one of those features are represented in in order to form those environments.

So for example, if you might be in a cafeteria and the overall level is loud, but there's amplitude modulation and there's temporal patterns and speech seems to be coming into that as well. So that would be classified as a loud speech and noise environment in the ReSound system. But it wouldn't just be necessarily all that way because the ReSound classifier is more sophisticated than that. We have different ways of classifying it, but we know that the listening environment is changing. There's lulls in the speech, there's lulls in the noise and it has to adapt to that. And so it uses probabilities to be able to mix certain components of each classified area that it is determined to be in so that it can achieve the most precise decisions of which features need to be turned on and when and how and in what direction.

So this is a really sophisticated system. I like to think of it as the brain of the hearing aid because this is what's really deciding what all those other features are going to do and when they are going to do what they're supposed to do. It's so important not to make errors in this area. This is a quote from Yelamsetty. And if you haven't read this paper in 2020, I do encourage it. It is a fascinating paper about classification in hearing aids and how important it is to be accurate because the cost of these errors, the cost of classifying poorly means that the user is not getting the benefits that they were promoted to have and that they're not gonna be as satisfied.

And so this is why we really need to pay attention to how accurate we are in classifying environments. So I mentioned that ReSound has a certain number of environments and we label them as such. And this is a very broad strokes picture of what we offer. There's the quiet environment, the soft speech, loud speech, all the way up through

speech and noise levels and noise levels. And this is oversimplified because there's not just seven different buckets that the environments could be classified into. They're not categories that are discrete. There are many times when you could be in a situation where it's warbling between soft speech and noise and loud speech and noise. All that would take in this example is for the signal level to be going below and above 75 dB.

How would you make that decision as a hearing aid? Well, to avoid making errors, ReSound hearing aids do not just decide, well, it should all go into this one bucket 'cause it looks like it's more in that. It takes parts of the soft speech and noise environment settings and parts of the loud speech and noise settings and applies them at the same time. So what you can potentially have is an infinite number of combinations based on how the environment is. And this is really important because there's never a time when the loudness or the sound environment that you're in as a person is always exactly the same. It's like a fingerprint. There's always going to be some kind of individuality.

And it might not even be the sound sources, but it might be wind coming through. It might be somebody dropping something on the floor. It might be a change in the reverberation. All of this is taken into account. So we wanted to make sure that the environmental classification that we use is accurate because as Yelamsetty says very astutely, it really doesn't matter what you do afterwards if you're not starting at an accurate place. So here is a study that was done. It was done as objectively as possible because it was done in a test box where the hearing aids were placed into the test box and exposed to a different kind of sound for many, many hours, for like 48 hours, long enough so that the data logging would pick up what environment they were in when the hearing aids are taken out of the test box and plugged into the fitting software again.

So we tested three different environments, quiet and speech only, speech and noise, and noise. And we put each hearing aid, including our own, into a test box individually, ran that sound file that was either the quiet and speech, speech and noise, or noise for 48 hours for each signal type, and then read back from fitting software what the data logging said in terms of what environment the hearing aid was in. You'll see the red bars are quiet and speech only, and those are going to be the easiest ones for everyone to classify because when there isn't a lot of speech and noise, it's not very hard to say it's pretty quiet, or when there's just speech and no noise, then it's easy to say there's just speech because there's so much modulation and identifiers that the systems use for making it identify as speech.

You can see that for many of these brands, including ReSound, a high level of accuracy is achieved. But then when you go to speech and noise, this gets a lot harder because it is so changing, and every system needs to really, really try its best to be accurate. And knowing what the hearing aids were exposed to, we could tell how accurate it was by how the data logging read out. So the data logging read out that everyone did a little worse with speech and noise, but as you can see, some did better than others. And then finally, with the noise, when it's all just noise, again, it gets a little easier. So the problem there is, unfortunately, the speech and noise environment that we all try to do well in, that's where you have to really make sure that your classifier is doing a good job.

And while no hearing aid is perfect in this situation at this current point, there are some that are doing really well, and we were happy to say ReSound was over 70% in that case, but across environments was doing a really nice job. Overall, the ReSound accuracy with ReSound Nexia was 91% across all environments. This was a really good number. We were very happy to see this because this means that our features are going to do what they are intended and designed to do for your patients. And as long as we're classifying mostly accurately, then we can go ahead and talk about the ways

that we handle speech and noise for our users. And the number one way of handling that with ReSound technology is with 360 All Around.

360 All Around is our premier directionality option, and it's available in the nine level of ReSound Nexia. It is the culmination of a lot of years of research into how users hear and what they want to hear in different environments. So for example, if you're in a quiet area, if you're taking a walk, this looks lovely, nice and warm walk here, you want to be able to hear the nature sounds around you, and you wanna be able to hear and experience your environment very well. So research shows that people prioritize hearing spatial cues, not only for safety to make sure that if there's something they need to be aware of, like a car approaching when they walk, that they can stop in time, but also just to experience this kind of environment in the most natural way.

But when you are in binaural listening, that is when you are trying to divert your attention quickly. That's when you're in a kind of cafeteria or a cafe setting where there's multiple talkers, where you're trying to be an active participant in the conversation, where there's sounds behind you, maybe in front of you. And this is a very difficult listening situation, but it's one where we innately as human beings are able to detect sounds that are interesting to us and really focus in on those. So that's a situation where you want to have a different kind of directionality than the one where you're hearing all around you as in spatial cue preservation. And then finally, with speech intelligibility, these are the situations where you just wish that you could put yourself in a cone of silence and hear what's going on in front of you because you really need to get the message and you need to get it quickly and it's a really difficult situation.

So that's in a mode where you prioritize speech intelligibility, where maybe hearing all around you isn't as most important as hearing that person from the stand telling you what the cost of these fruit are or at a airplane ticket counter when they're giving you

your options for your flights. So the purpose of ReSound 360 All Around is to allow automatic support for all of these natural auditory navigational abilities. And this is something that we have introduced in some of our previous products before Nexia, but it has been refined over time to get to a point where we are making an impact in how people are able to function in each of these distinct listening situations. So how do we achieve this goal for these three different areas?

Well, these three different areas roughly translate into an area where you would want bilateral omnidirectional to preserve your speech cues, where you would want to be able to detect and choose what to listen to in the cafeteria situation or the restaurant, and one where you really wanna focus in on the speaker in front of you in a very noisy situation. That's when you'd want beamforming directionality. So ReSound 360 All Around is a program that puts all of these benefits into a single program for your users. So they don't have to switch between program one, program two, et cetera, to get all of these benefits. It will automatically move to those different by neural directional or omnidirectional or asymmetric directional responses based on how the environment's being classified.

How it's been improved with ReSound 360 All Around is that the sound environment has been widened, meaning that there is more of that auditory awareness available to the user. We've sped up our processing and steering for faster mode detection and selection, meaning that we don't take as long as we used to to get to the right mode. And most importantly, most likely, is that it's increasing the precision of the beamformer by taking into account something really important when designing hearing aid technology. And if you're wondering what that is, it's all about the head and torso. A lot of hearing aid technology is developed with a free field in mind, and we just know that our patients are not like that.

There's going to be all kinds of sound reflections. So when you take the head and torso effects into account, you can achieve a very precise and narrow beamformer to the front, which will help them in those speech intelligibility situations. And the beauty of this is that it's all working at the same time across any sound environment, which enables users to automatically tune into what they want to listen to. And it's not the hearing aids choosing for them because it's giving them the ability to hear all around them even when they are trying to hear speech and noise. So let's start with the research behind the first part, widening our sound environment mapping. So our legacy directionality, all access directionality, was able to provide auditory awareness even when it was directional on one side.

However, 360 all around moves that auditory awareness more centrally around the head. So I'm gonna go back just a minute to show exactly the difference here. So what you see here is that you've got on the right side, the red circle indicates an omni-response on the right side. And on the left side, you have a directional response with a band split, meaning that there's some omni to help raise auditory awareness in the rear azimuth even for the directional ear. But as you can see that omni-response on the right ear was not necessarily centered on the head, meaning that there could be some blind spots in terms of how you hear all around. And that would be the opposite.

The same thing would be true if it was flipped and the right ear was directional and the left ear was omni. So one of the improvements that 360 all around provided is that when you want to have more auditory awareness around you, like in a restaurant, and you wanna hear that waiter coming up to take your order, you're gonna hear it better with 360 all around because we've taken into account that the user needs to experience that omni more centrally, more naturally, and so that it doesn't cause any confusions. So what it's doing to achieve that is it's streaming the off-axis sound from the directional side to the omni-directional side. And the end result is that you get more auditory awareness in difficult environments like a cafe.

When you want to have this is clearly when it's really difficult to hear, but you also are an active participant and you want to enjoy the experience. And I would have to say that being an audiologist, this is what drives people to buy hearing aids in the first place. It's not always being able to hear the person at the ticket counter at the airport. It's not that they're not hearing the bird song as well as they want to. It's because they went out to dinner with some friends and they felt isolated. They felt cut out. They couldn't hear when the waiter came up to ask their order and they were embarrassed that they didn't turn in the right direction or they didn't even know they were there.

And this is the part that, you know, this is the part that breaks our hearts as a hearing care professionals because this is the part that is important to them. The connections to other people and the ability to have a good time and to feel like one of the crowd. And that of course is way more important than just hearing. That's just how you feel as a human being. So what this is addressing is a need that people have to be able to feel like themselves, to be able to operate like themselves. And the research behind it all supports that end goal to help people hear more like what they say they used to hear like.

So here's the research behind it. This study was comparing ReSound ONE which used all access directionality, to ReSound Omnia, which uses 360 all around, as well as ReSound Nexia that also uses 360 all around. So we programmed the hearing aids with AudioGram+ targets, used power domes, and we created listening conditions for that binaural listening mode, like a restaurant. The target speaker was a female speaker at 120 degrees. So she is off access. She is coming from behind. And then we had the test participants participate in a speech recognition and noise test. It was the DANTEL-2 test. It is in Danish language, but it's similar to the HINT test in its construction because it also yields an SRT to determine 50% correct performance, resulting in a DBSNR score.

The lower score means that you are doing better in a noisier environment. So let's look at the results here. ReSound ONE with all access directionality versus ReSound Omnia and Nexia, which has a 360 all around directionality, we achieved better results for hearing that off access speaker in that binaural listening mode, meaning that when someone came up behind someone in the real world, let's say your friend comes to say hi and they just wanna come and just tap you on the shoulder and be like, "Hello, how have you been? I haven't seen you in so long." That's the angle they're coming from usually. And that's where you can hear them better. That's where you know they are there and you're able to direct your attention to them to start a conversation without being caught unaware.

That's where this is important to users. And that is where the benefits of widening the sound environment come into play with ReSound 360 all around directionality present in Omnia and Nexia. There's another study that we did to show how we are doing for surrounding conversations compared to other leading hearing aids in the market today. And all of these hearing aids have directionality. They're either for microphone being performing or they're conventional directional combined with strong noise reduction. So this is looking at how you would hear a target speaker now, this time just almost at 180 degrees behind you with some masquerade sounds of speech around you as well as noise. And this is in one of our more recent white papers that was launched earlier in 2023.

And here again, we see that the lower scores are going to be better. A very similar kind of speech test was performed and the lower DBSNR result is going to mean that people did better in this kind of situation. That's really hard to listen to you because remember they were indirectional and they were trying to hear someone behind them. This is a situation where usually we tell people don't try to hear someone behind you if you're indirectional because that's gonna put the null right where that person's talking.

You're gonna have to change your mode. But if you don't have the ability to change your directional mode or you don't even know someone's talking behind you, you need to have that ability to hear behind you even when you're indirectional.

And this is where the benefits come in for the user. We achieved a really low signals to noise ratio result relatively, especially considering that we were in beamforming at the time and they could still detect someone coming behind them. So this is a really important thing for our users 'cause we know that users are in this situation and this is what drives them to our offices. One other thing that we did to improve 360 all around was to speed up our processing and steering for faster mode detection and selection. So talking about the environmental classifier and getting to the right mode, all of it takes time and it's all on the order of milliseconds generally. And sometimes it can even go to seconds it's a really ambiguous sound environment but we need it to be fast enough to make a real difference because as you know, people talk fast and conversations can switch their speakers very quickly.

So we can't have the hearing aids struggling to keep up. And that is one thing that has been improved to create a more precise and meaningful benefit. What it does is the steering system switches twice as fast as it did in the past. And this gives us clearer distinctions among listening modes. So going between that spatial cue preservation mode of having bilateral omni, that's important. Get there when you need to be. Going to the binaural listening mode when you need to be able to detect and choose what to listen to quickly. And then finally that speech intelligibility where there's a lot of noise around you but you just wanna hear what's in front. We gotta get there when it's necessary to get there.

The third improvement to 360 all around is increasing the precision of our being forming for the best speech clarity. This is where you're at the airport ticket counter struggling to hear what that agent is telling you about your flight cancellation and your

options. I hope that you guys don't have any flight cancellations and options, it's not a fun situation but that's a situation where you would wanna be able to hear them distinctly quickly so that you can make the best decisions as fast as possible. And it's a really difficult listening situation. So for this, we have two options. You can stay in 360 all around and it'll automatically go into that situation when you are in that kind of listening environment.

But if you wanna make sure that it's fixed in there, so let's say your listening environment is a little more ambiguous and it's very noisy but then there's a lull, you don't want the hearing aid to go into a binaural listening mode in that situation. You wanna stay focused to the front speaker. And so that's why we have the front focus program also available as a second program option. And it is something that is chosen by the user. So they're the ones making that decision. We don't let the hearing aids to make decisions for them to put them into that narrow beam unless they wanna be there or unless the environment is very indicative so that's what needs to happen.

So if the individual wants to choose this, they always can through the app and it puts them into the driver's seat but it will also happen automatically as part of 360 all around when it is a dire situation for listening in noise. Binaural beamforming in ReSound is a little different than it is in other companies and it's because we apply weighting to the better ear to help users hear better in these difficult situations. So what do I mean by weighting? Well, we've got the ear-to-ear link between the hearing aids that's a magnetic induction radio that helps us share the audio and stream to a very narrow beam. But if you're in a situation where there's a lot of noise on one side but not so much on the other, you don't wanna necessarily have an equal contribution from each side because more of the noise could come in from that noisy side.

So what we are doing is we're weighting it to the side that is less noisy to get rid of more of that noise to make it even easier to hear in those situations. And that's a very

unique thing that is only done by ReSound in the industry today. What is also amazing about it is that it's not just when you're in the binaural, bilateral speech intelligibility mode of 360 all around, it's also applied in the asymmetric mode so that even when you just have one side to directional, it's going to take into account the noise environment around both sides and weight to the less noisy side, which is really helpful in those kinds of situations with restaurants, et cetera.

You're still having auditory awareness in all of them because we have a band split in all of our directional modes. And this is really important because research shows that the speech frequencies are the most important for hearing speech and noise. So if we can still provide some low frequency cues at the same time for localization and sound quality, that is important to users even when they're in difficult noisy situations, which is why we continue to have Omni in the low frequencies. So this study compared the legacy beam former that we had in ReSound ONE called ReSound Ultra Focus to ReSound Front Focus that's in ReSound Omnia and it also applies to ReSound Nexia. Again, audiogram plus targets with power domes.

We set it to the ReSound Front Focus or Ultra Focus program. So it would be fixed in that program too for all of the trials. And this time we wanted to make it a difficult listening situation by having the speech in front and also the noise in front at 75 degrees. So both the speech and noise are pretty much co-located because they're in that first quadrant. And we wanna see in this very difficult situation where your brain can't really spatially separate the speech and noise naturally because they're both in front of you, how the hearing aids are able to help the user detect speech and understand speech in this environment. Again, the same kind of SRT test was conducted.

The better score is going to be the lower score and here were the results. So comparing against our legacy binaural beam former which is Ultra Focus, we were able

to achieve more precision with Front Focus. And this is gonna make a difference if you've got a user that was fitted with a ReSound ONE and they're transitioning to a ReSound Omnia or Nexia. So with the omni-directional condition, which is necessary in this kind of test to create a DBSNR benefit score, the response was very wide, but you can see with Ultra Focus, the directionality reduces a lot of that noise already and gives a result that's 4.25 dB better than Omni. With Front Focus, that benefit jumps up another 4 dB to over 8 dB better than Omni.

So when you look at DBSNR tests and you're comparing against omni-directional which is the standard way of comparing against it, you're getting a whopping 8 dB better signal-to-noise ratio with Front Focus than in Omni. And you're even doing better than you were with Ultra Focus too which still had a very good benefit. So this is meaning that it's getting rid of more of the noise and making it easier for people to hear and do better on these kinds of tests. These were the individual DBSNR performances for all of the participants. And you'll notice that 14 out of 15 of them performed better with Front Focus benefit, with Front Focus versus Ultra Focus. And because we work with humans just like you do, you know that not every human does exactly what you would expect them and somebody did do better with Ultra Focus, but that was just one person, number 14 there.

So it's important to realize that our work is never absolute because we work with human subjects and every patient is different. But this is a very, very strong indication that Front Focus can provide a lot more benefit to your users than Ultra Focus in these kinds of situations that are really difficult where speech and noise are located in the same quadrant. The way that this is achieved, why is Front Focus better than Ultra Focus is because we've simply taken into account in the calibrations, the head and torso effects. The head-related transfer function is literally what we are factoring in when creating the Beamformer. And that's what gives you a higher DI for that

Beamformer. You'll see on the left here, a graph of ReSound Omnia versus ReSound ONE.

And the Beamformer for both of these only occurs between one and 5,000 Hertz. Why? Because those are very important speech frequencies for understanding and noise. And you see that Omnia gives a much stronger DI than ReSound ONE because it is taking into account the head-related transfer function or the head and torso effects in other words. So it makes a huge difference to remember when we're doing research that we're doing, but these products are for people. They're not for microphones hanging in a free field. And that is where we make the biggest differences for our patients. Remembering that nothing is perfect in the real world. People are not perfect in the real world and we need to design our technology with that in mind.

So the difference in directional response between 360 all around and front focus in a situation where noise and speech are both in the front. I've been asked this question a lot and this is a really good question. Is there any difference between if you let the person just stay in 360 all around or if you tell them to go to front focus in program two is the response exactly the same? Well, basically yes. 360 all around applies this response according to the environment automatically when the situation is like this where there's speech and noise in the front or when there is a need to hear speech in front in a very difficult, diffuse, noisy situation. Front focus of course is user selected and that's when the user chooses that on their app or by changing to program two.

So the way you get into these is different but at the end of the day they are basically providing the same response. But the possible differences between them are as follows. 360 all around will apply the directional mix setting that's the crossover between omni in the lows and directional in the highs based on the patient characteristics of their hearing loss as well as the hearing aid model. So for example, if you've got someone with a normal hearing in the lows they're going to get a lower

directional mix setting because we know that they do better and they have better sound quality with that setting than if they had a higher directional mix setting. And if they had more low frequency hearing loss they would be set to a higher directional mix setting right away in that all around.

However, front focus doesn't automatically apply that patient factored setting because we know there's also research saying that you get the best directional benefit from having more of the frequencies processed as directional. So that's gonna give you a high directional mix setting all of the time in front focus. It's not a huge distinction. It might make a one to two dB difference in DBSNR results between going between a low directional mix to a high directional mix but that could be a difference. Another difference could be the time constants. Front focus defaults to slow time constants and this is due to more recent research showing that you can maintain the integrity of the speech envelope if you have slower time constants whereas the 360 all around time constants will be set to a faster time constant because that is the way ReSound technology has been tested and validated to do very well over the years.

And there is also research saying that some people do better with faster time constants. And the third thing that might be different is the noise reduction setting because front focus automatically switches into a moderate setting whereas the 360 all around setting is typically set to a milder setting unless you choose differently. And the reason why front focus chooses moderate is because of other research that has been more recent coming out saying that strong noise reduction might actually have an adverse effect on the signal-to-noise ratio, speech recognition and listening effort without significantly improving your listening comfort. So the whole reason of having noise reduction is to improve listening comfort. It's not necessarily to create a better DBSNR result.

So going too far with noise reduction might actually be too much of that good thing and reduce or not even make a difference in the listening comfort while also hurting the speech recognition. So we go with a more middle ground on front focus and use a moderate setting as default. Of course, you can set these defaults as whatever you want but I just wanted to highlight some of the differences between the 360 all around automatic program and the front focus program that is user selected. So front focus is available here and this is what you're seeing but this is a schematic that shows how unique our directionality is and why we do it the way we do it.

We could do it the way everybody else does it but we do it differently. Why would we do this? So if you look in the box on the lower left you see that low frequencies are processed as omni-directionality and this is for a number of reasons, better sound quality, better own voice quality because there is a distortion in the user's own voice when you apply directional on the low frequencies. And so to avoid that, we keep it an omni. Also interaural timing cues are in the low frequencies and those are more maintained with omni than with directional processing. In the mid frequencies we have that directional beam former that's the speech frequencies where you're gonna get the best bang for your buck by having beam forming but you're not putting the user in a tunnel because they still have that omni-directional in the low frequencies for auditory awareness even in directionality.

And finally, in the high frequencies we apply fixed directionality which is a hypercardioid response. And this is because research has shown that there's a better sound localization for high frequency cues such as interaural level cues and monaural spectral cues if you keep it in that fixed directional as compared to a beam forming directional. So there's a lot of research that goes into why we are doing this multi-band directionality but it makes sense and it yields really good responses not only in the lab, but for your patients. I'm gonna share with you some lab studies though. This is a lab study that was done on a key Mar and we just wanted to see what is microphone

intake as we present white noise from the front and we measure at the right ear while swiveling key Mar on a turntable 360 degrees.

We did it at a slow rate, 7.2 degrees per second and we wanted to see what the response would be. Where can we visualize our multi-band directionality? And here you see it. This is an indicator of how we are beam forming and applying directionality and omni in the lows on the right side. You see that area of red, that's high intensity that is showing the beam former between one to 5,000 Hertz. That's a very narrow beam, meaning that you're gonna get a lot of reduction of noise and other azimuths because of that beam, which is good. But we're also not taking people out of their environments because we have the fixed directional in the highs which is that more diffuse but still directional response that you see closer to the schematic center.

So those are the higher frequencies from five to 8,000 Hertz or five to 10,000 Hertz rather. And that's giving them directionality maintaining some of those spectrum cues while still they're getting that blue area of low energy for the omni response. So this is a really different kind of system and we believe it works really well based on the measurements that we can get out of it and the results we see from patients. Putting it together because we're doing this as a binaural fitting, let's look at what it looks like when we put the right side and the left side together. And you see there's that distinct binaural directional beam from one to 5,000 Hertz with fixed directionally above 5,000 Hertz.

Another manufacturer that uses beam forming directionality doesn't apply it in the same way. There's no multiband directionality and there is more of that red that is coming through as a higher intensity meaning there's more noise coming through from different angles. We want to reduce the amount of red if you're in a bad situation where you need to hear speech and noise. So that is the difference objectively looking at how our system works versus another beam former available on the market. We did this for

a lot of different hearing aids and you'll see that there's no one that does it exactly the same and no one that does it close to how ReSound Nexia does it. So this is really important to remember that if you are fitting a couple of different manufacturers and ReSound happens to be one of them the way that ReSound directionality works is very specialized to meet this goal of helping users hear better in noise.

And it also means if I'm going to be counseling about how to use 360 all around in noise or front focus all in noise I'm gonna be telling my patients make sure that you're facing the person that you're interested in hearing because that's where you're gonna get a ridiculous amount of DBSNR benefit. I mean, that is really where you get that ADB benefit. So make sure that you're optimizing it when you're using it in the real world, tell your patients, you need to look at the person you're interested in listening to and that's where you're gonna get an incredible benefit that's really not matched anywhere else. As I mentioned, this is where we've gotten so far. I won't say the culmination because that would suggest that we're ending our development.

We never end development, but our development in GN has been working towards this for many, many years, since 2007, actually. So we are learning as we go and we are making changes but we have never strayed from the end goal which is to help people hear better in noise without cutting them away from the rest of the environment. When the user wants to go into this Front Focus program, we're not calling it Front Focus anymore because we realized our user experience team showed us that patients don't really, Front Focus doesn't mean anything to them. They haven't been studying our materials. They don't know our feature names. Why don't we just call it for end users something that they can relate to, which is the Hear in Noise program.

So you're gonna have your first program, which would be the all-around program. And then you're gonna have your second program that comes up on their app as the Hear in Noise program which makes it a little easier for them to remember when they should

be using which program and what it should do for them. Both Ultra Focus and Front Focus. So if you fitted someone with a ReSound ONE and they're using Ultra Focus or you fitted them with a Nexia 7 and it has an Ultra Focus instead of Front Focus, both of them will be represented to the patient as the Hear in Noise program. And it's replacing the old restaurant program because we know it's not only restaurants where you wanna hear well in noise.

So let's move on to the next topic, exploring the development of our new first-time user onboarding setting. So this is for your new users that are really sensitive and you know the type, they've got this look, they look anxious, they're not quite sure that they made the decision right to come in and get hearing aids. And the minute that those hearing aids turn on, they're saying everything is loud and you've got them with like 5 dB again. And I know this because I've seen it so many times with first users who are a little anxious about the whole experience. 95% of first-time users report challenges getting started. Not all of them are going to be to this degree of sensitive to the sound of hearing aids but we know that a good portion are and they need that adjustment period to get acclimated.

But in order to get acclimated, they need to not reject the hearing aids immediately. And so immediate acceptance is still important to get them over that acclimatization hump so that they can achieve the benefit over time that we know they can achieve. And this is a first fit to optimize comfort. So if you really wanna get them to benefits, you're going to over time, increase them to an experienced level of a patient profile setting. But this first bit is just meant to help them ease into it when they need to. So the goal is to make onboarding your patients easier. And this was done as a first-time user study. We recruited 11 people with absolutely no experience with hearing aids but ones who had a audiogram very similar to this.

And as you can see, the average age was around 67 years which is also very representative of the first-time user and when they start to really take the decision to get amplification. We compared three different settings. The first-time user setting which is still available in Smart Fit. The first-time users targets at 70% of their gains. So that was a 30% reduction there of those gain targets. And then the experienced non-linear user at 70%. Trying to figure out because we wanna make sure that when you fit ReSound technology, we don't make people jump out of their chairs and give you a hard time about, they don't know if they maybe wanna stay with this purchase. We know that they need to acclimate it.

So what's the best sweet spot to start them at? This was a two-fold study and the first part was test box comparisons. We wanted to compare what does ReSound look like for a first-time very sensitive user setting compared to two other leading manufacturers. And this was done for three different sound scenarios, piano, diner scene and single female talker. And it was done under headphones so that the user wouldn't have any kind of information of what they're listening to. So they couldn't make any subjective decisions that they liked a certain fit better or they liked the look of another hearing aid better than one of the others. So these sound files were played over headphones and it was a blinded test, double blinded so that the tester and the patient didn't know what's hearing aid recording they were listening to at which user setting.

So they were asked to make a decision, a forced choice decision, AB comparison. Which they preferred for a number of combinations to try to glean out what was the preferred setting amongst these other two hearing aid manufacturers and the ReSound setting when we determined that 70% of the first time user was the preferred setting. And this is the results. So for brand A and brand B, what we're looking for here is a significant preference of one setting over the other. And anything in the white bands in the center show that there was no significant preference even if there were trends in

one way or to the other. But in the hashed areas shows that either to the right, the first time user onboarding was significantly preferred versus to the left, the other response was significantly preferred.

So brand A or brand B. And what you came out with was that the first time user response was significantly preferred for the single talker condition and for the diner and piano condition, it was not better or worse than any of the other brands that we tested that are leading leaders in this area as well. So with that information, we went ahead knowing that the first time user onboarding setting, which is 70% of the first time user targets is going to create a more comfortable fit and it's gonna be more comparable for through sound versus other hearing aid brands out there as well. The impact that this has on a couple of different standard audiograms, the more severe the hearing loss, obviously the higher the gains.

And that means that the 30% reduction that you see with first time user onboarding is going to be greater as well. So for a more severe hearing loss like in this one on the left, the S3, you're going to see up to a seven dB reduction in the gains for the first time user setting. And for a more mild audiogram, you see less of a reduction. But again, these are users that are very sensitive to sound. And so while this might not be where you want them to be in about six months to a year, this is helping them get acclimated to the sound of hearing aids and be that user, that experienced user that you know they can become if they just give it a chance.

So in summary, the first time user onboarding setting was developed and validated both in TestBox and with users. It was validated against our own settings as well as other manufacturers settings to try to get at that good starting point where a user that's very sensitive to sound will be able to accept the hearing aids and get some benefit to allow them to acclimate. So it sets the gain level to 70% of the first time user settings. It sets the impulse noise reduction to moderate making the sound of the keys hitting

the table when they inevitably would drop those not be so jarring and it replaces our old comfort user setting. So let's finish up with diving into a new world of inclusive listening experiences.

And this is the connectivity piece that is now available in ReSound Nexia only. And it allows you to use Bluetooth low energy audio and R-Cast technology, which is already available in the Samsung Galaxy S23 devices and is being rolled out by other consumer electronics worldwide as we speak. What this means though, it's not just about streaming from the phone in this new kind of protocol, but it also means that venues that typically weren't set up for easy listening, that maybe couldn't have a telecoil system in them, a teleloop system in them before, they will now have an alternative to teleloop that will allow more people to hear better in difficult reverberant or noisy situations. So for example, in a conference venue, in the future, this can be retrofitted very easily and economically so that many, many people can hear that speaker in a reverberant area.

But it also goes beyond that and harnesses technology we've never seen before, such as you can choose a language that you want to have streamed to you at the cinema. It doesn't have to be the language that the film is playing in. This is the future. This is what this technology is opening up. It opens up to be able to hear the airport address system in your own language. It opens up all of these opportunities. And these opportunities are coming to us straight from Bluetooth, the Bluetooth special interest group that develops this technology. And it is available in our hearing aids today. So there's two different advantages here. You get calls and streaming from your device and they are direct connectivity to smartphone, tablets and computers for calls and streaming.

This is two-way streaming so that the user doesn't have to hold the phone up to talk anymore. It just would work with the hearing aid mics picking up the user's voice. So

it's hands-free phone use, truly hands-free. And it's also for broadcasting, like being able to hear stream sound in a public area. One new accessory that's been launched is the TV Streamer Plus. This works on Bluetooth low energy audio technology as well. It has some really nice abilities to replace our older street TV streamers to be able to use this technology, but more importantly, to be able to let others that want to come over and watch the Super Bowl with you at your house, if they've got that kind of technology in their hearing aids, they can also plug into your new street TV Streamer Plus and hear it.

And in the future, it's not just gonna be hearing aids, it's going to be headsets, it's going to be earbuds, it's going to be ubiquitous. And this technology is coming out right now. And it's really exciting to be able to offer this for the patients that we serve already. Bluetooth has come a long way, but it's not the first way that we've obviously been able to make environments more accessible. I mean, clearly telecoils have changed the world and they've been around for almost a hundred years and they still make a great impact today. And what's so great about this is that telecoil loop technology and Bluetooth low energy technology coexists. You can have both of them in the same venue and that just increases accessibility for everyone.

FM systems made things better. They still do today. Classic Bluetooth was introduced in 1999. I can't believe it's been over 20 years. And then proprietary protocols using low energy Bluetooth for both Apple and Android. But today we have new protocol of Bluetooth low energy audio, which is really revolutionizing our devices and will revolutionize the way that wireless communication is done in electronic devices for the next 20 years. Bluetooth low energy audio protocol is better because it has a newer codec, meaning that it has the potential for better sound quality because it is, it's brand new. It's not 25 years old, it's brand new. It's just been put out by that Bluetooth group. It also streams in that high quality at a very low energy.

So you don't have to recharge your hearing aids all the time to use it. And it offers that multi streaming and binaural opportunities. And the availability of AuraCast to have broadcast capabilities. This is a study done by the Bluetooth special interest group that shows how even when your signal degrades. So they're showing signal degradation here. The lower kilobits per second means the lower signal strength that you're getting. So if you wanna think of it as on your phone, the number of bars that you're getting, the lower number of bars is towards the left of the grid. And here it's like 160 kilobytes per second. That's not a very robust signal. But even at that signal, you're getting a very strong and robust response from the new Bluetooth low energy codec, which is the blue bars, the LC3.

The classic Bluetooth is shown as the SBC codec and those are the gray bars. Anything above the three on the Y-axis indicates that the user thought that the sound quality was good and there were no dropouts. And so this really shows that Bluetooth low energy audio does so much better in much more difficult situations and maintaining the signal and with good sound quality than the classic Bluetooth could do based on the new codec that's being used. And the best news for hearing aids being that they have such teeny tiny little sizes and teeny tiny little batteries is that those little batteries can last longer because we're reducing the battery drain by using this kind of technology.

What's nice to know is that our technology is becoming more inclusive. People who have struggled in situations in airports and in listening at the restaurant, at the sports bar when they want to watch a broadcast, they will be able to tap into situations that are difficult for everyone, but they themselves have this amazing new technology now that they can use with Bluetooth low energy. So that is the goal. As these newer consumer products come out and already they are being launched already with Arkans transmitters being retrofitted in cinemas. This technology levels the playing field and

makes everyone feel more included. And as I mentioned, it's not just gonna be hearing aids in the future, it will be earbuds as well.

So we're taking steps for a better society with this kind of technology. And that really is something that we can feel good about as a hearing professional, making people feel like they are included. So thank you for diving real deep into this research with me today. I know I covered a lot. Thanks for hanging in there. Are there any questions or thoughts? They don't have to be deep thoughts about this. I'd be happy to check them out this time.

- [Melissa] Tammy, thank you so much. That was just fantastic. At this time, if you have any questions, go ahead and type those in now. Otherwise you are welcome to go ahead and log out of today's class. Your exams on audiology online will be available within 15 to 20 minutes for you to take. All right, Tammy, I'm not seeing any questions. So it sounds like we are in good shape today. Thank you so much. This was such an amazing class. So excited we got to see you again today. Thank you all for everything you do and for being a member of our summit this year.

- Well, thank you so much for having me, Melissa and have a wonderful day, everyone. Thank you for joining.