The Science Supporting Infinio

Presenter: Sarah Dyke, AuD

And welcome to today's course, the Science supporting Infineo by Dr. Rachel Lamb. Thank you Melissa, I appreciate it. Today we are going to talk about the Science Supporting Infineo and I apologize for that small little typo there. My name is actually Lamb.

L A M B We're going to address the importance of transparent evidence that is timely with our current platform. When you go out to eat you look at Yelp reviews and I know I research almost everything I am interested in making a purchase about or looking at buying for family and friends. So we naturally have a lot of information at our fingertips and we find ourselves seeking out evidence to make informed decisions as well.

My name is Rachel Lamb. As I said before, I am a clinical trainer employed by Phonak and I have no other financial or non financial disclosures to let you know about or for you to be aware of.

After this course, participants yourselves should be able to describe how Phonak's approach to deep neural networks DNN is unique to the industry. List the products that feature Spheric speech clarity, describe the benefits of Infineo to your patients and hopefully have a good time as well learning all about science.

Infineo hearing aids have been developed to meet both hearing aid patient and hearing healthcare provider needs. But what does Infineo stand for? Exceptional sound quality from the first moment Connectivity you can count on with market leading connectivity taking a giant leap forward. A device that is tested, reliable and proven for Swiss engineering. At its best, Infineo allows personalization for you and your patients and clear speech from any direction with spheric speech clarity.

The entire Infineo platform is a culmination of years years of studies. At Phonak we talk about different types of studies. Feasibility studies are conducted during development and these studies guide research and development in how to parameterize our features or to give us early indications on how

our features deliver audiological benefit. We also conduct clinical studies with the final feature or product to confirm that these features really do deliver objective audiological benefit. In addition to gathering real world subjective responses from hearing impaired study participants, this presentation looks into some of the key feasibility and clinical studies conducted on Infineo.

So we'll start with exceptional sound quality from the first moment because those first impressions count. Research from Princeton University suggested that the first impression can be formed within a tenth of a second. The 711 rule from an NYU study showed that up to 11 assumptions can be made by someone within the first seven seconds with hearing aids. We have two opportunities to make the best best first impression. The first is when patients receive their hearing aids at the fitting appointment and the second is when they wear them into the real world for the first time.

Infinio ensures that this exceptional sound quality from the first moment in clinic and in the real world happens for your patients. And we also have evidence and so the research we have done takes into consideration both of those experiences.

Exceptional sound quality from the first moment in clinic is thanks to our proprietary fitting formula Adaptive Phonak Digital, first introduced in 2005 with Savia. We have been continuously improving on APD over the years based on hearing care provider and patient feedback as well as independent studies on hearing loss and gain prescription methodologies. In 2018 we made adjustments to reduce some of the high frequency gain for first time users to deliver love at first sound. With Marvel, paradise delivered on unrivaled sound quality thanks to a big change with APD 2.0 where we introduced three big improvements to optimize the adaptive compression speeds to linearize high level gain and third we added a new pre calculation for mild to moderate hearing losses. And now in 2024 last year we continued to further improve upon this exceptional sound quality with APD 3.0 with the first fit with new frequency response curves in both acoustic and and streaming programs.

What was the motivation for APD 3.0? Actually, some of our best discoveries are made by accident. One of my favorite accidental inventions is the post it note. I have some on my desk right now. In 1968 a chemist from 3M was trying to develop a stronger adhesive that well frankly backfired.

But but now we know we now have the strong enough but weak enough adhesive that we use most days in the clinic and continue to use during appointments and office work today for quick reminders of to do items. In this case, APD 3.0 actually started as an idea to improve the streaming sound quality in our devices. There are three parts of this study. The first is that we started with a feasibility study looking into that streaming program of ours. We know that this is something that has become important to our hearing aid users so we wanted to look into how it was received at the time and of course how can we make it better.

And when it comes to looking into consumer electronics or headphones, those are they are doing something very different from hearing aids. But there's been a huge point of success for steady improvements in sound quality with headphones. So we looked into that consumer headphone industry to see what they have done to optimize the sound quality of the audio input, namely for music. So this initiated that feasibility study at our Sonova Innovation Center, Toronto, looking at the acceptance of different frequency offsets based off learnings from the headphone industry and compared it to our current streamed setting. More specifically, if we augmented our stream signal to match more closely with what they were doing, would this result in improvements of the sound quality for our end users?

In this study, we had 24 experienced hearing aid users with mild to moderate hearing loss.

This image shows the three things that were compared in this study. You have frequencies along the bottom of the x axis, the gain correction offsets on the Y axis, and you have the modified gain curve 1 and 2 when compared to Phonak's proprietary fitting formula, APD 2.0. These modified gain curves are based on headphones. If the sound completely matches the gain response of the input of the sound,

and if it's above, we added more gain to it. If it's below zero, that means we took away some gain from it.

APD is in green and it's fairly flat. If anything, it's gently sloping. It starts at about a 5dB gain offset to down to a minus 3 gain offset. So not huge changes in terms of the overall frequency response compared to the original. And then you have the modified gain curves 1 and 2, and these are the ones that are modeled after headphones from the consumer electronics world.

And they are very different than what we were doing. As you can see, there's a little bit less gain between 200 and 800 Hertz and a little bit more at 13 and less at 25 again. So we did feel like this was something worth investigating because it is so different than what we were already doing. And the only difference between the modified gain curves 1 and 2 are in those highest frequencies above 5000 Hz, because it looks like overall they're pretty overlapping. There are three lines there and you can see at 5,000 hertz where that purple and blue differentiate in their offsets.

So we presented a variety of range stimuli covering various music genres, from jazz to classical, pop, and as well as speech. These are some of the samples that we used as well.

The music stimuli was presented under three test conditions. We had the three different response curves, the variety of inputs, and three different methods of presenting the stimuli within those response curves. One was a streaming program and the other two were through the acoustic program, meaning sound was going through the hearing aid mics in one condition in the booth and the other was outside. The primary objective of this was was to see how it sounded, how it sounded streamed, but we thought it would Also be interesting to measure ratings when the same stimuli was presented acoustically through the speaker in the booth and again acoustically outdoors in that type of a setting.

In the streamed condition, there was no clear trend with the preferences between our current settings and the two modified curves. So these were the results for the streaming condition. And unfortunately, they're a bit inconclusive. This was our main question, you know, will there be a big preference for one of these modified gain curves over the APD 2.0 curve? And is that something we could pursue?

Unfortunately, the answer was no, not really. There wasn't a strong trend or preference across any of the genres for the offset of curves that we showed you earlier, at least for streaming. And so we also played them acoustically in the booth. However, what was interesting was when the stimuli was presented acoustically outdoors, there was an overall preference for a modified curve. Participants made some subjective comments, such as it sounds quieter, the noise was less noticeable, and it's easier to listen to.

So here we have these two acoustic conditions, a very quiet sound booth and outside. And in that booth, that quiet environment, we don't see a great difference or trend across Phonak, the modified gain curves, just no preference overall. However, when we look at the outside acoustic condition. So when they're listening to the hearing aid microphones in these different genres in an outside environment, there was a clear overall preference for the modified gain curves over the Phonak APD 2.0, and a lot of spontaneous comments that people were making that the sound was more calm, the noise was quieter, and more noise was filtered out. So we got this really strong subjective effect using the modified gain curves.

So overall, the study was interesting. This first study was a very interesting outcome for that streamed condition in the sound booth. There is no clear preference for any of the three settings. Current Phonak modified one or two. It was inconclusive.

However, there was a clear preference for one of the modified frequency responses. And that first result of that feasibility study gave us an idea. So streaming is unclear if there's an effect acoustic booth

unclear. But then how often are you really in this dry acoustic environment, like a booth, but with the outside acoustic program, there was a clear preference, which is where most people spend their time listening to music. Maybe not outside, but definitely not a booth.

So what do we do with that information?

Although our initial objective was just to look at the sound quality of streaming, it triggered an idea in our team. Why not see if we can improve the sound quality overall with a change in APD 3.0 that can be applied in all acoustic programs and let's continue to find an optimal frequency response curve for the streaming program. In other words, maybe instead of just focusing on the stream signal, we can look at APD 3.0 overall and potentially reformulate that prescription. And that led us into our second study. This second study was again set up at Sonova Innovation Center, Toronto.

This time the objective was primarily to Compare our current APD 2.0 with a modified frequency curve. This modified curve had a gain reduction between 2-4k Hertz and 1000 Hertz boost. The objective was to see how this modified curve compares to APD 2.0 for comfort, noise intrusion plus objective and subjective speech clarity. The second objective was to investigate two new frequency response curves, both of which took inspiration from commercially available headphones. The Sennheiser HD 600.

This study had 20 subjects again experienced hearing aid users with that mild to moderate hearing loss. We had two different questions for them. So can we reduce that gain and boost at 1000 to give comfort and maintain speech clarity? And can we do all those things and still get great results? And then taking that second stab at exploring stream cap clear.

Excuse me, streaming sound quality. So let's see what happened.

This screen represents the things that we tested in these two test conditions that were completely new and different. The frequency response curves from the first study would were identified and tested. One for the acoustic programs. And then two new and very different curves from that first study were tested.

The HD 600 is a high fidelity headphone made by Sennheiser. And the yellow and blue are very similar modified gain curves that were explored to see if one of those two would improve or or the perceived sound quality. With the streaming signal. On the upper line, the APD2.0 line is black and the benchmark, the green line represents the offsets.

The results from the study show that the first fit with APD 3.0 is preferred over the first fit with APD 2.0. It is more comfortable, has less noise intrusion and no loss in speech clarity. These results are from a combination of 12 scenes that had a low level of background noise with and without speech. So a total of 12 in those situations. AutoSense classified the environments as quiet.

However, there were noises around during testing. Some of those noises included a river stream, a vacuum frying bacon in a kitchen, shopping centers. And those were all tested in the calm situation program. Please note that the noise values have been inverted to make it easier to understand for the reader. So on this graph, the higher the tally count, the less noise Intrusive the participants found the scene.

The participant's perception of speech intelligibility was also documented and measured objectively. No significant difference was perceived. This is a great result as we don't want to sacrifice audiological performance for comfort. Results from part of the study confirmed that the new frequency response curve should be implemented as part of our fitting formula for Infineo and this was very exciting for us. So, in terms of the two study questions, the first one was answered with a resounding yes.

The second one was also answered.

We wanted to still improve on the sound quality of the stream signal, which was our original goal in the beginning. So with the second study we used expert listeners rather than hearing impaired subjects. The reason for this is that the reliable and consistent rating of music sound quality is very subjective and among standard novices this is even more true. This leads to a large variance in rating across different subjects in untrained ears. Therefore, we elicited or recruited expert listeners who have been trained to listen for various characteristics of music and sound and can provide more reliable consistent ratings on sound quality.

So we compared the current which is the previous streaming program modification V3, a modification that was tested but decided not to go with and modification 4, the streaming program that was implemented into Infinio and you can see that the modified version 4 received the highest count and was what we finally used in the APD 3.0 streaming quality.

So we got a result indicating that APD 3.0 is looking better than our previous APD 2.0. Our streaming with APD 3.0 overall is better also than our streaming with APD 2.0. And now the final piece of this was to compare ourselves and benchmark against a competitive device. So in the final study of this three part series, we conducted this at PARC in illinois, there were 15 first time users. So people who have not worn hearing aids before they were slightly more mild hearing losses, but for the most part they were in that mild to moderate hearing loss range.

And this was a study about first fit acceptance. So when they were fit with a first fit using Infiniorm and adaptive Phonak Digital 3.0 and afterwards or before, depending on where they were in the process and the randomization, they were fit with a competitive device, they were asked some subjective questions.

Participants in this study were asked questions such as about the perception of loudness and sound quality for a speaker's voice, who was the fitter in that situation, about their own, the speaker who was the fitter in that situation and about their own voice, etc.

So you can. So now how to read the graph. This graph is about satisfaction. So 100% is completely satisfied. I love the way that sounds.

Our patients, we want them to be 100% satisfied. Zero was completely unsatisfied. It's not that if you were at 100, it was very, very loud. It was about satisfaction with how loud it was. So having higher bars is actually very good in this scenario.

And Phonak was rated over the competitor for all four of these conditions. The loudness of the first fit for the speaker's voice or the fitter, the loudness of the patient's own voice and the sound quality of the fitter and the patient's own voice.

When asked their overall preference, 93% of the study participants preferred the first fit with APD 3.0 compared with the first fit from another leading manufacturers. This really shows that not all first fits are created equal.

Everyone was blinded also, so they didn't know which hearing aid they were wearing. They didn't leave the office with the devices, so they didn't have a chance to look at them themselves or look at the chargers. And they were asked the question about preference while they were blinded as well to which device overall, which device was which. So it has been quite an interesting journey of discovery that had has led us to APD 3.0. It started with the idea that maybe the consumer headphone industry can inspire a new frequency curve for streamed programs.

These two studies resulted in two new frequency offsets. A reduction at 2 to 4000 Hz and a boost at 1000 Hz in all acoustic programs, as well as a reduction between 2-3 Hz in the streaming programs. These two implementations resulted in APD 3.0. Evidence shows a higher preference rating for comfort, noise, intrusiveness and speech clarity for APD 3.0 compared to APD 2.0 and a clear 93% patient preference for APD 3.0 compared To a leading competitor. So it's been very exciting for us.

We feel very good about this journey of discovery.

But what about first impressions when the patient takes their Infinio devices home for the first time? And one of the things I love about this is that it really is a win win, right? It's a win win for patients, so your patients can accept that sound. And we know it's a lot easier to wear something that you like the sound of rather than something you don't. But that also frees up chair time in the clinic because we know our practices are so Busy and having patients like the way a hearing aid sounds, not needing a lot of changes, which is what we have been hearing about Infineo since launch is, is a really great place to be and of benefit to you and your patient.

So let's pivot now and take a look at that next step once they leave the office in their home. Where do we go from here? So what's the situation where you and your patients are in the most? So when they come back and you're looking at data logging, you see the most classification in that situation or where they're spending their time. So when we look at the data from patients, we see that on average most patients are spending 68% of their time in calm situations.

That is why Speech Enhancer is a key feature in infiniorp that because most patients express significant difficulty in those quiet situations with soft speech, Speech Enhancer can help with listening fatigue and listening effort. It is really one of my favorite features to talk about these days. It's designed to give an extra boost to soft voices and quiet so we're not having to turn up everything that's soft. And it specifically looks at that modulated voice signal. So it could be those very soft spoken grandchildren

or family member or a family member who likes to talk from a distance, not up close or somebody whispering in your ear.

It's a situation we've all been in before and we're super excited to look at some of the emerging evidence as well as it pertains to fatigue and listening effort. It's well documented that one of the impacts of a hearing loss is fatigue at the end of the day due to that listening effort. We have evidence that Speech Enhancer improves speech understanding and reduces listening effort. But we were interested in investigating if this effect leads to reduced fatigue. A study was conducted at Oldenburg University which primary.

Its primary objective was to evaluate whether Speech Enhancer can lead to that reduction in fatigue thanks to that reduced listening effort. The secondary objective was to measure memory capacity, reaction time, concentration and word memory with Speech Enhancer on versus off. So investing in this project was very important because I think it's our most, our underrated, our most underrated feature because we have a substantial portfolio of evidence that supports the benefits and of Speech Enhancer and we want to share that with you today. These were 22 experienced subjects that were assessed with a mild to moderate degree, a moderate degree of hearing loss as well.

The study methodology is very interesting also. So this is one of the tasks that they did and it looks like something you might see at the optometrist. Right. And not the audiologist. But this is just a visualization of what they're calling a time compressed Auditory day.

And so each color represents a different task during their appointment. And as you can see, they repeated these tasks and they randomized them across the day. The idea was that by the end of the day, they should be auditorily fatigued. And then they could really assess if giving Speech enhancer or taking it away would have a difference in listening effort and as a result, a difference in perceived fatigue. So they did several different tasks, like we were saying.

And this is an overall two and a half hours of an appointment. So you might see on here ccolsa. And if you're unfamiliar, the ULSA is a test of speech and noise tests done in German. The version we have in the US is called the Matrix test. And essentially you're repeating sentences that have a predictive structure.

So it's like a name, an adjective, another adjective, and a noun. And the CC was also super difficult because it was a concurrent assessment, meaning that the sentences were happening concurrently. So it's very, very challenging. When you see Oculus, the one in the center of the screen, that's referring to Oculus, that is referring to a list eliciting effort, scaling task where they would listen to those OSA sentences, but then indicate on a rating scale how difficult it was to understand. So this was definitely a challenging situation.

I really love this first graph, the cumulative fatigue distribution. And this is showing us what their fatigue scores were. 0 being no fatigue and 10 being a lot. And the green is with Speech Enhancer, and the blue was without it. You can see at the start of that time configuration press day, they are very similar with and without Speech Enhancer.

Then as the day went on over those two and a half hours, we do see a difference in the overall fatigue score. It was more like a four and a half difference. Whereas without it, it was over a five. Excuse me, With Speech enhancer on, I apologize, their score was an average of a four and a half, but. But without it, it was over a five.

So we were cresting halfway point. That halfway point in terms of fatigue. That is very, very impactful. And if I just think for myself how much fatigue I have throughout the day without a significant binaural hearing loss, I could save about 20% of my fatigue with something like Speech Enhancer. What could my brain do with an extra 20% of energy throughout the day?

And I'm sure we all remember those classes in school where we Talked about cognitive load and how hearing aids hopefully lessen the cognitive load so that you have more cognitive resources to do other things. What this shows is that speech enhancer can read. With speech enhancer on, patients experience 21% less fatigue at the end of the day. You can think of that as having more cognitive capacity for other things than at the end of a day just by using a feature like speech enhancer. And it allows patients to be part of the conversation instead of two steps behind.

So we also had a few questions outside of fatigue that were memory and comprehension. We saw that within these two questions as well, speech enhancers significantly improved both speech memory and comprehension. So it's less listening effort, more improved memory and improved comprehension with speech enhancer. With this portion of the study, I don't know about you, but I really want to improve my memory and comprehension. And if it's part of my hearing solution, that's a nice added benefit, not only as a communication device, but allowing me to have less effort and reduce cognitive load potentially by the end of the day.

Because we don't want to just improve our ability to hear, we also want to improve the patient's quality of life. So I think this really speaks to that aspect as well. So this is also a separate study conducted at Oldenburg to look at the effect of speech enhancer on listening effort as a reduction in the electroencephalography alpha power. In addition to measuring listening effort from a distance compared to the standard test difference of 1 meter 4 meters versus 1.5 meters plus speech in an adjacent room. We know that patients often complain about difficulty understanding speech when a family members are speaking from those distances and from another room in the house.

So if speech enhancer does reduce listening effort overall, well, as we saw before, we wanted to see if this would play out in an EEG study. So there were 27 participants with mild to moderate hearing loss. And let's see how they did at the top. Here you can see the EEG results. We didn't see much of a

difference with just the eeg, and that's okay.

It could just be that listening effort with speech enhancer maybe isn't sensitive enough for an EEG to measure it. But we did find something really interesting when we looked at those challenging listening situations. So it says speech from 4 meters. You can think of a meter as roughly 3ft. So the distance of speech was 12ft away.

And in an adjacent room it was adjacent, but the door was open. So it wasn't a closed door situation. So you can think of it. Like a child in the bedroom and the parents in the living room, or one family member washing dishes at the sink versus the one sitting across the room or a spouse calling from the hallway. Did you take the laundry out and put it in the laundry room?

Those kinds of things. So it's a very challenging listening environment. And what we found was that with speech from 4 meters, speech enhancer showed a reduction of listening effort by 39%. And when speech was presented from an adjacent room, an impressive 45% reduction in listening effort was noted compared to when Speech Enhancer was off. And this is very significant in a real world situation for a patient.

And I've seen it with patients telling me that they heard a spouse in the kitchen for the first time in many years when they got their infineo devices and hearing soft grandchildren in the car or in the living room for the first time in many years. That's the impact and power of Speech Enhancer. Not just enhancing or impacting listening effort, it's improving those social relationships as well.

So Infinio delivers exceptional sound quality from the first moment. APD 3.0 has a frequency response curve that incorporates a reduction in the high frequencies and a boost in the mids in all acoustic programs, which is rated higher in preference for comfort and speech clarity and noise when comparing to APD 2.0. And when compared to a key competitor's first fit, an impressive 93% prefer APD 3.0. Let's

not forget the high ratings from expert listeners on our new streaming program in APD 3.0. And that exceptional sound quality continues when patients take their infineo devices home for the first time.

With new evidence showing that speech enhancer, the feature that is designed to enhance the peaks of soft input speech, speech signals in a quiet environment, can not only reduce the listening effort of speech from an adjacent room by 45%, but also reduced fatigue by 21% by the end of the day. So we're really excited about all of this. But that's not all we have to be excited about. If we look at that spheric speech clarity, it really, really does dive into that patient need, that key patient need of speech understanding in noise. So let's take a minute to look at how spheric speech clarity and the research shows and demonstrates its benefit.

Audeo Sphere and Finio transcends the limits of hearing care like never before. Delivering clear speech from any direction with spheric speech clarity. And Phonak has definitely broken the mold here. Unlike anything else that has been available in our market or in our industry ever. We have been able to do something that science has told us we cannot do, and that is you can't have a dedicated DNN chip in an instrument, a hearing instrument.

Phonak's use of artificial intelligence can be traced back as early as 2000 with our first iteration of our automatic system. We have continually innovated in this field for over 25 years. In 2019, we started looking into DNN signal processing models to specifically target speech enhancement to separate speech from noise to deliver benefit in those most challenging listening situations. Over the years, 19 studies have been conducted with over 150 hearing impaired subjects. We've been able to do this with DeepSonic, our unique approach to signal processing.

We felt really good that by the time we launched this device that we had thoroughly investigated the benefits of this technology and we're excited to share it with you. This has culminated in the launch of Audeo Sphere Infineo and the groundbreaking feature Spheric speech clarity enabled by the Deep

Sonic chip. We're very proud that the launch of this technology is backed by a wealth of evidence, technical measures, objective and subjective clinical results as well.

When we first look at the evolution of our technology and the benefit we have delivered over generations of features, all aimed at improving the signal to noise ratio to combat speech understanding in challenging environments. We now see this on this graph From a technical measurement perspective. The simple iteration of adding directional microphones, a proven way of improving signal to noise ratio, shows a 2.9dB benefit with fixed directional microphones when compared to the omnidirectional condition. When we add noise block, whether as a classic or conventional broadband reduction algorithm for noise, this brings the benefit up to 5.1 dB SNR. However, our previous benchmark level was Stereozoom 2.0.

With that spatial noise cancellation in dynamic noise canceller for a very effective and very impressive 6.4 dB SNR. However, when we launched Sphere or Sphere Audeo Infinio Sphere, we were able to test in challenging listening situations up to a minus 6 DB SNR for the stimuli and Spheric speech clarity can provide an unprecedented unprecedented signal to noise ratio improvement of up to 10.2 db Snr at its maximum strength. When tested, the scenes were presented at the recorded SPLs between 72.8 and 78.2 dB with food court, a dinner party as well as other types the cafe type of noise. This publicly available sound scene is ecologically valid, a realistic sound scene and these signal to noise ratios are significantly beneficial, especially when we look at the progression of Phonak speech and noise technology and sound cleaning over time.

So when you're looking at that 9 to 10.2 db SNR with spheric speech clarity, the strength will definitely depend on your acoustic coupling. So it may not be at the maximum for everyone. And even set to a moderate strength, you're still getting that 9dB improvement. So that technical result was very exciting. But we did some more technical testing before we launched as well.

We put Infineo technology to the test against competitors. We compared the signal to noise ratio performance of Spherix speech and loud noise program in the Infineo i90 sphere with the speech and loud noise program using Stereozoom 2.0 present in the Audeo Infineo 90R&3 competitor hearing aids premium level technology with and without artificial intelligence technology that were available on the market as of March 26, 2024. What you see here is that Audeo Infiniosphere provides a staggering SNR improvement of 5.9 dB in those realistic noise scenes, followed by an Audeo Infineo 90R with an SNR improvement of 4.8. Spheric Speech Clarity and Stereozoom 2.0 respectively, outperform three competitor devices who only show SNR measures between 2.2 and 3.3 dB. It is important to note that those SNR values are different to the previous slide because when we compare at the baseline for other competitor devices, that baseline which we compare against must be unaided versus an omnidirectional microphone.

The unique part of Spheric speech clarity is that that SNR benefit is maintained from any direction, not just from the front. This setup looks different than almost any other setup I've seen before. What we know is that directional microphones are highly sensitive at 60 degrees, due in part to the microphone's polarity. So we wanted to test beyond what the best case scenario was from the side. So we included three different microphone setups and positions.

And that benefit can be is independent. So we wanted to really challenge that situation and test it from different angles. Then we started moving behind the head to 120 degrees. That's for example, when the waiter comes up behind the person and says, oh, can I fill up your water? And you know, we always hear our clients say, I never knew they were there until somebody tapped me on the shoulder.

And what we found was that with Spheric speech clarity, we can give an almost 7 DBs. In our improvement with Spheric Speech clarity even when a patient is the speaker is behind the patient which is very impressive. It's not just relying on the directional microphone for noise reduction. You

have all around SNR benefit with a DNN based noise reduction system and when you look at the speaker array this is real life. But how do these technical measures translate into a perceptual benefit with the hearing impaired subjects in a clinical study In a study conducted at the Phonak Audiological Research center in the U.S.

this was our first clinical study on spheric speech clarity primarily to investigate if the technical measures translated into perceptual benefit to a hearing impaired subjects in various directions. Comparing spheric speech clarity to two competitor products as well as looking at listening effort. The internal comparison was measured using manual programs called SSC on or Spheric speech clarity on versus SSC Off. On was achieved with the Spheric Speech and loud noise program with the microphone mode set at real ear sound and Spheric speech clarity strength at its default setting. Off was achieved with Speech and Noise, a speech and noise program with the same directional microphone as the SSC on real ear sound with all noise reduction features turned off.

The gain models were the same. Thus the only meaningful differences between the programs were that one had spheric speech clarity on and active and the other one had no noise reduction. The competitive comparison was measured using the manufacturer default settings for the other competitor products.

The internal comparison was used for both the speech understanding and listening effort tasks and to avoid participant fatigue. The comparison with competitors was only used for the speech understanding TAS Speech understanding and noise was measured using the speech corpus developed by bolia et al. 2000 which became known as the coordinate response measure. Stimuli CRM Participants were seated in a speaker array with loudspeakers at 60, 120, 180, 240 and 300 degrees with a touchscreen at zero. They were instructed to press start on the touchscreen and listen for a sentence with the structure ready barren go to with a color or number now.

They then had to identify the color and number spoken in that sentence and select them from a closed set displayed on the touchscreen. The speakers were two female talkers and they were randomized throughout the test. After making the selection, the participants received feedback indicating the correct response and and the next test sentence was initiated. The Adaptive Atlas test is an adaptive method of measuring subjective listening effort. Three short sentences, the US Female Matrix test Speech Corpus were presented sequentially in fixed speech shaped noise.

Participants rated their subjective listening effort on a 13 point scale ranging from Effortless to extremely effortful. After each rating, the volume of speech was adapted. The algorithm of the ATLAS is designed to capture the range in the SNR that includes both the effortless and extremely effortful rating for an individual. That same loudspeaker configuration was used in the listening task as the speech understanding task. However, participants were turned 180 degrees so that a speaker was located at 0 degrees azimuth.

The speaker at 0 degrees presented the speech while the other four speakers presented the noise at a fixed summated output level of 72.

The initial output level for the speech was 72 decibels for a starting SNR of 0 dB. So this is a very challenging listening task. The percent correct for each condition was calculated by taking the sum of correct responses from the four possible speech locations and dividing by the sum total number of responses. The percent correct results were then used to calculate the percentile change by subtracting the percent correct of the poorer performing condition from the percent correct of the better performing condition, dividing this difference by the percent correct of the poor performing condition, and finally multiplying by 100. Overall, you can see these chances of giving a correct response were calculated and compared between the conditions.

So let's contextualize that benefit beyond the study participants. We wanted to do that as well and incorporate the hearing aid processing condition and sentences fixed effects while treating participants as random to test whether or not the odds of providing a correct response vary between different conditions. Hearing Aid Processing Conditions the model indicated that participants were twice as likely to give a correct response when they were using spheric speech clarity than when they were not using it. So in other words, to dig and understand is they had to get the color and the number correct in this task and with this closed set you might think it's easier, but it is a very, very difficult task to do. And what we see is that with spheric speech clarity on patients are twice as likely to understand and perform better in that condition.

So the next graph is comparing us to our competitors and again using manual programs and using spheric speech clarity and the loud noise. We chose the dedicated speech and noise manual program options from our two competitors. We used that same odds ratio concept before and found that you were up to three times more likely to understand speech versus compared to the two competitors when using Spheric speech clarity. In other words, 37% more correct answers with Spheric speech clarity versus the other competitor's product. Everyone, all the competitors, and even ourselves were attached to the same acoustic coupling as well.

So Those universal custom earpieces attached to receivers. So the physical feel on the ear was identical. And the only thing that was different was the processing.

Listening effort ratings were again modeled using those linear mixed effect models. And that's also important because we want to look at that listening effort. There were 13 points on that scale. And it's a lot in one graph. So we've pulled out three different parts that are much more impactful for a very effortful category, medium and very little effortful category of the stimuli.

And what we have on the vertical graph is the signal to noise ratio that they gave in those situations or they had called it very effortful. The patients called it very effortful versus less effortful. The blue is with spheric speech clarity off, off and the green is with it on. And again on this case, the lower on the graph you are, the better it is because it's a more challenging snr. So if you look at the two bars over at very effortful, you'll see that the blue bar is between negative five and approximately minus eight.

So by negative eight they were saying it was very effortful without spheric speech clarity. But with spheric speech clarity on. It wasn't until the signal to noise ratio was around negative 12 that patients were subjects were saying that it was a very effortful situation or environmental stimuli. And if you look at all three of those different categories, if we were able to look at all 13 of them, what we found was that patients could tolerate Approximately up to 3db more signal to poorer signal to noise ratio without perceived listening effort. In other words, they can be in more noise with poorer listening conditions of approximately -3 dB compared to using their other devices or with spheric speech clarity off.

So in other words, it is less effortful in more noise.

So objective measures are a good indication of benefit using some very controlled measures. But just because it's good objectively, it doesn't always translate into a subjective rating or preference. So we did subjective measures in both real world settings and in the lab. The subjective lab setting was done where participants listened to a simulated two person conversation three times using Sphere, Infineo and two competitor devices rating them on speech clarity, naturalness, speech and noise separation. And overall satisfaction ratings showed a clear preference for Audeo, Sphere, Infineo and in all categories.

And then what a better place to test spheric speech clarity than at a coffee shop, not one of those quaint quiet shops, but a very large coffee chain that is often busy with customers sitting around and coming and going. In this setting, participants wore three pairs of devices while there Infinio Sphere and

two competitor devices, all three in their automatic programs. There was a clear preference for Infinio Sphere over the other two competitor products, with 50% preferring Sphere, which is more than the other two competitors combined. The stories and experiences we're hearing in the field further support what was uncovered during that testing that patients prefer Sphere and do very well with it. Phonak is committed to unbiased, accurate testing so that you can be confident you're presenting solutions with real world benefit to your patient.

Audeo Sphere Infineo with Spheric speech clarity makes being in the moment easy the Infineo platform delivers a wealth of audiological benefit to our patients meeting the key hearing and communication needs of those with a hearing loss not only speech understanding in quiet but also in challenging speech noise environments. We have a wealth of scientific publications that showcase all of These studies on APD 3.0 speech enhancer and Spheric speech clarity thanks to technical evidence that shows patients can benefit up to a 10.2 dB SNR ratio, which is 3.7 dB more than key competitors. And since every word counts, patients are two times more likely to hear and understand every word in every direction which is 36.7% more than key competitors devices. The significant improvement in speech understanding also leads to reduced listening effort where patients can withstand 2.9 db poor SNR without a corresponding increase in subjective listening effort compared to when spheric speech clarity is off.

Exceptional sound quality from the first moment Connectivity you can count on by with market leading connectivity taking a giant leap forward. Devices that are tested, reliable and proven with Swiss engineering at its best personalization for you and your patients as well as clear speech from any direction to meet not only your patients needs but to set you up for success. Thank you very much for your time today and if you have some information, if you have interest in investigating further, here are the scientific publications that we talked about today.