ReSound Government Services: Directionality Designed to Support a Natural Sound Experience
Recorded November 18, 2020

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- [Kara] All right, well, we're gonna get started here right at the top of the hour. First off, I wanna welcome all of you to today's course, which is Directionality Designed to Support a Natural Sound Experience. My name is Kara Sinner and I'm a training and content development audiologist at ReSound. And I reside in our home office in Bloomington, Minnesota, which is just right outside the Twin City area if you're familiar with that. And I wanna certainly thank you and welcome all of you and thank you for spending time out of your day to join us with this course. So, our learning objectives for today are going to be, we're going to discuss the natural listening strategies utilized by the brain in the normal auditory system. We're going to describe how ReSound One M&RIE, All Access Directionality and Ultra Focus support these natural listening strategies. And then we're going to identify patient benefits provided by ReSound One directionality features. So to begin with, I wanna talk or start with what we call ReSound's organic hearing philosophy. So at ReSound, we have always really trying to use research and how the normal auditory system works when we develop algorithms for our hearing aids and for everything that we do within our hearing aid.

We wanna try to follow nature as close as possible, and we call that philosophy of doing so organic hearing. So, imagine if you were only able to hear what someone told you, you could listen to or what something said was important for you to listen to or maybe the loudest sound or speech in the environment or something that was only in front of you. So if you were gonna be in the situation, I'm from a very large family. So if you were in one of my family gatherings, you would be forced in this situation to listen to possibly whoever the loudest person was talking next to you and that might not be what you want to hear or what you want to listen to at that time. So, with directionality traditionally, that's how manufacturers have approached it and have sort of isolated listeners into hearing maybe just in a certain direction or pay, get the best signal for whatever is the loudest signal in that environment. And so that was the way we did it for a long, long time and fortunately for hearing impaired people, technology has come a long way since then. And at ReSound, we've designed with these things in mind of

being able to use the most updated research and how does that normal auditory system function and try to apply that into how we develop our different algorithms in our hearing instruments. So by doing that, we want to be able to have access and give the brain everything it needs to have that access, to hear things that are going on around us. So this has been our core philosophy for well over a decade and we believe that the patient should really be the person who decides what is most important to listen to, what is most important to attend to, have access to make that decision by having all those inputs available to them, versus having the hearing instrument decide what that should be. So with our newest product, our ReSound One, we introduced a new generation of our directional philosophy that's based on this organic hearing. So we have a new receiver type that we call the M&RIE receiver that we're gonna talk about. We have All Access Directionality, which is an enhancement to our previous generations of directionality and I'm gonna talk about how that works. And then we have also a patient controlled program that's called Ultra Focus. So all of these things together really allows patients to feel at ease, be able to engage effortlessly with others as their surroundings change.

So to be able to give them that best listening opportunity, no matter what is happening in their environment. And we know that hearing is unique, individuals are unique and we can say just like a fingerprint really that each person's hearing is one of a kind. And so we wanna introduce this new way of doing things and continue on this journey of organic hearing by being able to give the brain everything it needs to process sound and by doing that, we are gonna provide greater depth and direction. And it results in really much less effortless hearing, ability to be able to tune in to what is important or what the patient decides is important and have that access to everything going on around them. So at the heart, again, is this organic hearing philosophy. This is the belief that using nature as our inspiration, we're gonna develop technology that actually works with the individual ear anatomy and auditory processing in mind. So this philosophy is gonna closely mimic how sounds in the environment are naturally

collected and delivered to the brain and this is gonna enable people to connect to the world around them in this most intuitive and natural way. So what they've always been used to even before they were wearing hearing aids. It's our intent that this is going to be that same listening opportunity. We know that we're built with a very complex auditory system. We know that our auditory system uses both ears, together with the brain to be able to accomplish this binaural listening in the various environments. And for people who are normal hearing, we just naturally and subconsciously are able to use different listening strategies depending on what's happening in the environment around us. We can take into account or the system, the brain and the auditory system can take into account what our different intentions are for a given situation. Maybe what the goal of the situation is and this just really happens very automatically. We don't really even think about it.

So the brain uses that information from both ears. It evaluates sound like maybe if there's safety concern, if we're able to hear that bus coming down the road, we don't wanna step out onto the road or it can determine what's the most important, we can be able to discriminate speech from noise. It helps us to decide what do we want to attend to, what do we want to ignore? Because we have access to all of that information and then it also helps us to be able to localize and correctly place what's happening around us. So that kind of that spatial perception of all the sounds that are happening around us. So we're using all those inputs to both ears and the brain is that critical piece that's helping us determine all of this. So, if you kind of consider, in everyday listening situations, we do automatically choose what we want to listen to. So again, I mentioned I'm from a large family and family gatherings, not this year of course, due to COVID but in a normal year, I mean, my immediate family can be 40 some people and it's lots of chaos. It's lots of noise, lots of loud people who have the most important thing that they wanna say to be heard and talking over each other and all those other crazy family situations. But in that situation as a normal listener, I can be having a conversation with one of my siblings and I can still kind of monitor other

conversations that are going around me, I just do this naturally. And certainly when my kids were younger, they would be off playing or doing whatever with cousins and if I would maybe hear a cry, I could hear that. I can have access to hear that and I can choose then, if I want to or if I need to intervene, if I need to pay attention to that or if I give them maybe an opportunity to work out whatever the issue is that's causing this situation to happen. And because I have access to all of that information, I'm able to do so. Now, fast forward, my kids are older. Now, when I hear that person crying, I know it's not my kid and I can just continue and choose again to focus on the conversation I'm in. So we're able to just naturally do this and as the environment changes, so does our ability to keep up with that changes as well and our use of these different strategies when we need to use them. So what are these natural listening strategies? We kind of have them into three categories. We have a spatial cue preservation. We have binaural listening and we have speech intelligibility. And so depending on again, what's happening in this typical day or typical situation, if our walking outside and things, we wanna hear what's going on around us, we're gonna be using that spatial cue preservation strategy where we're able to hear all those inputs. We're able to place what's happening around us in our environment. As we get into something that's more speech and noise related, we're gonna have that binaural listening strategy so that we can be able to focus on a certain conversation, where you're able to get a really good understanding of the speech we wanna listen to but we can monitor also what's going on around us and be able to shift our attention if we choose to do so.

If something more interesting is being discussed, do we want to pay attention to that instead? And then we have a third strategy of speech intelligibility where when we get into those situations where we are focused on somebody, they're in front of us, we wanna hear what they're saying. We're in really heavy noise situation, but we only really wanna hear what's in front of us, ae have the ability to block out all that other stuff and focus straight ahead in that situation. So we do these things naturally. The brain helps

us with that by getting all of that input from both ears. So when we're in that situation for that speech cue preservation strategy, where we're out on a walk, maybe in a park and you want to be able to hear everything going on around you, maintain awareness of what's going on around you. If you're in a park and somebody is jogging behind you or maybe a bicycle rider, we wanna be able to hear that. We wanna be able to step aside if we need to, we wanna be able to hear that bicyclist say, "Hey, on your left." So we know that somebody is gonna be passing us. We don't wanna be caught out from that. Maybe if somebody calls a greeting across a neighbor or something, if you're walking down your street, you'll be able to hear that, you'll be able to localize where that is. You'll be able to turn your attention to it and respond to that or maybe it's just, you wanna enjoy sounds of nature, you wanna hear the birds. You wanna hear the leaves rustling on the trees in the wind, those kinds of things. We're able to hear that, we're able to place all of that information in our environment. And our brain is going to choose when we're in this situation to do that based on what's happening.

But we know that being in that speech preservation, that speech cue preservation strategy, that's not gonna be sufficient for every listening situation. We know like the research actually tells us that about, 80% of our time, we do spend in that situation for speech cue preservation, that we want to hear everything going on around us. It's about 80% of the time that we're in that. So we wanna make sure that we're providing or that hearing aids are providing what needs to happen when we are in those environments. But when things get a little bit more complex, when we start adding this lots of combinations, multiple talkers, noise happening in the environment, we want the brain to be able to switch to a different strategy so we can take advantage and again, give us that best listening situation. So when it is complex, instead of relying on those spatial cues, we want to actually rely on the ear that presents the best representation of the sound that we want to hear or that desired sound. So this is what we call a better ear listening strategy. So the brain is really sophisticated. It can take those inputs from both ears. It can compare them. It can decide which ear am I getting that

better signal to noise ratio from? And it can let us focus on that signal of interest but it doesn't cut us out from what's happening on around us either. So in this particular strategy, we're still able to monitor everything that's going on around us. And then we know when things get really, really tough, when there's lots of noise coming from all around and we have a particular person we wanna hear in the front of us, we want our brain to again, be able to shift to what we call the speech intelligibility strategy. We're gonna be able to focus in on what's in front of us, block out everything else that's going on around us so that we can use our best ability to enhance that signal that's coming from the front. So, our All Access Directionality is our newest directionality option in ReSound One and this actually goes along with all of these natural listening strategies that the brain uses and intentionally it does this.

This is what we have been using these well-researched human strategies to develop our directional technology for many, many, many years. And now with All Access Directionality, we've taken it to the next level with our ReSound One product and we're gonna talk about how we do that coming up. So with the all access, we're giving listeners the technology to have that better hearing and noise and access to their surroundings and be able to shift between these different listening situations, depending on what's happening in that environment. So it's going to be this automatic. So the patient doesn't have to worry about doing anything. They don't select a program. When they're in All Access Directionality, it's automatically making the shift between that spatial cue preservation, when we wanna hear everything around us. That binaural listening, when we wanna hear but also be able to monitor and that speech intelligibility strategy where we wanna focus on just what's in front of us. So when we're in the speech cue preservation strategy, our hearing instruments are going to be in an omnidirectional mode. When we're in that binaural listening strategy, that's going to put us in that asymmetric directionality mode, where we have one hearing instrument in omni-direction to monitor what's going on around us and the other hearing instrument in a directional mode, to be able to focus on what we want to hear

and get that best signal to noise ratio. And then when we need that really tough, heavy noise situations and we need that bi-directional, the system will automatically code to that and give us a bi-directional for that speech intelligibility strategy. So, kind of taking a step backwards or maybe not backwards but we have to do some things because of when we put a hearing aid on, what gets disrupted with our ability to hear sounds? Well, we know that 80% of our fittings nowadays have those microphones that are placed above the pinna. We know that sound actually across the frequency spectrum, the pinna plays a heavy role in shaping that sound and being able to shape it depending on where it's coming from, where it's approaching, what angle, what distance from the head and it provides the brain with these very sound shaped distinctive cues that we call pinna cues, right? Well, this filtering of sound by the pinna, it actually provides a huge, has a huge role in being able to localize where sounds are coming from not only horizontally but also vertically in our environment. So when we place those microphones on top of the ear and that sound gets delivered directly to the eardrum, basically, we interrupt all of the natural things that that pinna is doing for us. So it's basically bypassed and by doing that, by bypassing it, we're actually distorting these natural cues that we use to localize sound in a normal listening situation when we don't have hearing aids on.

So previously and we do today, as manufacturers, we actually do some compensation for these lost pinna cues by introducing some calculations into our algorithms that are based on some average pinna measurements and we do that so that we can restore some of these spatial cues. So in our spatial cue preservation mode, when we're out there, this is where is this gonna be important, right? When we're in our directional listening mode and we wanna increase signal to noise ratio, kind of preserving spatial cues is maybe takes the secondary place to being able to hear speech. But when we are in these quiet or mildly noisy situations, we want to be able to provide the brain with what it needs. The brain is going to attempt to maintain that time and place for all these different sounds that are happening around us. And with All Access

Directionality, when the environment supports this, it's going to be using the spatial cue preservation strategy and that's where we're gonna get this bilateral omnidirectional microphones. And we're going to add spatial hearing algorithms to preserve that spatial cue hearing that's lost when we put those microphones above the pinna. So when we do this, if we're using our standard receivers in the three system with the ReSound One, that preservation of spatial cues is what we call ReSound spatial sense technology. And what we do with that is we implement what we call binaural compression and what binaural compression does is that it maintains into oral level differences that actually get disrupted from a different thing that we call wide dynamic range compression. So if we didn't do anything to take care of that, normally wide dynamic range compression is gonna give us our most gain for soft inputs. Well, as sound travels around head, we lose some of that energy, so that if you have a sound coming from your right side, when it arrives to the left, it's going to be softer. So that when we put hearing aids on with wide dynamic range compression, we're gonna get more gain to that soft side input and we end up kind of eliminating that natural cue that's normally there.

So with binaural compression, we're gonna evaluate that and we're gonna say, what is that level difference between the ears? And that when determine that, I'm gonna figure out what does that mean for my wider dynamic range compression. I wanna apply enough gain to each ear so that I can maintain that level of difference cue. The second piece of spatial sense is actually going to be using a pinna restoration cue to again, maintain those pinna cues that get disrupted from where that microphone placement is. And in the case of our standard receivers, those pinna measurements are based on an average ear or an average pinna influence. With our new M&RIE, M&RIE receiver is actually making this even much better for the patient listening. So when you fit a M&RIE receiver, it's actually going to incorporate those benefits of binaural compression, the same way it did to take care of the wide dynamic range compression issues but it's going to use actually individualized spatial cues from the pinna. Because

what we do with M&RIE is we place a third microphone in the ear canal and by doing that, we can preserve all that spectral filtering that's individual to that particular ear. So basically the spatial cues are preserved based on how they always are preserved for that listener. Instead of being able to being preserved based on some average ear that may be close to what you need or may not be close to what you need. So we're able to actually preserve using that individual information that the listener has always heard. So when we use M&RIE, that's gonna be very important in this particular spatial cue preservation strategy. And as I mentioned before, this is about 80% of our listening time that we're in this situation. So we wanna make sure that we're managing that well. So M&RIE stands for Microphone and Receiver in the Ear and this is truly the epitome of organic hearing by providing those individual pinna cues. We have this little microphone that's right on the receiver module, gets tucked in the ear and there's definitely some benefits of doing this. And certainly evidence is a big piece of it, right? So we wanted to make sure that yeah, we're putting this there, this makes sense, like in theory, but is it really a good idea and are we getting some benefits?

So, some of the advantages and benefits that M&RIE actually provides us are gonna be three main areas here for improved localization, natural sound quality and comfort in wind. So with the first one, the improved localization, we are able to better improve localization front and back and actually all around the listener by placing that microphone in that ear canal and using those individual pinna cues versus if we were using average pinna cues. For the natural sound quality, again, placing that microphone in the ear canal is going to use all of that spectral filtering that is unique to that ear. So this is kind of think about it that we're providing the brain with that information that they've always heard because it's coming right from that individual ear. So they don't have to acclimate to some new kind of sound quality. This is how they've been hearing even before they had hearing aids on. And then that third area being comfort in wind. Again, placing that microphone in the ear canal just gets naturally protected by wind noise so that you just have less problems. You don't have

to use a separate algorithm to manage wind. It's just doing it naturally for us. So, when we look at a spectrogram here of the open ear, this is giving us kind of this image of sound information or cues and the different intensities of those that are received at the eardrum whereas we move the sound source around the head. And the intensities are represented by different colors. So, less intense, it's gonna be kind of this blue color here and the more intense are gonna be those reds and oranges indicate that it's a less or that it's a more intense type of sound. And certainly when we do these spectrograms, this is going to be unique for everybody's ear. So, this is this particular open ear but if I ran it on 10 people, these would all look slightly different because everybody has a different individual ear. So we talked about pinna restoration algorithms and how we wanna try to mimic this open ear as much as possible. So when we use that average ear pinna calculation, we can see that we sort of have that same pattern but you can also see that it's much less intense than what is represented in that actual open ear spectrogram that we're looking at.

And so, while it's good to do this because it's better than not doing this, right? We wanna present spatial cues. If we can get this closer to looking like that open ear, it's gonna be a much more natural listening situation and improving that localization all that much more. And we're able to do that with our M&RIE microphone. So when we do that same spectrogram using the M&RIE microphone again, we see that same pattern but it's much, much more intense compared to that pinna restoration that's above it and much closer when we look at it side by side with that open ear. So we can see those areas are matching up much more closely to what that natural listening situation is. So, I'm gonna play a video here that's actually going to just demonstrate this spatial cue preservation that we have with M&RIE.

- ReSound One introduces a revolutionary new class of hearing aids. The first M&RIE, Microphone and Receiver-In-Ear combines the traditional two microphones with a third, discretely placed inside the ear canal. This third microphone is responsible for

collecting sound right inside the ear canal, using the unique shape of the outer ear for a more individualized and complete sound experience. Spectrograms can be used to show how the placement of the microphone inside the ear canal can be used to preserve spatial cues, the natural response of the ear. A spectrogram is a visual way of representing strength or loudness of a signal over time at various frequencies. Today, I will show you how ReSound One provides a similar response to the natural response of the human ear, preserving individual cues for sound localization. We will record three spectrograms. An unaided ear, a traditional hearing aid and a ReSound One hearing aid. Let's start with the first recording. The response of the unaided ear. This is the natural response of the ear. Now, let's record the spectrogram with a traditional hearing aid, where the sounds are collected behind the ear as the microphones of the hearing aids are placed on the top of the ear and not inside the ear. In this case, the spectrogram from a traditional hearing aid differs from an unaided ear. It makes the user lose some of the spatial cues, important for localization and speech recognition. Now, let's do the same recording with a ReSound One hearing aid. The signal will be collected by M&RIE, the microphone placed inside the ear canal. As you can see, the spectrogram has a similar response to the unaided ear, thereby taking advantage of the individual ear anatomy to collect sound as nature intended.

- [Kara] So we did get a question, I just wanna to touch base on asking about explaining why again, microphones are put above the pinna and that really has to do with just the design of the Ricks and the BTE hearing instruments, right? That's where they are located physically when we're choosing those models of hearing instruments. And when we do that, again, we're not able to take advantage of anything that that natural pinna provides for us. So, that's why we have to implement some other strategies, like pinna compensation or what we just saw with M&RIE by placing that microphone in the ear. We can compensate that way as well. So our next item here is this improved localization. So, we see improvement with both front and back localization as well as overall localization. So these charts in this study are referencing

percent of error. So this was basically presenting sounds coming from the front or the back or from all around and the overall localization and having that listener identify where did that sound come from? And there were three different conditions that were tested here with omnidirectional. So just regular hearing instruments with no kind of spectral cues pre-reserved. Hearing aids, again, above the pinna, and then turning on a pinna compensation algorithm and then measure it again with the M&RIE microphone being used instead and there were two groups of people here. We had those with hearing loss and those with normal hearing and it makes sense that we see like the normal hearing people perform a little bit better than the hearing impaired people. And that makes sense because normal hearing people don't have the added effects of the hearing loss.

So we would anticipate that even if they're wearing these hearing aids, they're gonna do a little bit better than somebody who actually has a hearing loss. But what we can see with this is we get the most errors in both conditions when we're in that omnidirectional mode, right? We're almost approaching for the hearing impaired people, 35, 40 over 40% in some cases kind of that guessing, like I'm not sure where the sound is coming from. And the reason for that is because those microphones sitting on top of that pinna, all the sound is heard in that area. So we can't spatialize where it's coming from very well. Then when we add that pinna compensation, we see a drop in the error rate for both groups of people and we would expect that, right? But now we're doing something, we're trying to enhance those spatial cues, we're adding in that average pinna influence. So we're adding some help to be able to localize where that sound comes from. So, it's a good thing, right? We wanna do this over versus just having people sit in an omnidirectional mode. And then we see a further drop when we do that same measurement with the M&RIE microphone. So again, we're doing better this time because we're providing those individual pinna cues that are meant or that are designed for that individual listener. They're able to localize much better than just using something that's based on an average. We also looked at natural sound quality.

So overall sound quality and actually specifically spatial sound quality and what's interesting, we looked at the M&RIE versus hearing instruments using pinna compensation algorithms and for both of these sound qualities, we can see that for M&RIE the rating, zero to 100, with 100 being a very good sound quality rating are all kind of clustered near the top here, are all being perceived as very good sound quality. And then when we look at pinna compensation, we see a much wider distribution of responses. So we had some people who thought, wow, this is great, really good sound quality and then we had some people down here that said, this isn't very good sound quality at all. And this makes sense again to us because when we're using pinna compensation, remember it's based on an average ear. So if my ear is close to that average ear, I'm gonna think it sounds pretty good, but if my ear isn't close to that average ear, I'm not gonna think it sounds pretty good. So we see this wider range of preference for sound quality because it is again, it's just kind of an estimate and we don't get that with M&RIE because those cues or that information is provided by that individual ear. And then our third category here, comfort in wind is a measurement that we took different wind speeds that you can see there. And we used a KEMAR mannequin and we kind of had them coming from different angles of incidence and made these measurements.

And we compared M&RIE versus just omnidirectional in this situation and just to reference one of them, this five meters per second wind, this is kind of equivalent to, if you think of a fresh breeze that can kind of make small trees sway. And when we compared that, what M&RIE did by tucking that microphone in the canal, we got 15 dB of wind noise reduction just simply by doing that versus omnidirectional, which was picking up all of that really noisy wind when they were outside. So just tucking that in provides that natural wind noise protection, we don't have to do some separate algorithm to take care of that when those microphones are more superficial or exposed to the wind. So here's another video that I wanna play for you that demonstrates that windy noise environment.

- There are many groundbreaking benefits of using a hearing aid with a Microphone and Receiver-In-Ear, such as improved localization, speech recognition and overall improved sound quality. Another benefit of using M&RIE is understanding speech in a windy situation. Today, we will listen to two different sets of hearing aids, ReSound One and another brand. First, let's listen to another brand which has microphones responsible for capturing sounds of the environment located behind the user's ear. Thanks for joining me outside though I hope it's not too windy. There really is nothing like getting some fresh air. Now, I've replaced another brand's hearing aids with ReSound One. ReSound One uses three microphones, including one placed inside the ear canal. Let's listen to the same scene. Thanks for joining me outside though I hope it's not too windy. There really is nothing like enjoying some fresh air. As you can hear the microphone and receiver of ReSound One enables better speech understanding in a windy situation. So, whether you're out for a run or just enjoying a summer day, you can hear comfortably.

- [Kara] And so then another area that we wanted to make sure that we were paying good attention to is feedback cancellation. So with M&RIE, we see that the proximity of that microphone to the receiver is very close, right? These are both residing in the ear canal and from everything we know about that means that the closer we get those components to each other, the more potential we have for having a feedback issue to occur. So we wanted to make sure that we can still provide very robust feedback control, just like we do with all of our receiver types. So we have redone our DFS Ultra to a DFS Ultra III that incorporates actually a calibration for that M&RIE microphone in addition to the two microphones that are on the hearing aid themselves. And we can make sure that we are providing very robust feedback control. So no matter what receiver type you're choosing, you're not going to have that feedback issue with any of the ReSound One products. Now, this is gonna be like, again, super important that we had to pay special attention to this with M&RIE because of that close proximity. But

really in our field trials, we didn't run into this, which was something that was really positive that our DFS Ultra III algorithm was doing exactly what it needed to do in managing all of that feedback. And then, last thing on M&RIE here is to talk about the M&RIE mode and I just wanna point this out. So when you're in our fitting software, under our all around program, our All Access Directionality is going to be the default, right? This is gonna be that automated ability to switch between these strategies. But if you had somebody who wanted to have a program that was dedicated to just being omnidirectional all the time, we have what's called M&RIE that's listed underneath this. And what this does is it would put them full-time in a bilateral omnidirectional listening mode, but it's providing all those individual spatial cue preservations when you select that program. So if you need somebody or somebody desires to have that omnidirectional listening situation full time, M&RIE provides those spatial cues. If you look up here, you could still choose an omni program, but then you're gonna get omnidirectional without any kind of spatial cue preservation. So I just wanted to point out that that is an option to select here, underneath that all around program. All right, our binaural listening.

So we know that spatial cue preservation, we use it a lot, 80% of our time, we want that type of listening situation but we know that when those listening situations get more dynamic, more complex, we introduce speech and noise together. It's not going to be sufficient for what we need as listeners. So we want to have that ability to shift into a different type of strategy. So binaural listening, this is going to provide that omnidirectional microphone on one ear and that directional microphone on the other ear, so that we can be able to focus in and get a really good signal to noise ratio on what we are intending or wanting to listen to. But we can continue to monitor the environment with what's provided by that omnidirectional microphone. Now, with this binaural listening situation or binaural listening strategy with all access, we do things a little bit different where we're now using a binaural beam former for that directional side and that has huge advantages of being able to provide that very narrow directionality

to what we're trying to focus on. And then our third strategy is going to be that speech intelligibility strategy. So all access will also go to this speech intelligibility strategy using bilateral directional microphones. And again, this provides that bilateral beam former. So again, very narrow directionality to the front when we find ourselves in those listening situations where we wanna focus directly to the front, and there's lots of noise happening around us, the system will automatically put us into this mode for listening. But how we actually implement this in All Access Directionality is different than what we used to do with our previous generations and this next section, we're gonna talk about how do we do this differently? So the first thing would be how we apply the strategy. The second has to do with us that we're now using a multi-band directionality and the third area is going to that we're using a Weighted Beamformer. So part of our new chip that we're using with the ReSound One product introduces a new magnetic induction radio. So we still have the 2.4 gigahertz wireless radio and that's gonna be responsible for all the data ear-to-ear transmission.

So any kind of determining what kind of directional mode we should be in, any kind of volume or programs synchronization between the ears, any kind of volume or noise reduction that automatically happens in a synchronized between the ears in our products, the environmental classifier is gonna use it to determine and share that information between ears. All of our wireless connectivity, all of our made for iPhone, direct audio streaming, all of the direct audio streaming for the Android. This all is using still that 2.4 gigahertz radio that we've always used. But now, in addition to that, with ReSound One, we have a magnetic induction radio and what that's going to allow us to do is exchange audio information between the ears. So it's going to exchange all that audio information between the four microphones on both hearing aids and what that allows us to do is create that wireless beam former using that information. So we get that very narrow directionality capability with this new radio that we've implemented. So again, just another illustration of it, that audio exchange on those four microphones, creating that one wireless beam former signal. Now how we apply this, the application

of it is when we're in that binaural listening mode, that asymmetric directionality, right? We're gonna apply that to the directional ear. So we're using that wireless beam former, whenever we're in that binary listening modes, we get that really nice narrow directionality for the best speech understanding we can get. And then again, that omnidirectional allows us to monitor our environment nicely. And then when we're in the speech intelligibility, which is bi-directional, that binaural beam former is going to apply to both hearing instruments 'cause they're both in that directional mode. We also use a multi-band directional approach. So with ReSound, we've always used what's called split band directionality. We've used that for more than a decade and what that always has done in the past is processed low frequencies omnidirectional and then there was some blending point where above that everything was processed directionally. So you could get good signal to noise ratio and the best speech understanding.

What we're doing now with ReSound One is we're still processing all of those low frequencies omnidirectional and what that allows us to do it actually provides the ability to preserve all the inter-oral time differences that happen, because those are all low frequency based and it also provides really good sound quality. So if we think back traditional directionality, when we activate directional microphones, all those low frequency waves cancel and we get that roll off in the lows, right? And what does that do? Well, it creates kind of an audibility issue and it disrupts these time difference cues that are naturally there. And then what we did as manufacturers, kind of before we started doing split band was we would try to artificially boost up that low frequency area. We'd use a bass boost, which kind of took care or helped with that audibility problem. But it still wasn't really the same kind of, it was different processing. So your timing cues were still not quite where they needed to be, they were still disrupted and you also introduced more noise because we're bumping up those low frequencies. So, it wasn't a perfect solution to do it either way. So what split band or split band processing did was to allow us just to leave those low frequencies alone and let them

come through Omni so that we get all those timing differences are preserved. We don't mess with them and we get that really natural sound quality that low frequencies provide for us. Well then, so we're still doing that and then we have what we call that blending point between the low frequency and now what will be the mid frequency band. And that's in ReSound language called our directional-mix. So our directional-mix is going to be, where does that transition from omnidirectional to directional processing happen? And it is based actually personalized on the patient's audiogram and the hearing instrument that they're wearing so that we make sure that we're providing the best blending point, depending on what their hearing loss is. Now, you can further customize it. That's what the adjustable means is in the fitting software, you can go in and change it. We have four different options to choose from. We have a very low, a low, a medium and a high and when there's a high directional-mix, that means we're providing more directionality. So our blending point is actually gonna shift down to a lower frequency. When we're on the opposite spectrum or if we're in a very low means, we're gonna have more omnidirectional and our blending point would be a little bit higher.

And so when you have normal hearing in the lows, you want more omni. When you have a more significant hearing loss in the lows, you want more directionality. So it will be adjustable from that perspective. When we get to this mid frequency band, this is where all of our speeches, this is where we wanna concentrate on maximizing that signal to noise ratio improvement. This is where this mid frequency band we're applying that binaural beam former. This is where it matters, right? We need to have all that good signal to noise ratio happening here so that we can understand speech the best. And then with ReSound One, we've actually added a third band that begins at 5,000 Hertz and above for our high frequency band. And what we apply in our high frequency band is an independent fixed directionality and what this allows us to do is actually preserve monaural spectral cues, so those that the pinna is providing and it actually helps us preserve those high-frequency level differences that are naturally

there. It doesn't distort them. Again, what research kind of points to is that when we apply adaptive directionality up in this high band, that we can kind of disrupt some of those inter-oral level difference cues and those pinna cues that are normally provided there. I'll just point out, one of the handouts I have is our white paper on the All Access Directionality and the Ultra Focus and that kind of discusses sort of that research behind that finding where they seem to see that with adaptive directionality that can disrupt that. So when we do this multi-band approach, which is now different and unique for ReSound One, we're providing that maximum signal to noise ratio benefit in that mid frequency band where the speeches, where we need it, where we need that better signal but we're still preserving this awareness or these spatial cues, right? By doing that low frequency omnidirectional processing and that high frequency, independent fixed directionality in highs, we have that ability to preserve some of that spatial cues.

So we're not putting them strictly into a tunnel. We're actually allowing to get that really nice, good directionality and some awareness of still of what's going on around them. So another thing that we're doing unique with our directionality and All Access Directionality is we're doing or using what's called a Weighted Beamformer blending. So in a lot of listening situations, we can have oftentimes more noise on one side than the other. So in this example, we have all this noise that's shown here on this side of the listener and we have just a little bit of noise here represented by the fan on the other side of the listener. Well, what we're going to do is actually provide some weighting when we have these asymmetric noise situations, when there's more noise on one side than the other where we're gonna use that exchange of information, that audio exchange will determine like, hey, I have more noise over here. I want to use more of the signal from the less noisy side and what that ends up doing by weighting it that way, we can get a better signal that includes less noise, so that better signal to noise ratio and better speech intelligibility by doing it. So just another illustration or a different way to illustrate it, again with those same noise components. If I have all this

noise on the right side, I'm gonna use a little bit when I exchange all this information between the ears, I'm gonna use a little bit of that information from the right side but I'm gonna use more information from this less noisy side, being the left when I create my beam former so that you can see by the illustration that it has more of a blue component. And what we can do again, is effectively take out some of this noise that's there and provide that better signal. And then the same would apply if I had more noise on my left side than my right. You can see that the signal, the beam former is gonna include more of that signal from that less noisy side, being the right ear to again, provide that best signal possible. So how does this look when we actually do some measurements on this Weighted Beamformer? Well, we looked at AI-DI measurements for ReSound One actually, compared to legacy ReSound, for the different frequencies listed there, as you can see, we can see that with that binaural beamformer when we weighed it, we're able to provide about two dB more signal to noise ratio improvement or AI-DI measurement versus what we could do even with our legacy ReSound. So this is providing a huge amount of benefit by being able to remove some of that noise. And again, just another illustration of the Weighted Beamformer.

When we tested this, we actually used 10 normal listeners and they participated in speech and noise recognition task, where we use some cafeteria noise and it was presented either from the right or the left, that's illustrated here. And the effect of this weighting, we asked them to participate in this speech and noise recognition tests for these different conditions using that cafeteria noise. So speeches of course, represented by the bubble here in the front of the listener and the noise by the speakers and for each configuration, we tested it with and without the weighting of the less noisy side. And on average, again, we saw kind of that same performance as we saw on the KEMAR of that improved ability by about two dB. And then when we think about when we can add two dB of improved signal to noise ratio, that can really, depending on what kind of measurement you're using, be 10 to 15% per dB. So you can get really upwards of 30% better speech understanding in noise by applying this

weighting. All Access Directionality, where do you find that? It's going to be located underneath the all around program is where you will see it, it'll be the default for that program. So you can select it there. And I'm gonna show you another video demo here, illustrating All Access Directionality.

- There are many factors that contribute to a natural listening experience. A hearing aid should enable awareness of the surroundings while providing adjustments to enable speech understanding, no matter the situation. Features such as All Access Directionality, give the user confidence to transition between environments and never miss a sound. Today, I will demonstrate how ReSound One offers superior sound quality and speech understanding while shifting between different sound settings. We will listen through two different sets of hearing aids, ReSound One and another brand using the same sounds and sound levels in the environment. First, let's listen to another brand talking to a demo head wearing the hearing aids. There's nothing like a good cup of coffee to start the day. What can I get you? We have cappuccino, espresso, latte, black coffee? It's your choice. How are you? I hope that you can hear what I'm saying because it's very noisy in here. Well, summer is finally here and it's perfect weather for a walk, should we get going? Now, I've replaced the hearing aids with ReSound One. Let's listen to the same scenes. There's nothing like a good cup of coffee to start the day. So what can I get you? We have espresso, cappuccino, black coffee, coffee with milk? It's your choice. How are you? I hope that you can hear what I'm saying because it's very noisy in here. Well, summer is finally here and it's perfect weather for a walk, should we get going? As you can hear All Access Directionality is the perfect feature to help you feel at ease and engage effortlessly with your changing surroundings.

- [Kara] So yeah, demonstrating how that kind of switches depending on what the environment and how that automatically, it's happening as those environments change. Also, what's new with ReSound One is what we call the New Ultra Focus program. So

this is where if you think about Ultra Focus is a program you can set up where you can override the automatic All Access Directionality. So this would be used when those situations get really heavy with noise, you need to focus to the front, you need that speech intelligibility strategy and you wanna make sure that you are in that strategy. You can override the automatic All Access Directionality and choose Ultra Focus and it will put you in that bi-directional. So we're giving that patient the control to be able to choose the setting when they think they need to use it. Now, it is a program that you have to actually add. So when you're in the fitting software, if you use underneath the program environment, you'll see Ultra Focus listed there. When you select it, then they simply need to use their app or the switch on the hearing aid or remote control or accessory that allows the ability to select programs to be able to access it. But they have the control to choose when they want that and then you get, again, that extra two dB signal to noise ratio when you're in that situation, which is gonna be huge in those high noise environments. Now with Ultra Focus, we've actually optimized some of those settings so that we wanna make sure that you get the most directional situation. So with the directional-mix, it'll be that high setting to give you the most directionality. We're gonna use slow time constants because we know that sometimes when you're in those really, really noisy situations, those slow time constants can kind of keep that overall level comfortable without actually disrupting the temporal envelope of speech the best and then we're gonna have that moderate noise tracker, kind of our internal studies when we did trials on it. People preferred that moderate noise tracker to setting when they specifically wanted this in noise listening situation. So these defaults will already be set for you when you select that Ultra Focus program. And again, another demonstration video, quick of the Ultra Focus.

- There are many factors in a hearing aid, which contribute to speech understanding. It is very important that hearing aids can be adjusted to offer speech clarity in the most demanding environments, such as a food court, a busy restaurant or an airport counter. Today, I will simulate a demanding situation to demonstrate how Ultra Focus

helps speech clarity coming from in front in a very noisy environment. We will listen to two different sets of hearing aids, ReSound one and another brand, using the same sounds and sound levels in the environment. First, let's listen to the other brand while I speak. Hi, thanks for meeting me today. How are you? It's very noisy in here, so I hope that you can hear what I'm saying. Now, I've replaced the hearing aids with ReSound One. Let's listen to the same scene. Hi, thanks for meeting me today. How are you? It's very noisy in here, so I hope that you can hear what I'm saying. As you can hear, the Ultra Focus feature allows ReSound One users to enjoy conversations in the toughest environments, which they might've avoided in the past.

- [Kara] Okay, so yeah, you can definitely tell a difference when we can put you into that really specific bilateral directional when they wanna choose it. And that with that ReSound beam forming that we're using, they're getting that benefit, we're maximizing that signal to noise ratio for that speech in the front. But we're also still providing some access to the sounds around them, just that spatial cue preservation, which is gonna be important. We don't wanna put somebody in a tunnel where we block them out from their environment completely. That multi-band that we're using in that beam forming is that weighted ear-to-ear audio blending, right? So we're using more signal from the less noisy ear, which again is just gonna remove some overall noise, increase that signal to noise ratio and increase that speech understanding as a result. And then that can improve that AI-DI by about two dB compared to when we don't use weighted in the non-weighted beam forming system. So definite improvements with how we're implementing our All Access Directionality with that beamformer. Benefits. So again, All Access Directionality, that's gonna be that automatic, right? They put it on, they don't have to worry about it. They're gonna go from environment to environment. It's gonna choose that best listening situation for them. Speech intelligibility, with the environmental awareness, right? We're gonna have that provided with All Access Directionality and then that specific beam forming, that one-to-one conversation when those really noisy environments happen, that automatically will switch depending on

what that situation calls out for. And then Ultra Focus, again, letting the patient control it, letting patient decide when they need that bilateral directional. It's gonna give them more confidence in those difficult listening situations and by providing that additional signal to noise ratio much better speech understanding. And then with M&RIE, when we're in that speech cue preservation mode, when we wanna hear everything that's going on around us, that M&RIE, putting that microphone, using those individual pinna cues is gonna provide greater depth and direction. So we're gonna be able to tell where everything's coming from, how far away or how close it is. It's gonna provide that natural wind noise reduction and then that natural sound quality 'cause we're using what that individual ear has always used and what is he used to hearing? So that brings us, I think, to the end of the talk. I'm gonna check up here and see if we got any questions. I'm not seeing anybody, if you have any, type them in there and we can certainly address them. I have the phone number and the website listed there. There's always lots of good information on the website, of course but the phone number, certainly reaching out to our government services team. They're always happy to hear from you and certainly happy to answer any of your questions that you have. I'm not seeing any additional questions. So, we'd like to thank all of you again for joining us and I hope you certainly have an opportunity to try ReSound One and see those benefits for yourself and what you can provide for your patient.