Grand Rounds by ReSound: WARP Processing

Presenter: Jordan Cyrus, AuD

So hi to everyone. Happy Friday. We are going to go into today's grand rounds by Resound. So we'll be talking about warp processing. I'm Jordan Cyrus.

I'm a field training audiologist with Resound. I'm out of Columbus, Ohio. I cover Ohio, West Virginia, Pennsylvania, and now Kentucky. So you're many, many brave souls for signing up for this course on a Friday. It is a little bit more kind of of dense information.

So I appreciate you being here. It's a very technical presentation, but it'll be a good one. So we're definitely going to dive into some advanced discussion about one of our processing features that we use with our Resound technology, and we call that warp processing. So I do like to get pretty technical. It gets a little scientific and nerdy with this topic.

But we'll definitely explain some of the reasons behind why we opt for this type of signal processing in this presentation. Specifically, it's going to go a little bit more into the background behind kind of why we have the number of handles that we have in our software, the reason that we have the number of bands and channels that we do here at Resound, and just give you a little bit more of that scientific perspective on things. So we'll definitely include a little bit of a refresher on some cochlear anatomy, how the anatomic functioning of our cochlear organ plays a role in why we use this type of strategy. And it'll be a nice refresher of a lot of that information that maybe you have put into the back of your mind since your graduate school days will be bringing it all back up to the surface. So more processing, I will say, is something that we include a lot in our white papers.

If you attend any of our dinner seminars or presentations specifically around, like, launch seasons. It's definitely a topic that we include in our discussions. And so I do like to revisit and review it from time to time, just so that people are kind of on the same page in terms of how we we design our technology. And you'll see this a lot in our discussions with Resound. But we like to follow what we call the organic hearing philosophy.

And what that means is that sound is to be processed as naturally and as close to a normal human auditory system as possible, because that's what we believe is going to give our patients the best sound quality possible. So we kind of follow that incentive with all of our product portfolios, which is why I like to review it. In fun fact, one of my very first days at Resound actually had a provider come up to me with a white paper and say, can you tell me everything there is to know about warp processing? Like, I've seen this, this word here and there in some literature. And I was like, who sent you here?

Because it is a very detailed kind of discussion. But we'll make it as simple as possible. We'll give you a lot of good fundamental information and we'll go from there. So we've got our risks and benefits. And this is just really a disclaimer.

Of course, obviously the information and the research that we're talking about today, it's relevant based on our findings and methods that we're aware of at this time. You know, given that this is a live webinar that we are going to record. I am employed by Resound, I am on GN Resound payroll, but I'm the presenter today and that's obviously important to disclose. And as always, as a field trainer at Resound, we always include learning outcomes in any presentation that we give for educational purposes. So I'm going to read these honestly, because I just want them to kind of stick in your mind.

So after this course, anyone who's attending today is going to be able to identify cochlear anatomy relevant to signal processing. Our participants will identify how warp processing works to contribute to the quality of the amplified signal. And then participants will be able to recall the number of channels available in Resound's processing strategy. So just a heads up, take a little mental note here. You might find some of this information to be relevant when you are taking your CEU exam.

So again, these are some of the highlights. If we have time, we'll actually review that exam and maybe go over some refresher information for you. So I really want you to get the most that you can get out of this course. So starting with some basics, not to feel like we're dumbing anything down. So most of the participants on this call are likely hearing healthcare providers in some capacity.

But just for the sake of being thorough and comprehensive, I definitely like to do kind of a detailed anatomy review because personally I think it kind of helps explain the reasons why we do things from a mechanical standpoint. Always keeping in mind obviously the human auditory system itself. So we're all familiar with cochlear anatomy, or hopefully we are, and some of our more basic anatomical functions of this system. But again, we could have younger professionals or students on here. So we'll just start everybody from kind of the ground up.

And so I like to make the connections between our cochlear anatomy and then its direct involvement in how we kind of design our signal processing itself. So up on the screen you've got your diagram. Of course, we're all familiar with the cochlea. We'll start with hair cell function just to get a little kind of more acquainted or reacquainted with some of our knowledge that we have there. So you all know hair cells are specialized to respond to specific frequencies.

If you're like me from my time in clinic, you will never pass up an opportunity to explain to a patient. If we unravel the cochlea, it's like keys on a piano. And so that's kind of why I like this visual up here. So we know the high frequencies are coded more towards the basal end of that structure, and then our low frequencies are coded more towards the apical end. So instead of sound vibration just being totally dampened by that loss of energy as it travels through that system, we have hair cells.

So we've outer hair cells and they are providing that electromotility to add energy as sound enters through the cochlea. And we know for a fact that outer hair cells essentially act as our non linear amplification system. So we've got about 12,000 of those things when they're nice and healthy. And their specific role is to mechanically kind of those low level sounds that enter the cochlea and they are going to contract and expand with that basilar membrane, whether that is upward or downward movement, kind of depending on what's happening. So all that's to say is this is a live system, it's an active system, and that is the main, primary goal of those, those hair cells.

So obviously we would want quiet sounds to be amplified more than louder ones because we've got a lot of sound pressure that we need to red kind of that smaller range of hair displacement. And so of course that's going to be for only those lit mid to low intensity sounds. And it is very dependent on that metabolic activity and that's what's going to influence that frequency selectivity. So I feel like a lot of these, you're probably hearing a lot of buzzwords and like, who feel like I'm back in grad school, but it's for a good purpose here. So then of course we've got inner hair cells, we have much less of those.

We have about 3,500 inner hair cells and they're primarily responsible for doing the decoding information. So things like frequency, temporal information, intensity, and then they're actually transforming that sound vibration in the cochlear fluid into the electrical signals that we know are transported to the auditory nerve and then up the portions of the brainstem into the higher level auditory processing systems. So how does all that relate to tonotopic organization? So we know tonotopic organization is not just what's happening in that peripheral portion of the system. There are portions of it that extend centrally.

And so whether you're talking about hair cells themselves or the peripheral or central part of the system in general, it's not a uniform system. So it is not linear, which is really a really key word when we are thinking about this topic. So anytime we are attempting to mimic or replace, quote, unquote, I guess you could say, for lack of a better word, outer hair cell function, like we do with hearing aids, we need to create a model that's really precise and as precise as possible to what the actual outer hair cells do in a normal hearing system or an undamaged system. So we have to create that nonlinear function and non uniform compressor, the amplification in those particular frequency regions, because the whole goal is to avoid distorting frequency itself. So our artificial compression, like what we use in hearing aids, it obviously exists because we have outer hair cell damage or outer hair cell loss.

And it compensates for that nonlinear system because in result a patient's going to have that reduced dynamic range in terms of their hearing threshold. So, so again, compression makes soft sounds audible, keeping loud sounds comfortable. And all of this is important because this entire system has to be functioning in a non linear fashion, just the way anatomically that it's laid out. Because if the basilar membrane processed information totally linearly, if you took something like an 83 decibel SPL sound, it could yield a deflection 10,000 times greater than which would obviously result in some pretty severe cochlear damage. So the compression of the basilar membrane acts as that kind of protective mechanism.

So how is this impacted by sensorine or hearing loss? Hearing loss is obviously occurring because when we think about how that energy moves through the system, really loud sounds are really just large pressure waves. And that's what causes those hair cells to break or to bend. And then we know at this time hair cells don't regenerate naturally. We don't have anything in science that's allowing us to do that, at least consistently.

And so that's going to inflict that permanent sensory damage. So we have to find a way to overcome that. When we are thinking about amplification solutions. So the impact of that to the system, obviously from an anatomical standpoint, from an acoustic standpoint, we're getting a reduced dynamic range. So again, soft sounds are inaudible, there's recruitment.

So we've got that abnormal loudness perception and growth, we have loss of sensitivity and frequency discrimination, we've got low intensity, high pitch phonemes that can be inaudible, we've got phoneme smearing. Temporal resolution is poor. All of these things change when we have the damage to that auditory system. So moving out of grad school, we're going to get into a little bit more specific here. So again, we're all familiar with the layout of the cochlea or the basilar membrane more specifically here, as you can see on the screen.

So that's going to be that gray portion of the graph there. So the gray portion is the organization of the natural membrane from basically basal to apical end. And so the wart processing system is what you can see laid out on top with those little red bands. So that's what we're going to use as our reference here as we kind of work through some of these explanations. So the basal end of the basilar membrane, we know it's wider, that's where all those high frequencies are coated and it's more stiff compared to the apical end where the low frequencies are coded.

And that's obviously where that membrane becomes more flaccid and flexible. So you can think about it and remember it like the strings of a guitar specifically. So we've got stiffness and looseness. That's kind of what's helping us code those frequencies. And obviously since things vary in, you know, width, diameter, flexibility, this again is a non uniform system.

So at one end to the other we've got some differences in those parameters that are making it physically and objectively different. So because of that, the properties of the membrane, just depending on which point you're looking at, they're going to determine a different characteristic frequency and that's going to be the frequency where we're the most sensitive to that particular sound vibration. So again, that sounded very grad school coded. So maybe we're not completely out of it yet. So when we think about kind of what we learned up to this point about how the system works, that's where we get that kind of mass spring system comparison.

And that's what's going to dictate those different resonant properties of this particular system. So when we think about what war processing is specifically, because obviously that's all the kind of technical acoustic parameter information, wart processing. It's an actual auditory processing technique that attempts to emulate frequency resolution of the human auditory system. So we're trying to get as close as we can to how that cochlea would naturally function if hypothetically it didn't have that damage, if it didn't have the portions of hearing loss that we have to overcome to get that signal to be nice and clean and clear. And so if you look up on the screen, you can see we've got those 17 kind of smoothly overlapping frequency bands.

And those are what kind of logarithmically correspond to the auditory bark scale. So if you remember that scale from probably textbooks you've read, giving us a little bit more information about frequency. But that's what this system is based off of. And we have white papers for that as well. So we use that in conjunction with our wide dynamic range compression system.

And obviously that is what's going to give us that kind of more natural frequency information. So this translates to, you know, virtual, no distortion, minimal processing delay. So again, when we think back to the organic hearing philosophy, which is what we are always kind of emphasizing as a point of our research and design process at Resound, I guess you could say it's always to keep that sound quality truly as natural, as clear as it can be, trying to emulate that natural system without making things quite as artificial. So as far as I know up to this point, we're one of the only manufacturers to base our amplification and our basically frequency processing on an actual accurate model of cochlear frequency analysis, which is what you're going to see up on the screen here. So warp processing, again, it emulates the way an unaided ear analyzes frequencies of incoming sounds and it breaks them into more distinct pitches.

And so it does this by decoding frequencies and intensities of sound in a once again a non linear way. So the same way that ear does, it's a nonlinear system. So I like to point this out and I like to bring this up. I think it's a good topic of conversation because there are, and you know, I specifically for this job go into clinics and practices. I'm an audiologist, I work with audiologists who obviously are patient facing.

And one thing that people could be skeptical of is the fact that we only use 17 channels in our signal processing. So a lot of people will say, well, you know, there are other manufacturers who use 24 or other manufacturers who use 32 or even more than that. So While other manufacturers may have a high level of channels, you know, they're processing sound in a different way, we actually use that nonlinear frequency filtering, which is more beneficial. And we'll kind of get more into that on the next slide here. So research actually does tell us that there's no significant improvement in sound quality if we're tacking on additional channels to that processing system.

If we are using the non linear frequency filtering system. If you're using linear processing strategy, that could be a different story. So we'll go into that. So warp versus linear processing. So you can see here the top, we've got that warp processing system that we were talking about on the last slide.

On the bottom there, we have a more linear processing strategy. So that's just kind of reference what we're looking at in terms of the overlapping bands versus those very distinct channels that are kind of uniform and smushed together there. So like we talked about before, other manufacturers, they might use linear processing and have a various number of channels and bands, again, sometimes up to quite a large number. Sometimes. You know, this can be viewed as like super impressive by our healthcare professionals, our fitters, that that particular system, because it has so many channels, it must be very sophisticated or very specific to those tiny variations in frequency.

There's definitely a problem with that line of thinking though, because we're ignoring the fact that the human auditory system itself receives this frequency coding in a nonlinear fashion. So translating that into more of a digital linear way of processing is not going to completely compute into like a natural signal quality. So again, there actually are manufacturers that specifically market having 48 frequency bands, and they do use that particular uniform spacing for most of their products, if not all of them. And so even if we are using 48 channels, we may not be getting the appropriate frequency resolution specifically in like lower frequencies, at least not that we would get with warp processing. And this is actually going to waste processing power of the device itself by having finer resolution in frequencies that the ear itself may not even be able to detect, or what would be not really even beneficial to amplify itself.

So a large number of bands might appear more sophisticated. And when we think about what we do from like a research and development design, it could from a research perspective, look like it's more beneficial. But we are human beings, we are not machines, obviously. So a mechanical focused research model is not going to compute into, you know, what would be realistic for a obviously real life patient wearing that particular type of technology that uses that particular processing strategy. So in other words, Adding all those channels, it's not necessarily adding anything to that particular patient's user experience.

So again, if you go into our software, so we are now on SmartFit 2.2 as of the time of this broadcast. And so if you look at the amount of handles that we have available, I do get that as a commonly asked question as well. So providers will say, well, why do you only have 10? I feel like you could have 16, 18, 20, 25. This number of handles is actually is what, going to make a clinically noticeable difference when you're making decibel changes to those particular handles.

And again, since we're using warp processing and we've got those kind of overlapping bands and channels, having 10 handles within the software might mean that, or if we had more than 10, I should say if you're manipulating the handles in the software and trying to make even a 1 decibel change, you may not see an actual, like clinically significant difference in the response that you're getting, especially if you're using something like real ear or another form of verification. And so we try to make things as specific as possible so that our providers can obviously be confident that with this particular model and this particular signal processing, that a change in a single gain handle is going to definitely translate to an objective difference when we're looking at those real ear responses responses. So again, more handles does not equal, more like uniform control. Essentially, we, we want it to make a difference and we're not seeing a clinically significant difference when we add all of those additional channels. So again, a purpose of using warp processing, if you really get anything from this presentation, Warp processing is geared and designed towards overall improved sound quality.

So we want to make our hearing, make our process sound as natural as possible. We want to emulate the natural cochlear function that we have in an undamaged auditory system. And then overall, we want to reduce the distortion of sound so that we know our patients are getting exactly what they need in terms of clear signal, better speech understanding and higher functionality for these products. So what we can do at this time is quickly go over our review, which is our CEU evaluation at the end. And so prior to doing that, let me pull this up here.

We're going to exit out and bring up our quiz questions. So let's start with number one and let's get the chat active here. If we've got some people watching and if you're going to fill this out later, then we're going to go ahead and walk through it together. Just so we know that our knowledge is comprehensive up to this point. So question number one is in what fashion does word processing analyze sound?

So we have A linear B non linear, C digital and D parallel. So if we want to use the chat. And these are always exciting because I don't always know who's on the other end of these. So if anyone wants to participate, that is just lovely. Okay, so we've got an answer.

B. That is correct. So we are processing in a non linear fashion. Question number two. How does warp processing work to contribute to the quality of the amplified signal?

So A processes sound in a linear way, B emulates the way the unaided ear analyzes the frequencies of incoming sound and breaks them into distinct pitches, C mimics the way inner hair cells process sound, or D word processing does not contribute to the quality of amplification. So what do we think for that one? That one's a little wordier, correct? Yep, we're looking at B. And then question number three here.

How many channels does Resound integrate into their amplification solutions? So A24, B36, C17 and D8.

Yep, we have got C17. So again, kind of linking things back to that research. Having more channels does not necessarily compute to having better sound quality, higher functioning. So we are going with C17. Number four, what Cochlear strategies or structures, I should say, like word processing, function in a nonlinear fashion.

A, outer hair cells, B inner hair cells, C the organ of corti or D the tympanic membrane.

Correct. We've got a lot of A's in here. That is A, outer hair cell. So good job pulling that grad school knowledge back in. And then number five, probably the most important here.

So why might a provider choose to fit a device that integrates wart processing over a linear processing solution? A warp processing requires more channels, B reduce distortion of sound, C linear processing of sound, or D louder sound quality.

Good. We're getting a lot of Bs. You guys definitely paid attention, so that's awesome. So hopefully everyone will go over and get their CEU credit for today since we did all that together. And just on behalf of everyone here at Resound, thank you guys so much for attending today.

Thank you for your attention. Like I said, it's kind of a dense topic, so I appreciate all of the participation and discussion. And again, I'm Jordan Cyrus. I'm a field training audiologist. If you have any additional questions, any feedback, feel free to shoot me an email.

I will provide my email in the chat. And if you have additional questions that you would like to discuss, feel free to reach out to me. So definitely take your CEU course after this to get your credit and keep an eye out for more grand rounds at resound. And thank you all so much.