What Can Your Eyes Tell You About Your Ears?

Presenter: Aren Bezdjian, PhD

- [Aren] Hello, everyone. Hope everyone's doing well, having a great day. Thank you for joining the Oticon Medical Course today. The title is "What Can Your Eyes Tell You About Your Ears?". So we'll touch a little bit about eyes, but mostly about ears. I'm just gonna give an overview of what I do on a daily basis. So I'm Aren Bezdjian. I'm a PhD. I've done most of my work in auditory implants, so cochlear implants and bone-anchored hearing implants. I used to work in an academic institution. I'm based in Canada and we did a lot of innovations, surgical or outcome measures, a lot of the different topics I'll touch upon today. And then after my academic career, I joined Oticon Medical to help them develop and really better their technology, their surgical approaches. So I'm a Clinical Research Manager. I work for Oticon Medical LLC. As you might know, Oticon Medical is a global company. Headquarters are in Sweden and in Denmark. Sweden which is the home of, the birth of the bone-anchored hearing implants. I'll also touch upon a little bit about that today. So thank you again for joining and without further ado, I'll start the course.

So a disclosure, I am employed by Oticon Medical and this course is sponsored by Oticon Medical. And a lot of the content that I'll be talking about is about, some of them, are about our products. Oticon Medical products, technologies, improvements and a little bit about the recent developments in our product portfolio. So the learning objectives for today's course. There will be on learning the effect of OpenSound Navigator, which is a concept that those of you who work with bone-anchored hearing implants might already know. A second is we're gonna talk about pupillometry. Pupillometry is the study of the eye and, hence, the reason why this lecture is called "What Do Your Eyes Tell You about Your Ears?". And last is, how are we gonna be able to differentiate between speech understanding from listening efforts? So there are two different concepts that I'll talk about today. And then we'll be, hopefully, able to differentiate them, know which one's which and how they interact with one another. So before I go into the depth of the study, I wanted to talk about the clinical study process. What is a clinical study? What do I do on a daily basis? Basically this slide, I

won't go into too much details, but I just wanted to show you that companies, such as Oticon Medical, have clinical study groups. So basically, our job is to create clinical studies and the whole process is done by various different types of people. Most of them are within our organization. Sometimes we go and seek outside vendors. But this is essentially how a study research team, a clinical research team within an organization such as Oticon Medical is comprised of. So as you can see, there's a lot of different people. There are three main stages of the study. There's a synopsis, which is basically the development of the study. But following that, you'll see study startup and planning. study conduct and then study closure. Some of you I'm sure have done clinical research in the past and you've seen some if not all of these different players. So it might not be very new to you. So are study's important? And the best example I have is, basically, this survey that was done in physicians. So we asked the physicians are clinical research, published scientific articles, do they influence what you prescribe your patients? And 84%, sorry, 80% said that peer-reviewed publication is one of the biggest indicators of how they're gonna change their prescribing process. This is followed by conference presentations.

As you know, physicians and audiologists attend conferences to learn more about what's going on. And companies such as Oticon Medical are always there to present what's new. There's sales reps, there's colleagues, there's the Internet, there's references, but really peer-reviewed publication is, I'd say, the gold standard for a physician seeking answers, trying to change their practice. They'll go and look into this. So of course, based on this we know that it's quite important to have great scientific studies out there so physicians can base themselves on. So this is the hierarchy, the pyramid of evidence-based medicine. So it starts with an expert opinion. This is an opinion. What is someone thinking about a certain topic? Then we have case reports. Case reports are a single event or multiple events, but they're reported as single cases. We have observational retrospective studies. We have survey studies, that is also observational. And then we have prospective studies. Retrospective is in the past,

prospective is currently and in the future. So this kind of section of the pyramid is, this is how it looks, the evidence, this is how it looks. And then the highest form of scientific evidence is meta-analysis and systematic review, which is basically a summary of randomized control trials. So the two upper ones kind of correlate to one another because to conduct a systematic review, often you go and look for randomized control trials. So some of you might be familiar with this. Randomized control trials often have placebos and this is really the highest, highest form of evidence. And then the systematic review is the process of really reviewing what's in the literature. So I'll go into the scope of our talk today. Bone conduction hearing. Some of you do already work with bone conduction hearing implants. You do fittings. You already know the procedures, the process, the surgeries that are involved here. Oticon Medical's main focus is on bone-conduction hearing implants.

And basically, this concept of bone conduction hearing is really the essential part of what's behind Oticon Medical technology. And often the way I like to say or present bone conduction hearing is your voice out of a recording is always off, right. You hear yourself in a recording when someone records you and you're just not content about the sound of your voice. And this is really because when you speak every day, like currently I'm speaking right now and the sound of my voice transfers to you via my microphone and the computer through air conduction. You hear the sound of my voice through air conduction, but I'm the only one that can also hear me through bone conduction. So you're the only one that can hear the sound of your voice via two auditor pathways, air conduction and bone conduction. And the voice out of a recording, the sound of your voice out of a recording only enters your auditory pathway through air conduction. And this is why the sound of your voice is weird because you lose the bone conduction pathway. Bone is a great conductor of sound and when you speak your facial bones, your jawbone, your cheekbones, all the bones vibrate. And this vibration is captured by your inner ear, the cochlea. And they say the bone conduction is better for low frequency sounds. And that is why the voice that you hear

out of a recording, the sound of your voice is more high pitched because air conduction is more high pitched. So fun fact of the day is the sound of your voice, you're the only one that hears it the way it is. Everyone else hears you like the voice in a recording. And this is an important concept when we think about bone conduction because there's two ways we can hear. And bone conduction implants utilize the bone conduction pathway of it. So you know you might think of if there were two ways I could see, would we find a way to optimize one of the pathways of vision? So we do. We do in the hearing world and I think that's quite fascinating. Bone conduction devices come in many, many different folds. There are direct drives. There's over the skin drives. Those of you who are familiar with bone conduction devices, at the bottom, you already recognize some of them. So the Ponto by Oticon Medical is a very commonly implanted device. The Baja by Cochlear. Sentio, also by Oticon Medical. BONEBRIDGE by MED EL. The BCI by MED EL. Osia by Cochlear. ADHEAR by MED EL. So all of these companies work in this sphere and really it's a tight niche. There's not a lot of companies out there that produce auditory implants. So I'm sure you're familiar with some of them.

But yeah, essentially there's about four. So let's go over real quick, what does a bone-anchored hearing implant do? A bone-anchored hearing implant utilizes the body's natural ability to transfer sound through bone conduction. So let's look at the graph here. Number two, you have an external sound processor. This sound processor works like a hearing aid. It captures auditory information traveling in the air, but instead of amplifying it and sending it in your auditory canal like a hearing aid would do, it converts these signals into vibrations. And these vibrations are sent via, number one, the titanium implant to vibrate your skull base and that is captured by the cochlea. So we're using bone conduction hearing, but via a device. So we're transforming sound from acoustics to vibrations. So let's look at the anatomy of the ear simply to see who is a candidate for this. I'm sure you work with hearing aids. You know of cochlear implants, you know of bone-anchor hearing implants, but what is for who? So sound

travels in the auditory canal and then it hits the tympanic membrane, which sets off a motion of the ossicular chain movement, as you already know. And this moves the fluid filled cochlea and this is how, essentially, you hear via the auditory nerve. So in order for bone-anchored hearing implant candidates, you need to have hearing impairments in the external or middle ear. So external ear you can think of atresia, those who do not have an auditory canal. And then in the middle ear, otosclerosis when the smallest bone in your body found in the ear are either malformed or dysfunctional. And then if ever the hearing loss was at the cochlear level, that is when we opt for a cochlear implant. But that is not the topic for today. So we spoke about bone conduction hearing. Bone conduction hearing implants rely on two factors. Bone conduction hearing, which we already just spoke about, but second is osseointegration. And I've spent about seven years of my scientific career really looking at this. How does the bone accept these implants? And this is extremely important, because basically if you don't have a titanium screw in the bone, then you won't have sound transfer. So the structural integration of the implant surface in the surrounding bone is the definition of osseointegration.

This concept was developed in Sweden and that is why a lot of the auditory implants companies come from Sweden because this concept, and it was developed in the field of dentistry, not even the field of audition. So a really, really interesting field. A lot of scientists around the world work on ways to better this. And we won't go into the biology of it, but here it is. So whenever there's a breach of the skull there's certain things that happen, really, and it's all a bunch of bodily reactions that set bones to create new bones. So you might know of bone cells called osteocytes and osteoblasts. These are two cell types that are extremely important for the science of bone. So whenever the implant is placed in the skull bone, you need the body to accept it, to form new bone, to create fixation, to have a stability and this is really a lot of the bone implant scientists this is where their focus is on. Because if you better this, then you understand how to better sound transfer. How you can better the overall sound quality

of patients. So we often overlook this because we're so focused on ears and you know the surgery of the ear and the obstacles and the auditory canal, but we forget that the interaction of bone is so important. And if you've seen patients with bone-anchored hearing implants, you know that we don't couple the processor before we have this fixation. Extremely, extremely important. So bone-anchored hearing systems, there is really three components of research. There's the surgical component, technological component and then there's the patient component. So these were three folds of my everyday job that I look at. How can I improve the surgery of these implants and this also includes osseointegration because essentially it's why we did the surgery. Number two is technology. So technology is extremely important and most of this talk is gonna focus on technological advances in the hearing world. And finally, patient outcomes. This like any other research in medicine, at the end of the day, we wanna improve the quality of life of patients and we ask them for their reports. How do they experience the innovation?

Moving on to our first study. I will wanna introduce to you OpenSound Navigator. OpenSound Navigator is a technological advancement in our sound processor. And this is done, it's basically a modification within the implant. So it's not a modification of surgery and we're not looking at patient improvements, but also just the technology that encompasses the implant. So this study is done on the Ponto 4. As I mentioned earlier, Oticon Medical's bone-anchored hearing implant family are called Pontos. And then basically, I won't go into the details of the engineering and the technical specs of what the OpenSound Navigator is, but essentially what you need to know is that it's a speech enhancement algorithm. It's an algorithm in the processor that helps the patient analyze sound, balance sound and remove noise that is not important to understand the speech. And there's a whole concept that Oticon Medical Works on is more sound to the brain and OpenSound Navigator is really this. It's really giving the patient access to a whole scope of 360 sounds. As you can see here, the father is speaking to the daughter and then there's a dog and a conversation next to them and

there's a man speaking on their phone and there's a bicycle passing by. So OpenSound Navigator really takes into account that in real life sound is not omnidirectional. It doesn't come just from one side, it comes from multiple, multiple sides and it helps the user really filter which sound is important for the tasks that they're carrying. So two studies that we're gonna talk about today. One, as I mentioned, is OpenSound Navigator and two is some clinical data on the Ponto 5 data that we have. So these are the two studies that I'll be presenting. They're both conducted in Europe in our headquarters in Denmark and colleagues in Freiburg, Germany. So let's focus on study number one. The aim of the study is to find out the effect of OpenSound Navigator at a fixed signal-to-noise ratio at +4 dB. The way we did this is we presented hint sentences. You can see next to the little diagram that shows kind of the experimental setup. So the little triangle is the patient's nose. So they're looking at the speech, where the speech is coming from. Usually you turn your head to listen to the person that's speaking to you. So we tried to recreate this and we have four speakers around the participants of the study and they emit noise. So they're called babbler speakers 'cause they create babble sounds. So we had two conditions, OpenSound Navigator on and off. And this might seem a bit too much information for you, but it'll be really simple in this slide.

So here I wanna introduce also pupillometry when we're gonna conduct it in this experiment. So for each trial, the experimental setup goes as follows. There is noise, all right. So here, the four speakers behind the patient create noise. The noise is along the lines of this chh. That's kind of me recreating the noise that the speakers create. So that noise starts and then at 0.0, so three seconds after this noise is heard, a sentence is said. So the participant listens to the sentence while there is noise and then there is a part that is called a retaining window. This is when the patient's brain said all right, I just heard a sound. What was that sound saying? And this retaining window is when you say, "Okay, it was saying that the sky was blue." So I remember that the sound said the sky is blue and then there was a response window. The response window is

basically us asking the participants, "Hey, could you repeat what was just said?" So to repeat this again. We have noise, chh. We have the sentence, the sky is blue with the noise. I can't do both at the same time, but you get the picture and then there's a retaining window. We allow three seconds for the participant to kind of understand what happened. And then, "Hey, could you please repeat the sentence that was said?" And we judge it. We judge whether the sentence is correct or not. But we also judge listening effort via pupillometry. So pupillometry is this here. But let's give the definition. It's the simple measurement of the pupil size and reactivity. And what is listening effort. Listening effort is the deliberate allocation of mental resources to overcome obstacles when carrying out a listening task. Mental resource, that's how I say listening effort. Listening effort is how much brain I give to this task which is listening. And if you combine them both, you get a really, really cool scientific study. Pupillometry has emerged as a useful tool to study listening effort for a while now. It's been a couple of years that we've been using this technique.

Obviously, you need a fancy experimental setup, but you do see that this is more and more becoming common as an indicator of brain resources. So pupillometry is the dilation and the constriction of pupils are usually associated to a couple of things that we already know of. A use of drugs is one of them. Whenever a pupil's dilated, there's often an indicator of drug consumption. But also just interest. When you speak to someone, they often say that when you speak to someone you're extremely interested in or in love with, your pupils dilate. Well, you know I'm not sure if it's actually scientifically proven, but it just shows that pupil dilation means interest. Means I am trying to give you my brain resources. I'm trying to let you know that I'm extremely interested in what you're trying to say. Some of the drugs that people consume, this is what it does. It creates a wow effect. It creates a, I'm interested in what's going on. And then when the pupils are constricted, it's the opposite. It's you're restricting the information that comes in. So you can think of light. When you need more light, when you need more stressors, you dilate. But when you have too much light, you constrict.

This is mainly the fundamentals of pupil dilation and constriction. So let's look at our participants. We did the study in 22 experienced Ponto 4 users. The mean age was 58 and it varied from 21 to 81. Etiology of hearing loss, which means what kind of hearing loss do these patients have? Well 10 had mixed hearing loss. Eight had conductive and four had single-sided deafness. Bone conduction thresholds. It varied about 27.6 dB hearing loss. It went from 11 to 45 dB. So here is, okay, let's go back to our experimental design. You guys remember, let me see if I have it. Ah, there it is. Okay, so we have the baseline. So that chh sound is baseline. We are recording pupil dilation. Please remember that, that there is a camera in front of the eye of the patient. There is sound that comes on, chh. And then as soon as the sentence is said, sentence is said at times zero, there is an increase in listening effort. So there's an increase in pupil dilation. You see that it increases, increases, increases. And as soon as the sentence is said and finished, there is an even higher peak. So the highest peak is not when you're listening, it's when you're retaining.

So let's go back to baseline, chh. The sentence is said, the sky is blue. Increase in pupil dilation. Sentence is finished, even more increase in pupil dilation. This is when the participant is like, "All right, I know what was said." And then the pupil constricts again and it constricts even below the baseline level. So how do we measure listening effort? It's via this. As you can see here, when OpenSound Navigator was on, there was less pupil dilation. So less effort to understand what was said. We're not even looking at whether the patient, the participant, answers correctly. We're just looking at how much effort are they putting to understand this task. So the orange line is an indicator of when OpenSound Navigator was on. Whenever it was off, there's a higher peak. So more listening effort. So 36% reduction in pupil dilation, which essentially translate to 36% of less mental resources I need to allocate to this task, which is understanding a sentence that is said. Let's look at how they actually did. So results in speech understanding. So when OpenSound Navigator was on 70.4% answered correct sentences, 58% answered wrong sentences. So over here, again, I just went

back a slide, whenever OpenSound Navigator was on, people had better responses, had about 21% better scores and this is really interesting. So whenever OpenSound Navigator is on people are answering 70% correctly. However, me as a scientist, I'm interested in that cohort. What about the 30%? What about the rest of the sentences? Why aren't they answered correctly? And how can we look at pupils to see what's going on in the brain of these participants? Cool, right? So I'll go into the details of this. So about that 30% of incorrect sentences. When OpenSound Navigator is on 30% is not answered correctly. So let's look at pupil dilation. So here we have two graphs. We have one for correct sentences and we have one for incorrect sentences. Let's look at the correct sentences here. So let's try to understand this graph together. Again, there's a baseline from zero to zero, from minus one to zero, sorry. Chh, listen, retain. If you see at the graph when OpenSound Navigator is on a lot less resources is required to answer correctly. When OpenSound Navigator is off, you need more resources, more pupil dilation to answer correctly.

Now let's look at the other side, and this is to me the most interesting graph of this study, is when OpenSound Navigator is on there's a huge effort. It's the opposite of correct sentences. When you're answering incorrectly, you're allocating so much more resources to answer incorrectly. So I'd like to focus on the second graph, incorrect sentences when OpenSound Navigator is off. The participant is answering incorrectly. So there's the noise, there's the listening and then there's not much effort after that. This is called the giving up effect. There is a sound, there is a noise, there is a sentence said, but you know what? I'm not gonna understand this sentence. I'm not gonna allocate resources to this sentence because I just cannot understand what is being said. But when OpenSound Navigator is on, there's more pupil dilation. So there's a higher engagement process. And this is extremely important, because even if you answered incorrectly, I'm happy with this study because I saw that you gave a lot more resources. And this is super important when we think of the giving up process. When people are just so tired that they don't wanna engage anymore, they wanna isolate

themselves. They don't wanna allocate mental resources to listening, because it's just too hard for them. And even if you answered incorrectly when OpenSound Navigator was on, OpenSound Navigator this new technological advancement that enhances speech algorithm, you were engaged. You were still wanting to understand what was being said and this is the main difference of what the pupil dilation can tell us. But what whether you answered correct or incorrect, doesn't tell us is this allocation of resources. So this giving up process is extremely important. I'm sure you've seen in your practice that as people grow older and then they don't wanna allocate the mental resources. It's not that they don't want to, it's just very hard for them, so they give up. Take home message. The improvements of the OpenSound Navigator is evident in the pupillometry study but it's obtained in experienced Ponto 4 users. The improvement of OpenSound Navigator in speech understanding was similar across hearing losses. And now I wanna go to the second study, which is a bit different in structure and I'll just go over it quite quickly.

So the second study was done, was a comparative crossover study with a within-subject controlled design. This is a fancy way of saying what the next slide will kind of represent. And we evaluated the performance of the Ponto 5 SuperPower. If you're familiar with bone-anchored hearing implants and you work with Oticon Medical already, you know that there's a Ponto 5 family that is available now. Ponto 5 SuperPower, Ponto 5 Mini are important, important innovations that Oticon Medical came up with. And essentially, our research team kind of gives the science behind it. Why are these improvements good and why shall we sell them? So the main goal of this study was to evaluate speech intelligibility using Ponto 5 SuperPower. The effect of OpenSound Navigator, again, was tested in this study and, finally, we looked at Ponto 5 SuperPower and Ponto 3 SuperPower. How do these two implants compare to one another? So that fancy statement that says comparative crossover study was within subject controlled design, this is it. It's basically the same person that is giving us, they're their own control. So they give us their baseline results and they give us the

control of the study. So again, let me explain this. In the study design, we worked with people who wear Ponto 3 SuperPower, so everyone is experienced. But we have this period that we call trial period. This trial period is when we tell everyone, we normalize them. We call this a washout, washing out. It's a bit of a weird uncommon phrase, but it just really states that we want everyone to be on the same level and, obviously, everyone uses their processors differently. Everyone have their automatics on. Automatics is, basically, adjustment to the participant. So in automatics is OpenSound Navigator. Because OpenSound Navigator is fitted for the participant. So this study is comprised of four visits and in between visits are two weeks. We do the washout period where everyone uses Ponto 5 SuperPower. Whether you use Ponto 3 SuperPower or whatever, if you're in the study you'll get a Ponto 5 SuperPower, let's say, in a baseline model. So no automatics. Everyone has the same device. After that, there was two groups. We separate the study into two people. One of them gets on Ponto 3 SuperPower with automatics and the other one gets Ponto 5 SuperPower with their modifications and then after that they switch. And the reason why we do this washout period is we don't want people using Ponto 3 SuperPower to go into the second group using Ponto 3 SuperPower. So you kind of need to create this baseline for this study. And speech intelligibility was done at visits one, three and four. And this is important for the next parts of the study is we collect questionnaires. We hand out questionnaires, but speech intelligibility is the main outcome of this study. So just to review real quick again how the study worked is baseline is a washout phase, everyone wears Ponto 5 SuperPower without any modifications.

Trial period two, you either wear a Ponto 3 SuperPower with modifications or Ponto 5 SuperPower with modifications and then you switch. You wear the one that you weren't wearing before. And the reason why we did this is because we wanted to know would the Ponto 3 SuperPower wearers be more opted for an upgrade for a Ponto 5 SuperPower? Is the experience good enough for them to want to switch? And this is, basically, how and why we designed the study. And then at the end of the study we

asked them which device do you wanna keep? Do you want the Ponto 5 SuperPower or you want the Ponto 3 that you've already been wearing for X amount of time? This study was done on 12 Ponto 3 SuperPower users. Mean age was 64, ranging from 32 to 80. Hearing loss was seven mixed, two conductive, three single-sided deafness. The mean PTA score was 29.6. And then the randomization sequence, basically, which one do you get before which one? It was seven to five. So this was not done on purpose, it's really the way the study unfolds itself. We have dropouts. We have people that that don't show up, so their data we can't use. But for the people that completed the study, the 12 participants, seven of them did the washout phase, which is Ponto 5 SuperPower without automatics. Then they used Ponto 5 SuperPower modified to them, Ponto 3 SuperPower modified to them. And then five of them did the opposite. After the washout period they used Ponto 3 SuperPower and then Ponto 5 SuperPower. Improved speech intelligibility with OpenSound Navigator. So we're looking at now visits three and four. And why we do this, because this is where speech intelligibility was conducted.

So we look at whether OpenSound Navigator is on or off. So this is off is washout period, on is automatics. It's important to note that. And we see that when OpenSound Navigator is on, like the previous study that looked at listening efforts, we saw that there is more speech recognition. So it's significantly higher, too. When OpenSound Navigator was off, there was less speech recognition, 3.21 dB improvement with OpenSound Navigator, which basically translates to 32% of improvements in speech understanding. Next OpenSound Navigator, improved speech understanding by more than 30%. And the way we did this is, basically, comparing speech intelligibility using the signal-to-noise ratio study that we did. So scientific evidence is great. It tells us a lot. But what's more important to our teams and you is how the patients really react. And these are some of the comments that we got. The study was conducted in Denmark and I'm sure they've spoke in Danish, but this is in English. So they said that, "After being upgraded to Ponto 5 Superpower, I had such a wider soundscape than I

already have." And if you've done this in your clinic, you've had people experience Ponto 5 SuperPower, really the overall feedback has been overwhelming. Almost everyone that that I've seen really, really says that it's more natural. It's less tedious. The sound is cleaner. It's clearer. It's natural. So basically I always put these quotes here, although, scientifically it doesn't mean much. But for us as humans, as health practitioners, it's very, very important. Then we look at improved speech intelligibility between Ponto 5 SuperPower and Ponto 3 SuperPower. So this we go back to visit one and we look at without automatics, Omni setting, when noise reduction is deactivated. So OpenSound Navigator is off. This is when we compare Ponto 5 SuperPower just as a device, without modification. How did it compare to Ponto 3 SuperPower? And the reason why Oticon Medical is interested in this, because if you are fitted with a Ponto 3 SuperPower, you are eligible for an upgrade. You're eligible for a Ponto 5 SuperPower. But we need to prove, scientifically, that this upgrade will benefit you. This is not just an upgrade to sell a new device that's essentially the same. No, there's a lot of modifications that went on and even without the OpenSound Navigator that I've been speaking about all this talk, the Ponto 5 SuperPower is better. The algorithm is better.

The Omni setting, the directional setting, is better. Because as we see here, we have 1.73 dB improvement and this is statistically significant. This translates to about 17% of improvement in speech understanding. Now let's compare when there's an increased gain in Ponto 5 SuperPower due to the improvements of the OpenSound Navigator. So the second graph you see here is when we allow the modifications, is when we compare Ponto 5 SuperPower that is modified to you with Ponto 3 SuperPower. And we see that there is, again, a benefit of using Ponto 5 SuperPower over Ponto 3 SuperPower. This is a bit, it goes into more detail. It used the Software Genie Medical to kind of fit these participants. You know that here you can understand that in the graph where it's highlighted, there's an improvement when OpenSound Navigator is on. And this is really allows for more stable gain and this is really improvement that we have not seen before is that the gain is stable, especially, across

the higher frequencies. So this is very important for speech understanding. It goes into more details of basic audiology and physics. But this really shows us that the gain is stable and it translates to, as we saw in the other test that we did, into a better speech understanding. Now let's compare on and off. Oticon Medical's newest edition the OpenSound Navigator, when it's off speech recognition thresholds how they react and when it's off. So basically we're comparing here visits three and four, but for Ponto 5. So the first group used Ponto 5 with their superpower. So we're comparing their visit one to their visit three. And then for the other group we're comparing visit one to visit four. And we see again, a significantly higher, better speech recognition threshold with the Ponto 5 SuperPower OpenSound Navigator on. And again, when we look at when the Ponto 3 SuperPower, so the OpenSound navigator on and off, basically translates to omni versus full directional.

This was the terminology that was used for the Ponto 3 SuperPower. You see the similar pattern. You can see that the full directionality, like the OpenSound Navigator on has a better effect. But just comparing the two among each other, you see that there's an overall better performance with the Ponto 5 SuperPower, both in omni and with automatics. And this is really the fundamental of this study is we showed that the Ponto 5 SuperPower is perceived better than the Ponto 3 SuperPower. Whether you have modifications or not, it's essentially better in all the directions. So our friend Christian here says that, "There's also been less wind sensitivity and the device is much less sensitive to touch, so you don't get feedback howling sounds," that some patients might complain for, "which was very common with the Ponto 3 SuperPower." But the Ponto 5 doesn't have this anymore. And now Christian can put his hats without any howling noises. He can put his arms behind his head and watch TV without experiencing feedback and this makes his everyday life so much easier for him. As you know and as I mentioned previously, we also handed out questionnaires. So what do these questionnaires tell us? They're called the SSQ12 questionnaires. If you've done clinical research, this is a very commonly used questionnaire for auditory performance.

Sorry about that. And it basically asks how the patient perceives sound in different scenarios. The participants report significantly better performance with the Ponto 5 SuperPower in the questionnaires as well. So we did this questionnaire. The SSQ12 gives us a total score and the total score was better, although not significant, was better for the Ponto 5 SuperPower group. And when we split the questionnaires in speech and spatial and in qualities, we see that overall for each subscale, Ponto 5 Superpower outperforms the Ponto 3 SuperPower, although, still not statistically significant. Now let's look at the specific questionnaire. Let's see how they did in conversation. In the conversational level, in the big group is where we saw the less difference between the Ponto SuperPower and the Ponto 3 SuperPower and this is an indicator for us maybe to better it for the future. In the end of the study we asked the patients, overall what is your preference for the Ponto 5 superpower? And 83.3% said that I have a preference for Ponto 5 SuperPower.

The remaining didn't say that, necessarily, I have a preference for the Ponto 3. They might've said, as well, I just have no preference. So overall we see that the Ponto 5 was perceived better. Some of the participants reported to prefer the Ponto 5 SuperPower based on the overall better sound experience. We heard a lot, we hear better. There was better sound in all situations. Overall better sound quality. And most importantly, one thing that I really enjoy hearing from participants is the sound is more natural. It really feels like it's pure and clear. And this is very rewarding to hear in the scientific setting, of course. There was also a lot of comments on better speech intelligibility in general and looking at the different subclasses, we can understand why this was perceived because of the Ponto 5 SuperPower outperformed or in terms of preference the Ponto 3 SuperPower. So at the end of the study we asked the patients, okay, now that you've completed the study, now that you have experienced with Ponto 5 SuperPower and you have Ponto 3 Superpower experience on the study and also beforehand, because everyone involved in the study were Ponto 3 SuperPower users. So there is that feeling of, I wanna keep the device that I'm more comfortable with

because this is what I've been wearing for the past, I don't know how many months or years. Even with that comfort, 90% chose the Ponto 5 SuperPower over the Ponto 3 SuperPower just in a clinical, laboratory setting. No influence by health professionals. Just a simple, scientifically sound study showed that the Ponto 5 SuperPower was chosen by 90% of the participants. So let's summarize real quick the two studies. I know this was a lot of information. We summarized a lot in this small one hour talk. OpenSound Navigator gives Ponto SuperPower users more than 30% improved speech understanding. This was seen in the pupillometry study. Ponto 5 SuperPower is preferred, sorry, is preferred by 83% of the participants mostly due to an overall better sound experience. This was then seen in the previous study, the crossover study. And Ponto 5 was chosen by more than 90%. So 11 out of 12 chose the Ponto 5 SuperPower. You can ask yourself, what about that one patient? Why was he or she preferring the Ponto 3 SuperPower?

But this is, unfortunately, unanswered. So the conclusion in the clinical standpoint is that speech understanding was better with the OpenSound Navigator. There was an overall reduction in pupil dilation, which meant that listening effort was reduced and 32% improved speech understanding. And, finally, we see that there is better speech understanding with less listening effort. And this is really, really crucial because this is one of the first studies that actually goes beyond what we normally test in an audiological setting. As we actually went and looked at an indicator of the brain, which is pupil dilation. So OpenSound Navigator can significantly increase better speech understanding. And like I had mentioned, previously, the most important part, it was that giving up effect. We saw less giving up effect with our newer technologies and this is really important for isolation, really important for the overall experience of the devices and the rehabilitation of these implants. Significantly reduction of the overall effort process when we listen to noises. So this is our new Ponto family, it's called the Ponto 5 family. If you've seen it in your clinics or if you haven't, please reach out to your Oticon Medical representative and then you can really test these on SoftBand. So we

have five main points that we vouch for. No compromise on sound or power. Ponto 5 Mini actually is extremely, extremely tiny and has really, really great benefits. I'm doing a lot of studies on that now. The feedback is prevented with the OpenSound Optimizer, which is another feature in our device. We have the access to that full 360 soundscape with the OpenSound Navigator, which I presented to you today. We have a lot of connectivity. So direct streaming and smartphone accessories. And then we have patient care from, literally, anywhere because we launched the Remote Care Program. And basically, this kind of summarizes the Ponto 5 family standard that we're launching and we hope that you can gain experience using that.

My name is Aren Bezdjian. It was a pleasure, pleasure giving you this course today. My email is on the screen. Please let me know if you have any questions, any research ideas, anything that has intrigued your curiosity or you have any questions about it after this talk, please feel free to reach out to me and now I can answer questions. So if you have questions, I'll look at the Q and A real quick. I think I'm still confused. Increased dilation indicates increased effort. Effort is greatest when repeating sentences. Yes, the first part. Increased dilation means increased effort. That is correct. When your pupil is more dilated, you're more looking for the correct answer. You're more allocating mental capacity to retain what is being said. Effort is greatest when repeating sentences? No, no effort is greatest when retaining sentences. So as you saw in that graph, we have the baseline, the chh sound and then effort increases, pupil dilates. And as soon as the sentence is finished, then you see the peak. The peak is at the retaining window, repeating is after that. So it goes back down and then we tell them, what did you hear? And this has no pupil dilation. This is basically the same as normal day. So it's extremely effortless repeating a sentence. It's extremely effortful retaining what is just being said. So that's the small discrepancy. I hope I was able to answer that question. Any other questions? Feel free to write in the chat if you have any. I'll give a couple more minutes-

- Yes.

- Yeah.

- [Moderator] Aren, I'll go ahead and send you out some questions here.

- Please do.

- We can add a couple more minutes to our class today. I do have a question. Again, could you repeat during the pupillometry study, when again is dilation the largest?

- So yeah, let me just pull that slide if I may real quick because it's really tough to grasp. But once you do, it's really interesting. So we have it here, actually, we can have it here as well. So this is basically how your pupil dilates. So baseline is zero, that chh sound is there and then there's listening. When you listen to what is being said, your pupils start dilating as you hear the sentence and then the sentence is finished at those little lines there, the vertical lines. And then you have a peak. Right after the sentence is finished, you have the peak and that is when your brain retains the information. That is the most allocated resources that your brain gives and that is the biggest your pupil will get is right after the sentence is done because that's when you capture, all right, I understood what was said and then you see that pupil constrict.

- [Moderator] So that, I guess to add onto to that, that would kind of indicate a very, a significant increase in listening, of course, at that time.

- [Aren] That's correct. Yeah, that's correct. It translates to that. Of course, you know we can do MRI studies and we can really look at the anatomy of the brain and how much resources or where your brain fires, but this is an indicator of what's actually going on in your brain is these pupillometry studies and they're really great because

they're normalized. They always compare to how your pupil was when the noise was just noise and that is why this design is done this way.

- [Moderator] Is there any other research that is out there that would be good for your audience to look into today on this?

- [Aren] Yeah, great question. There is a reference here by McCloy, et al 2017, if you wanna note that down. This kind of summarizes how pupils dilate in different animals and then different noise stressors and different types of sounds. It's really the fundamental of pupillometry for listening. It's quite new. It hasn't been used widely. And the reason why it hasn't been used widely is because the setup is really complicated. As you can imagine, you know in the audiology setting we're used to our chambers, we're used to our way of evaluating sound and listening effort. This is completely new. So the devices are expensive. The setup is really fragile, as you can probably imagine, having the camera right in front of your pupil and your head not moving and then doing the task. There's a lot of controlled environment that is necessary for these studies. That's why it's often done in academic centers or within the industry like it was done for our case.

- [Moderator] With our audience today listening in, do you have any recommendations for our practitioners that could, who would they talk to in their local areas maybe to, I guess, connect with more for their patients? What would be the best for folks moving forward?

- [Aren] Well, you can definitely contact me and I can relay you to the right person but-

- Right

- I know with audiologists a lot of you are interested in research, do sometimes have time for research. It might not be a part of your everyday practice. However, if you do have ideas or if you're interested in certain topics, please feel free to reach out. This is what we do. We go into your centers and if you have an idea, we help you kind of realize it and if it's publishable, it's publishable. If it's presentable, it's presentable. So yeah, feel free to shoot an email if ever you have an idea and I'll gladly chat with you and kind of discuss it more.

- [Moderator] That is wonderful. That's wonderful to hear. Thank you very much. If there are any other questions, please go ahead and send those in now. Again, thank you Aren for joining us today. This was a fantastic class. If anyone has any questions also after this, please don't hesitate, as Aren said, to reach out to him at any time. Contact also people that you know at Oticon Medical as well. I'm sure anybody in that company would be happy to help and point you in the right direction to get you to Aren. All right, thank you very much. I don't think we have any other questions. So with that, we can go ahead and close down today. Thank you very, very much-

- Thank you everyone-

- Have a great rest of your week.

- Thank you for attending. Thank you.

- Thank you.

- [Aren] Take care. Bye-bye everyone.