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Measuring the Effect of a Hearing Aid

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- [Donald] Well everybody, this is Don Schum, Vice President of Audiology at Oticon and I wanna welcome you to this seminar. This seminar is all about measuring the effect of a hearing aid and what I'm gonna be talking about primarily today are behavioral measures. In other words, typically some sort of measure of patient performance, speech and noise performance and other approaches to trying to see what the hearing aid really seems to be doing for the patient. So let's go ahead and dive in. It always starts with the question why and I think one of the important aspects of why this discussion is important is that healthcare professionals only have so much time period. I mean, that's the simple reality is that you don't have the unlimited amount of time to dealing with patients and also one of the things that we know about patients, especially patients with sensorineural hearing loss who get fit with hearing aids is that it's very individualistic how they're going to relate to the benefit provided by hearing aids.

You know, what are they gonna walk away from once they get fit with a hearing aid? And so if you're gonna spend your time assessing what the patient is getting out of the fitting, it should be time that's used well. And there's a lot of different ways that the effect of a hearing aid on a patient's daily life, especially their speech and noise performance can be assessed and it's important that if you're gonna spend the time to do it, that you are spending the time doing it in a way that makes sense for your needs as a clinician and also for the patient's needs. Specifically in terms of learning objectives. I'm going to encourage as always developing a patient-oriented mindset in terms of affecting or to assessing the effect of a new fitting. And I think patient-centered testing, patient-oriented mindset, those terms, can sometimes get overused, they're easy to say. Might not necessarily be all that easy to actually implement in practice and so I'll talk about that issue to some degree. The second thing that I wanna deal with is I wanna talk on both the pluses and minuses of clinically validated standardized speech noise measures. There's several of them out there, they're used a lot in the assessment of benefit for patients. They tell us some very

important things but also there's some things that they don't tell us and I think that's important to just keep that in mind. And the third thing I'll talk about is I'll kind of move more into the area of experimental testing and talk about if how if we use more complex testing paradigms we can learn a lot more about the effects that the hearing aid fitting is having especially at a cognitive level. In other words, how the patient actually understand spoken language and is using cognitive resources to the speech and noise test. Before we get into details, I wanna do a few initial observations and the first initial observation is that I think it's important to keep in mind about whether or not you're doing this assessment for clinical reasons or experimental reasons. Some of the testing measures that I'm gonna talk about especially in the last part of the seminar are gonna be much more related to experimental testing approaches, both that we're using at our company at Oticon plus also that experimental procedures that have been used in other places.

These aren't necessarily things that can be easily implemented at all in typical audiology clinics. And so I do realize that when I get to that area, I'll be talking about some relatively complex testing paradigms that aren't something that you can easily do in your clinic and that's important but my reason for going there is to inspire you a little bit more to think a little bit more about what you are and aren't learning using just more traditional clinical measures. The clinical measures, definitely have some advantages that we'll talk about, but they don't tell us probably everything we'd like to know. I think the big question that you have to ask yourself, anytime you spend your time and the patient's time, is why are you assessing the impact of the hearing aid? In other words, what is it that is driving you to spend your time to do that? And there's a variety of things that can be and I'll give you a list in a second. But I think it's very important that things don't get done just for remote, just sort of reactive, sort of, this is the way we've always done it sort of routine. If you're gonna spend your time it should be being spent for a particular reason. And there's a lot of different reasons, like I said, but I think it's very important to always whenever you do something professionally is to really stop

and assess whether or not this routine that you're using really is telling you something or giving you the sort of information or giving you the sort of documentation that you need for a particular reason. For example, one of the reasons to be assessing the impact of a hearing aid is because for some reason you need to live up to certain institutional or payer client compliance. For example, you'd be working in a very large hospital setting or some other clinical setting where you're required to test in a certain way and if that's the case, then you are you know, and you may not necessarily be the person who gets to decide what testing gets done, maybe you are or a small enough field that usually, you know, we're not so far removed from the people making decisions that you should be able to do that. But it's important that sometimes you just have to do it. And I realized that you have to use a certain standardized method because that's kind of the protocol in that clinic. There's always the opportunity to comment on that, of course, to who's ever making those decisions and to question the decisions if you think there are better ways to do that but I recognize that sometimes you simply have to do that.

Sometimes insurance companies or other third parties who are involved in the financial side of things, either in terms of who's paying for the hearing aids or who's reviewing compliance issues within a network, they require certain documentation and that simply might be all it is. But just because somebody else has said this is the way you assess the effect of a hearing aid, you are still a clinician, you are still the person who's in charge of that patient's treatment. And if that's not telling you really what you need to know then you might need to add things to the assessment. You might not be able to cut out certain things but you might know need to add other things if you're trying to find out what you really want to know. The second reason is that many healthcare professionals wanna have some consistency in the database. In other words, let's say you work in a private practice or stream, a chain of private practices, for example and there's a desire to test all patients or as many patients as possible using the same protocols. So you have some sort of view over your entire database about how things

are going, so that if you have a patient and they're newly fit and you think that they're not doing as well as you think they would you have something to fall back on to justify that impression that you have that the patients aren't doing as well as they are because you say well, I have plenty of patients who have similar audiometric characteristics, their speech and noise testing reveals performance within a certain range and this person's far outside of that range. So it's a good way at least locally or maybe within a small, relatively small sort of connection of offices or clinicians, that there's some consistency across there. It also works well in situations where different clinicians will trade patients. Well, not trade patients but will cover for each other. And so if everyone's using the same sort of testing, then it's easy to trade information about the patient that you may find relevant. The data still should be relevant to your needs but sometimes it's the consistency that's important. So you don't necessarily change your speech and noise tests just because a brand new one came into the marketplace. Unless you wanna change it for all situations or in case you feel like you're very motivated to change the way you go about testing.

A third reason is tracking over time. Obviously, the performance with amplification can either be stable or get worse or get better over time. You know, that's just the nature of the beast that we deal with, which is hearing loss especially sensorineural hearing loss. So one of the things about always doing a hand or always doing a QuickSIN or always doing another speech and noise test under certain conditions every time the patient comes in, it's just a good way of tracking that over time. There's gonna be a certain amount of test-retest reliability within any test that you use but as long as you have a feeling for what that sort of normal test-retest range is over time, then you have the opportunity to track to see whether or not you're seeing any changes that you think that you should be paying attention to over time. Another way, another good reason of using especially more standardized testing is to compare options for the patient. Let's say you believe in your clinical routine that you like to test different products against each other, I'm not necessarily saying that that's a good approach. But let's say you do

decide that you wanna do it that way, well, you wanna use some standardized method to be able to do that so it's not just sort of hit and miss sort of things. Or perhaps you're testing different configurations or different settings in the hearing aid and you're trying to find whether or not you know, one is objectively better than the other. And so that that happens a lot. Just be careful how you use it and if not misuse it. I remember when I was a young audiologist, I was a senior undergrad doing like my first in-house clinical assignment and I had a supervisor in audiology and she was like lousy. Unfortunately, she's no longer in that, she left the field a long time ago. This is back in the time where some patients were really questioning whether or not buying oral hearing aids really mattered. So this audiologist was absolutely bound and determined to prove that two hearing aids were better than one.

So she had me retest the patient under tremendous number of different conditions with one hearing aid versus another hearing aid. And this is back at a time when we weren't doing adaptive speech and noise testing, we were doing wordless testing on our fixed signal to noise ratio conditions and then we would use a Thornton rapid charts to look for clinical differences, statistical differences between two scores. And she made me test that patient about 10 different times until we found one set of scores that were clinically different or statistically different based on a Thornton rapid charts to prove to this patient that they really needed two hearing aids. And even though I was just, you know, a young, naive, audiology student, something's dunk about that, you know, I could, you know, you just know when something doesn't work well and it just really didn't sit well with me that she was misusing the idea of trying to find statistical significance to try to justify the use of two hearing aids versus one because, you know, she felt that that patient really needed it. Now, if you believe that two hearing aids are better than one and nearly every hearing care professional believes that then you make that case to the patient. But you don't do something that's so clearly manipulative in order just to try to find that sort of evidence, so, just be careful with that. That really stuck with me for well, it still sticks with me after 35 years in the field that that wasn't

the way to go about doing your speech and noise tests. Sometimes, it's a go/no-go decision about getting amplification. And I don't necessarily agree with this because you'll find out through the course of this seminar that, you know, I think that there's are significant limitations to audiological based assessments of a patient's benefit from a hearing aid as opposed to the patient's opinion. But there are some clinicians who strongly feel that unless they can prove a benefit using a standardized method that they believe in they're not gonna recommend the fitting to the patient. It's relatively infrequent but it occurs. And to me I have a lot of issues with that but that's just a personal opinion on my part. But sometimes you do have that attitude.

Or sometimes you might work in a situation where some other entity is forcing that go/no-go decision on the process, whether it's a payer or some sort of administrator or something like that. I think there's so many aspects to the benefit that people get from hearing aids that doing it based on a speech and noise measure it really shows kind of a naivety about, you know, the true effect of hearing aids under different conditions. But sometimes that happens and that would have to be the case. In that case, then you wanna make sure that you're using a very stable sort of validated procedure to do that. And finally, then there's probably the reason that most times that happened is that there's this belief that you need some sort of documentation of benefit. And sometimes it's because the hearing care professional, yourself feel some sort of sense of reassurance that, yes, I did a good job because you know, I improved the score by 5dB in noise which is a great thing if you can do that. Or you know, something else where you have the sense that you weren't sure if the patient was gonna get benefit and then you were able to prove to yourself. That doesn't necessarily that you're proving that the patient believes that or maybe you can't see the benefit yourself but the patient feels there's a benefit and we'll have that discussion a little bit later. But sometimes just having that documentation of benefit is reassuring to hearing care professional. Same thing for the patient and many times the family, you know, they just wanna know that you have documentation that just this made some difference

because for example, if you go to a health care provider and let's say your blood pressure is high, they put you on a blood pressure medication. You wanna go back in three months or whatever and then, you know, have them reach out to say, oh yeah, we brought your blood pressure down, you know, or, you know, we brought your cholesterol levels are more in line now because of your blood testing or something like that. So it's pretty standard, of course in the medical field to do some before and after effects just to see whether or not the treatment made any difference. And so that's what people are used to. The problem with sensory neural hearing loss is so varied in terms of the effects it has on patients. And there's so many other factors that affect perception in the idea of somebody doing well with their hearing that it's hard to really make a watertight case to say that a standardized speech noise measure is gonna be the thing that's going to absolutely prove that the patient did or did not get benefit from a hearing aid. But sometimes that's the case.

Probably one of the most important uses of it in my opinion is a counseling input. If you've ever listened to any other seminars that I've done then I'm sure you've listened to everything in the Don Schum portfolio at this point in time in your life, just kidding. But I'm a big believer in the value of counseling around hearing aids. We know that there's so many emotional and psychological things that may hold a person back from doing well with hearing aids or even making the decision to get hearing aids. And so sometimes, you know, having some documented numbers that you can share with the patient is the sort of thing that is necessary to make your case. Now, I gave that example just a little while ago with a supervisor I had who totally missed us the idea of trying to find proof to be able to walk into the sound booth and bludgeoned a patient with the proof to say, oh, I've absolutely proven now that two hearing aids are better than one, that's not what I'm talking about. But if for example, you do a HINT or a QuickSIN and you show that their speech and noise performance is way worse than the typical patient with hearing aids and that can tell you a lot about what the patient should expect in more noisy situations that they just have enough distortional aspect to

their hearing loss that they're going to struggle in noisy environments even with very good hearing aids. Now, the hearing aids might make things better but it doesn't necessarily make things normal. And it's using the data that way to help explain some of the things that the patient might be feeling subjectively. So there's a lot of different reasons to test. All of these are valid reasons for one way or another but I think the most important thing is to make sure that you understand and you have a clear idea in your mind, why you're doing it and what you expect out of it. And it could be multiple things on this list that you use it for. But I think the only thing that that doesn't make sense, is to do it without a reason. Just to do it because you've always done it, that just the routine. If you're not using the data, if it's not telling you something, if it's not telling something that you can share with the patient, if it's not fulfilling a requirement that you have in your institution, then why are you spending the time to do it? You know that always should be the question 'cause time is money and time is a limited resource.

I think most hearing care professionals when they treat patients, they treat them one patient at a time. In other words, that people obviously in our field sincerely want to help this patient within the context of the difficulties that this patient is facing and in the world that this patient lives in. And if that's the case, then there can definitely be a role of speech and noise assessment, for example or subjective assessment of hearing aids or whatever but I think it's important that the hearing care professional has an opinion about what gives good information that you as a clinician can use to help you understand how the patient's doing and help you in your counseling with the patient or your treatment decisions with the patient. And as long as you feel like you have some way of assessing the benefit of the hearing aid that tells you the information that you're looking for or tells you the information that you wanna share with the patient, I think then you're in great shape. And again, I think most times people are being tested and treated one patient at a time. Unless, like I said, you know, from the list previously that you have some, you know, just some compliance things that you just have to live into.

The term patient-centered care is starting to become a throwaway term a little bit in healthcare in general. You drive down the highway, every billboard from a hospital system or healthcare system is about how they care, how they listen and treatment built around you and things like that. And it's such an easy term to say. It's same thing like evidence-based practice, it's a very easy term to throw around, that's not necessarily something that we live into every day. And just because, you know, an institution or a hearing care professional, not just hearing care professional, but a health care professional in general talks about patient-centered care, that doesn't necessarily mean that that's really what's going on there. And I think when you assess the benefit of amplification, I think, you know, if you really say it's patient-centered care then you really need to have an attitude that is really focused on that patient's life, what they are telling you about their struggles, what they are tell you about what's important than whether or not you're living into the reason that they came to see you.

Remember, using amplification is a voluntary decision. And so if an adult patient decides that they're gonna use a hearing aid, they're probably making that decision you would assume because it's doing something good for them. If they decide not to use hearing aids then there's something that's holding them back and it could be the lack of benefit that they're perceiving. And of course, then any sort of assessment that you end up doing about what the hearing aid is doing for the patient has to be related to what they are experiencing as a patient. One of the things that is important is that the patient actually has to use the hearing aid. In other words, you know, the first step of getting benefit from a hearing aid, of course, is that the hearing aid is actually on the head and not stuck in a drawer somewhere, as we say, and that, you know, hearing aids in drawer's still a problem in our field. Or hearing aids being used intermittently or hearing aids being used without passion or perceived benefit is something that continues to hamper us. And you'd be surprised you would think, well, if a person is really not getting a benefit from the hearing aid, then they're not gonna pay for the hearing aid because, you know, the majority of hearing aid still being dispensed in this

country are being paid with some amount of out of pocket expense to patients. Well, you'd be surprised how much people will pay just to get their family members not to bug them anymore about doing something about their hearing loss or other reasons. And so just because they keep the hearing aids and even though if they paid for them and they kept them, that doesn't necessarily mean that they're using them. And so I think one of the first big ways of thinking about the benefit provided by hearing aids is basically as a patient putting them on. And so, you know, what are the things that are required for daily use for hearing aid? Well, one of the things we know is that the patient has to have a perceived need. In other words, they have to believe that they have a true reason why they need amplification. And again, this isn't always the case. It's not enough for the family members, for example, to believe that they have a perceived need or it's not enough for the hearing care professional to test somebody's hearing and say well, according to this chart I have on my piece of paper here it says that you have a hearing loss, that means you can use amplification. They have to believe that's the case.

Our Eriksholm Research Group, if you don't know much about the Oticon company we have a semi freestanding research institute in Denmark outside, you know, separated from our main developmental office called Eriksholm and it's been there for 40 plus years now as a hearing research institute and hearing loss hearing research institute. They did a very good project about a decade ago or so called the Ear Miles Project where they really took a look across all the studies that they could find that talked about the parameters that seemed to predict whether or not a person would get amplification and use amplification and feel benefit from amplification. And the only consistent factor that they could find that would predict those three elements, you know, getting amplification, using amplification and perceiving benefit was a perceived need on the part of the patient, not a perceived need on the part of the family, not a document and hearing loss, not anything like that. The patient had to feel that they needed the help because hearing aid, you know, using hearing aid everyday is a

decision that someone has to use and it's easy to fall away from doing that if you're not receiving any benefit. So that's the idea that going into the process, they really needed a perceived need. They need motivation and confidence. As you know a lot of adults with acquired hearing loss because of stigma issues, denial issues, maybe normalization, passive acceptance, issues of age related hearing body changes, they just don't have the motivation to use hearing aids and sometimes they don't have the confidence that they're gonna do well with them. Sometimes especially younger hearing care professionals might not appreciate how important confidence is but sometimes older adults will start to lose some self-confidence that they're making good decisions about how they're taking care of themselves or whatever.

Maybe that's changing generationally but at least in previous generations that was always concerned about older adults facing hearing care issues or health care issues in general is that sometimes they didn't have the confidence that they could make right decisions about themselves. So they need they need that counseling to really go into it with the right mindset. The amplification has to be functional on a daily basis. If it's not working and they're getting frustrated with it it's gonna be put away. It's got to be easy to use. It's got to be easy to get on and off, it's got to be easy to clean, it's got an easy connection to communication devices, smartphones and other things. Just easy to recharge, if it's rechargeable, easy to change the battery. All those things have to be there because you never know what's gonna stand in the way of a patient from using hearing aid especially if motivation is high as it needs to be or the perceived need is not as high as it needs to be. So these first four things on the list are things that are potential deal breakers in all the cases. But the number one thing in my mind to whether or not someone's gonna make that positive decision every morning to put their amplification in their ears or on their ears, is a perceived value or benefit. That they just feel that this is worth their time, it was worth their money and it's worth the effort that it takes to put their hearing aids on every day. And that's the number one issue. And the question, you know, the way it relates to the topic of this seminar, is

whether or not the testing that you're doing or the assessments that you are doing to try to understand the effect of the hearing aid really relate to what the patient perceives as benefit or value. In other words, if you're doing a HINT or a QuickSIN with a patient and you could say, well, I've improved your signal to noise ratio by you know, 3dB and that's a very good improvement, that's a significant improvement in that. But if the patient doesn't experience that, if that's not meaningful to the patient, if it doesn't have a gut feeling that it's helping out then it doesn't do you any good to report that data if the patient doesn't feel that that data relates to their life. It could be the flip side, you could test and not necessarily see an objectively measured benefit to the hearing aid but the patient might be absolutely convinced that the hearing aid is doing something very important, their hearing aids are doing something very important for that patient. And that's an absolutely legitimate assessment. We don't know enough about how amplification relates to hearing difficulties so that we can absolutely always prove that this test measure is the absolute number one test measure that's gonna tell me everything I need to know. So to me and this is my opinion but this is the most important thing that is going to drive whether or not the hearing aid is being used or the hearing aids are being used on a daily basis.

An interesting observation about baby boomers. This has been an area that I've been a little bit more interested in lately because they're here, they're part of our patient flow as we're seeing them now. As the front edge of the baby boomers are in the early to mid '70s at this point in time. And it relates to just one of the questions I asked myself is, is whether or not this generational change from going from like the World War II Silent Generation patients that audiologists like throughout my career have been... Throughout my career as an audiologist, those have been the patients who typically have been our older patients that we've talked about. But obviously that is changing as time marches on. And now it's the baby boomers are starting to fill up the offices and the clinics. And so is there something about some of the generational differences in baby boomers that is important and something that we should pay attention to? And if

you're interested, I did a whole show on this a little bit earlier this year to talk about some of those effects. But one of the things that came out of the background work I was doing in preparation for this class is the observation that one of the generational differences that seems to be work at work is that baby boomers have a different attitude about their health care providers than previous generations. Again, in general, these are generalizations but you know, sometimes in generalizations there is some truth to these things. And one of the things that they point out is that baby boomers tend to want to be more equal partners with their health care providers. It's not the old days where it was that overly paternalistic, sort of your primary care physician told you what you should be doing and you follow the directions. And in everything, you know, with things like WebMD and the internet in general people are doing much more searching about health issues. And they know much more about their health issues than they ever used to know.

They just don't go into their health care provider and expect to be told everything they need to know and without doing some background research first of all. That happens in a hearing aid field also and baby boomers are just much more like that as a generation. Again, I don't wanna over generalize but that's part of it. And because of that, then if a baby boomer is in there and comes in to see somebody about hearing loss, they're already gonna be prepared with a certain amount of information, maybe miss information but it's information anyway to them, attitudes and things like that. And they don't expect to be told what to do as much as provide recommendations and very importantly justifications and they'll make up their mind. And that is probably you know, in that state to transition generationally. And so as a hearing care professional, I think that's an important part to keep in mind. It's not as paternalistic as it ever used to be. And so if that's the case you need to be prepared to justify whatever recommendations that you make. And the other thing about that is that baby boomers, one of the other observations I read is that they tend to be more holistic about their decisions, about, you know, treatments and whether or not that they're making the

effect. And they'll decide the dimensions that feel are important to them. So if they think user convenience factors are the very most important thing which is not something that I think is a great idea, but you know, of course, hearing aids should be convenient. But that's not the primary reason why people wanted to get hearing aids to start with, they having communication difficulties, that's a different discussion. But the point being is that they will sort of set up dimensions that are important to them. So if you are considering what you're gonna do in terms of assessment of a patient, I think it's very important that you keep in mind that the assessment should relate to what's important to the patient. And anytime you evaluate your clinical routines, I think that's important to keep in mind. Let's talk about technical versus behavioral performance. And basically, we're talking about real ear here. This talk is not about real ear, of course. I mean, that is a verification measure that's important in our field but it doesn't tell you anything about how well the patient's gonna do with the hearing aid, it just gonna make some baseline.

You know, just quantification that the hearing aids is technically performing the way it should do. So what does real-ear tell you? It basically tells you whether or not speech in quiet is audible. And I'll tell you if speech and quiet is audible for whatever number of levels that you test. A lot of people when they do real-ear testing they're only testing at one level typically at moderate input levels because they're trying to match targets, which is fine. It's a very important thing to do to make sure that acoustically the hearing aid's doing what it's supposed to be doing. But it doesn't tell you how the patient's gonna perform with the hearing aid. And it definitely is not gonna tell you how the patient is gonna perform in a noisy situation, it's not gonna tell you how the patient's gonna perform with different talkers, it's not gonna tell you how the patient's gonna perform, how much effort they're gonna put into the task. They're not gonna tell you how much the patient's going to get from a conversation with somebody else. Those are all cognitive based aspects to perception and using amplification in the presence of hearing loss. And so it's important, you know, to keep in mind exactly what real-ear

testing tells you. It tells you whether the speech signal is available to the person at whatever level you test it but it doesn't tell you what the patient's gonna do with that. So patients that can come in to you and say, you know, I think that hearing aid is doing very well because I could tell that my audibility across the spectrum is meeting the targets that, you know, now or whoever else is set up for me, you know, they don't talk that way. They talk about how well they're doing with the hearing aids? What does it allow them to do that they haven't been able to do for a while? What doesn't it allow them to do? Why are they still struggling? Why are they still having difficulties? What's the sound quality like? Is it good enough for them to hear? How do they feel that they really are not working as hard as a listener like they used to be? Whatever, really doesn't tell you any of that. It just tells you whether or not you're meeting a baseline recommendation about how much gain should be applied at different frequency regions for the patient.

So it's important to keep in mind that it's not an outcome measure of the performance of the hearing aid, it's just a technical measure to verify that the hearing aid is doing acoustically what it's supposed to be doing. Let's just keep that in mind and then move on beyond that. So let's talk about traditional speech noise measures that are being used in the clinic these days. Back when I was a young audiologist coming up in the mid '80s we did wordless testing, you know, 50 words at a fixed signal to noise ratio either in quiet or fixing them to noise ratio. And you would check your score differences under different conditions with the thought and graphs and charts to see whether or not you had a statistical difference. What has happened in our field is during the '80s and the '90s we transitioned to more adaptive speech and noise testing. It's important to realize the reason why we did that is that adaptive speech and noise testing, although it's a little trickier to do, it was done basically because of ceiling effects. What we started to notice was that there's enough variability in speech and noise performance across a group of patients with sensorineural hearing loss that always testing at a fixed signal to noise ratio like plus 10dB. For some patients that

could be very, very hard and for some patients, that can be very, very easy. And so if you're running into the either the ceiling or the floor, meaning that you're testing at a level that's either so easy or so hard for a patient, that it really doesn't give you the sort of information you need. So using adaptive speech and noise testing allowed you to be testing at a signal to noise ratio that made sense for that patient. And then we start reporting it in terms of signal to noise ratio. So it used to be like a 15% difference in speech percent, you know, percent correct, you know, that would reflect by, let's say, a dB and a half signal to noise ratio improvement or something like that. So, we transitioned for a very practical reason. And then most of the tests that you see when somebody develops a new test, it's usually done as an adaptive speech-in-noise testing for very practical reasons. There's some very important positives to standardize speech and noise testing. They're reliable and standardized. In other words that you know that that you're using material that has gone through the appropriate statistical experimental development so that you have multiple lists available.

That you know, a signal to noise ratio score is going to be within a reasonable amount of test-retest reliability, that confidence interval is going to be pretty tight. That allows you to compare different conditions against each other, it allows you to compare different patients against each other, different products against each other because there's some standardization applied. So that's a very, very important part of why you might wanna use these. They're readily available. Obviously, you have several choices. QuickSIN and HINT were some of the first two that came in, that were commercially available. But that decision, noise testing has started probably a decade earlier than that. At UCLA Med Center for example, they were doing a lot of that back back in the day before these became kind of more standardized procedures. And there's been more that have come online since HINT and QuickSIN. But HINT and QuickSIN they came on board during the '90s, were probably the two most popular and they probably continue to be some of the most popular ones in the marketplace. They're relatively time efficient. One of the nice things about doing adaptive speech noise testing is that

if the patient is relatively consistent in their responses, then you can zero in on the signal to noise ratio pretty quickly. And the same thing like if you're doing an SRT, right? There's some patients where you're kind of all over the map when you're trying to get an SRT done. But if other patients are pretty consistent about what they're doing or even pure tone threshold testing, then you can kind of lock in pretty quickly. So there can be some time efficiencies with signal to noise ratio testing. It matches the typical equipment setup in most booths. So for example, if you have, it depends on where you put your speakers. So you almost always need two speakers to do this. If you only have one speaker, then it's only gonna tell you certain things. If you have two speakers, then you have the opportunity to test directional effects and things like that. Sometimes it matters whether or not you're at a zero 90 setup versus a zero 45 setup that can only tell you certain things. I know some booths are set up for zero 45 in order to test children, you know, to do core and things like that with children. And so kind of depends on how things are set up.

But typically, if you have two speakers and typical stereo setup on your equipment, then these tests have been set up to be able to be used within the typical clinical setup. You don't need like a ring of eight speakers or something like that in order to do something then you're moving away from the clinical testing to more of an experimental testing. So these match typical clinical setups pretty well. They're relatively simple to perform for both the hearing care professional and the patient. Definitely by the patient, you know, they just have to listen to noise and try their best and repeat back the words or sentences as best they can. For the hearing care professional, like I said, when we first started doing this sort of testing, it was a little bit more complicated 'cause you're working multiple dials and you know, it was a sort of thing that you had to learn to get good at in order to do that. They'd become a little bit more automated or a little bit more simplified and streamlined these days, they're relatively easy to do, you know, most people have no problems doing it. And very importantly, there's useful spread in the results. Meaning that, you know, usually if you

do let's say, you you test 30 people using the HINT or the QuickSIN, you're going to get and then you test, you know, 20 people with normal hearing. The group of patients with normal hearing are gonna have a very tightly controlled group of data typically within, you know, maybe plus, maybe within about a 5dB range. You're gonna see everybody's scores about at the same level. And then you take a look at the group of patients with hearing impairment and you're gonna have some who are down there performing about equal to normal hearing but then you're gonna see a big range going up in terms of needing better signal to noise ratios across a group of hearing impaired individuals. And that tells you something very important. You're able then to relate this person's performance to a more typical hearing impaired individuals performance or definitely related to the patients with sensory hearing loss are doing better than most. And so you can kind of use that as a judge, either from your perspective to kind of size this patient up to see how well they're doing or definitely from the counseling perspective. So it tells you something useful because of the tests.

There's few observations though that I think you should keep in mind about standardized speech and noise testing. First of all, it's primarily testing peripheral integrity. And that is either a good thing or a bad thing or a neutral thing. But what I mean by that is, of course, speech understanding is still cognitive. You don't understand words or sentences in noise in your peripheral auditory system. That doesn't happen in the cochlea, that's happens in the brain. So, you know, it's not to say it's a peripheral test but these tests are pretty simple in terms of the task demands that it puts on the patient. So that when you use you do a HINT or a QuickSIN or a similar test like that you're basically testing how well the peripheral auditory system can handle background competition. You know, basically, you're looking at frequency resolution and temporal resolution issues going on in that patient. And as we know, there can be a lot of variability from patient to patient on that. These are typically better referred to as speech recognition testing and not spoken language understanding. Spoken language understanding is what you're doing right now when you're listening

to me because you're doing more than just hearing and identifying individual words, you're trying to get meaning out of what I'm saying. You wanna be sitting for an hour while you're doing it 'cause you want to get to see your credit, I get that. But you're trying to get some information out of this, you know, you're reacting to it. You're seeing whether or not you agree or disagree with me, you're trying to figure out if I know what I'm talking about or not or if what I say resonates with you or if it really sort of kind of runs contrary to the way you think about things. Whatever, you're doing all that while you're listening to me and if you're on a lockdown still and you're also trying to do it while you're making a peanut butter and jelly sandwich for your kids or whatever, but it is the sort of cognitive based thing that we do when we listen to somebody else talk. Speech and noise testing in a sound booth under very controlled conditions doesn't tap into all that aspect of spoken language understanding.

So it's really a speech recognition test to really kind of pretty much tell you how good the peripheral auditory system can handle noise. It's a simple tasks, simple constructions, you know, they're just either words or simple sentences you know, that are very predictable in terms of the structure of the sentences and things like that. And very importantly, there are no time demands. If someone's doing a speech and noise test. Of course, you can't leave them unlimited time before they answer the question but it's not under the same time constraints as conversational speeches. I'm talking at a rate right now which I'm a conversational rate a little bit faster, that's kind of the way I present especially in these seminars. And so because of that you have to keep up if you're gonna do something with what I'm saying. If you're going to interpret what I'm saying, either agree or disagree, find information. Remember, whatever it is that you're doing with your cognitive system and you're listening to me, you have to do that quickly because I'm continuing to talk, I'm not waiting for you to say, aha, aha, aha, I'm just talking at the pace that I think is appropriate and you're trying to keep up with me. When you do speech and noise testing under standardized conditions, those sort of time demands don't really come into play. The sound environments that we use are

pretty artificial. Just because you're doing a speech and noise test under clinical conditions that doesn't mean you're testing the person's ability to understand spoken language in realistic situations that they find themselves in every day. We just simply do not replicate that when we do clinical testing and I think that's one of the most important things to keep in mind. The location of the sound sources is very, very standardized, front back or front side sort of testing because of where your speakers are at, it doesn't really give you much information beyond that. There's basically very low reverberation under most conditions where we test which is usually within a sound booth or in a room that's very, very quiet and well treated acoustically. The competition is very stable and very predictable if speech-shaped noise or a clinical babble, which remember clinical babble doesn't give you any linguistic information but a clinical babble tape has been produced properly. You really don't even understand individual words out of that, you just know that there are multiple people all speaking at absolutely the same level and you really get no or very little linguistic information out of it, you just know that it's speech like.

That's very different than that trying to have a conversation with one person at a restaurant when there's a loud talker at the next table going on and on and on. That's a very different situation, that's not the same as listen to speech in babble. And so the way we manage the competition is pretty artificial at something like that. The type of competition is usually just one, it's usually speech-shaped noise or white noise or clinical babble and that's all it is. It doesn't test you on a variety of different conditions and things like that. Usually, there's only one talker that you're listening to under this test material. And the sound of the talkers is pretty standardized and it's pretty predictable from sentence to sentence. The length of the sentences or the length of the words are usually always the same, always the same talker and so you don't get that variability of what it's like to actually listen in the real world, so in order to be standard and reliable and give you stable results you have to control all these factors. So from an experimental or from a statistical and repeatability reason, we have to do all these

things with speech and noise. But it's just important to keep in mind that this isn't necessarily real world conditions that you're talking about. And then the question comes, is this truly patient-centered? You know, in other words, are you really trying to assess how well these hearing aids are doing under the world that the patient lives in? Or are you testing the performance of the hearing aid under the world that you set up in your sound booth? And if you're testing the patient under the conditions that you set up in your sound booth then you could start questioning whether or not that's really, truly patient-centered. And that's what I mean by this is that, that this is your primary way of assessing the benefit of a hearing aid, then you have to really question if this really meets the standards of patient-centered care. So let's turn this to subjective approaches. Basically asking the patient, how do they sound? How are things going for you? You know, that's the way that get it. I remember when I was a young audiologist, we would kind of snicker at this as a way of testing hearing aids.

You know, we would say, oh, well, that's not you know, that doesn't meet certain qualities of the way I wanna test things. But as I've gotten older and hopefully gotten a little wiser in my years, who knows? That's debatable but that's really what it's all about, right? The patient has to be the one who decide to get hearing aids, the patient is the one who has to decide to keep hearing aids, the patient is the one who has to decide to wear hearing aids on a daily basis and the patient is gonna be the one to decide whether or not it's helping them out. So for them to tell you it's working well or not working well or working well here but not working well there, that's exactly what you wanna know. If you're truly patient-centered about your care, that's what you wanna know. Are the hearing aids helping you for the sort of situations where you were seeking help? And to me that's exactly the question you want answered. You know, that's exactly what we're after. And just because it's not easy to test it and standardize it and things like that, that doesn't mean it's not the right question. It's just a matter of recognizing that you're testing one patient at a time or you're assessing one patient at a time and it's got to meet these qualifications. Now, as you go throughout this field,

especially if you're a younger audience or younger hearing care professional, as you go throughout this field you'll get better about interpreting the answer to this question, knowing the right time to ask the question, knowing the right follow up questions to ask, knowing how to interpret what the patient's saying. Are they telling you things because they're still fighting the idea of wearing hearing aids? Or they are telling you things that you truly can believe in are good are good ways of answering the question. But that's something that you only learn through experience. When you ask these questions though it's important to understand when a patient can give you good information. I think that's one of the things that really is important to know is that you can't just ask a person, how's it going with you if they're really not ready to answer that question legitimately. For example, if you put a set of hearing aids on a patient sitting across from you in your desk, in your office, you put it on and then the first thing you say is well, can you understand my voice better? It's kind of like give them a break.

They've gone for X number of years without doing something about the hearing loss. They finally get hearing aids on and then five seconds after they get hearing aids on you're trying to get them to tell you how the world of sound now sounds to them. Why does this sound shocking to them? And so I think it's important to always keep that in mind about when you ask these questions. To me this is the time course of useful feedback with first time users. In other words, you have to know what questions that the patient can legitimately answer when. So things like loudness and discomfort hopefully they can answer immediately. Not that things are louder than normal, of course are gonna be louder than normal but you put a hearing aid on them and you're amplifying things but whether or not they are uncomfortable for the patient, because when they first get fit, you want them to walk out and where the hearing aids and not take them off immediately. And so it becomes very important. A colleague of mine, Randy Yogesh and I did a study several years ago where we tried to find out, you know, when people reject hearing aids, how quickly they make the decision. And we were shocked to find out that nearly half the patients were making that decision within

the first week or so, where it was like, no, I'm not gonna keep this much quicker than we would have ever guessed. It was kind of testing the 30 day trial sort of model and it became very clear that patients can reject things very quickly and there's a lot of reasons why they would, it could be attitude and motivation and things like that. But it's got to not hurt, you know and that's gonna be the very first thing that gets assessed. Sound quality, I think sound quality is something that's very dangerous to test when they first put the hearing aids on, because of course, it's gonna sound different. And many veteran hearing care professionals will tell you how patients will try to fine tune their hearing aids when they first get fit back to their hearing loss. In other words, meaning that they want it to sound like what they've been used to for the last five, 10 years, however long they've been delaying getting hearing aids or developing the hearing loss. And so sound quality is something that you have to give the patient at least several days to kind of adjust to things before you start making adjustments to sound quality because the high frequencies typically are just gonna be sharper and more apparent than they were before and that can be both a good thing but then a bad thing if it causes rejection.

So you have to understand when you can really start making those adjustments and adaptation management in hearing aids has gone a long way to solve that problem. And then it serves almost universally use now with first time users. But that's part of the idea of trying to get that under control. And then performance and quiet and noise or performance in realistic situations, that's probably the third thing that you can adjust. You don't have to wait forever to do it. We used to think that he had to wait 30 days before the hearing aid effect is gonna stabilize, that's not true. The data that we've been seeing is that that happens pretty quickly but it has to happen once the patient is kind of adjusted to things like loudness and discomfort issues and sound quality issues before you can start assessing that because it could be for sound quality, they turn up or turn down the high frequencies or the low frequencies or something else and so you don't want to be testing the objective performance with the

hearing aids until you're sure that the patient is satisfied in the fitting is relatively stable. So I think there is a time course to the way you wanna make these kind of unstructured subjective assessments. Then you can go into questionnaires and you have the alphabet soup of questionnaires. I put on some of them that I could remember on the screen. The point being that there was a time during the '80s and into the '90s, where this was the rage, this is all the rage, it was developing the next new questionnaire. And so you do a questionnaire that would test the patient under five to six different conditions on how's the hearing aid performing or how much trouble did you have hearing and things like that and it was sort of starting to little bit to get out of control. In other words, the people who develop it would come up with a different reason to do a test, kind of approach the situation from a different angle. And these are very good in terms of some of the reasons why I talked about even with the speech and noise testing, why you wanna do it in terms of standardization and comparison and testing over time and things like that.

But one of the observations that was being made was that you're asking about a lot of situations where the patient might not find themselves in or might not be relevant to the patient. And so one of the very important things that happened in the mid 1990s was the development of the COSI. And Harvey Dylan and his colleagues who came up with the COSI should have won a Nobel Prize in audiology for this one. Because this was probably one of the most thought through ideas to really, you know, really question the way we were doing things and say, wait a second, if we really wanna know whether or not the hearing aids helping patients for what the patients came in to talk to us about then we should be focusing our rehabilitative efforts on what the patient thinks is important. And so the COSI being a blank slate where the patient basically tells you these are the situations I struggle in or these are the situations where I need to help. They put that down, you put that into the COSI and then you structure, you rehab around that. Sometimes it's not gonna affect one bit, the sort of testing that or that sort of fitting you do for the patient, you're pretty much doing the same thing but

sometimes it makes a difference. And the COSI turned out to be I just think a watershed moment in our field to really give us something that was kind of a different approach than we were using before. So that's kind of a review of kind of the standardized things that are out there for clinicians these days and I've thrown a lot of opinions around about the way I think you could do it. What I wanna turn out to then is to start talking about deeper levels assessment. Because one of the things I think is very important to keep in mind is that you really don't kind of really get into the day-to-day effects that are going on with a patient by using overly standardized approaches. That tells you some information, of course, but it really doesn't get into to what the patient is really dealing with. And it goes back to something I talked about earlier about the observations about standardized speech and noise testing is that it really is not getting at spoken language understanding, it's getting at much more simple, more peripherally, relevant sort of observations which are good observations, it's good information to understand the effect of the peripheral hearing loss on the basic ability to identify individual words or words and sentences but it really doesn't tap into what the cognitive system does with speech information.

And there's some things that we know that the brain does very well. The brain does things like recognize individual voices, it tracks speech over time, it predicts and fills in, it can shift focus from one talker to another thing, these are all things that the brain does really well for us in complex listening environments when you have normal hearing and it's one of the things that starts to break down when you start struggling in noisy environments. But if you wanna know how these things are going for an individual patient, you need to test in different ways than we've done in the past. One of the things we know is that when you talk about spoken language understanding that the person uses a lot of different information. They use acoustic information, of course, coming out from the periphery but they also use a lot of stored linguistic or situational or knowledge information within their cortex to be able to really fill in what's being spoken. And if you really wanna know how efficient, how effective people are at doing

these sorts of things, you need to test in different ways than we typically do in clinical speech and noise testing. One of the reasons why this is so important is that for example, older individuals who are going through normal changes within their cognitive system might not be able to use stored information as effectively as they once did. And so those are some of the reasons why this becomes very relevant. One of the things to remember is speech understanding and effort. Speech understanding in the gray is kind of like the typical growth and performance of speech and noise testing across signal to noise ratio. That at one point, you're getting nothing and then you start getting more and more and at one point you're up to your maximum speech and noise score. Effort is something different because effort is the amount of effort a person has to put into the task to get that. And what I'm trying to point out with this graph is that even a normal hearing, you can be at a point and now efforts going from high effort to low effort, so it's kind of reversed function here.

So there's a point when the signal to noise ratio is very good when you're understanding all the words and you're not putting very much effort into it at all, it becomes very, very automatic. But there is a range at which you might be topping out in terms of your speech and noise performance but that doesn't mean it's effortless. You still arrange in which you are putting in some amount of effort to get to that score. And I think that's important, that's one of those aspects of understanding exactly what the effect of hearing loss is and this is even the relationship of just when you talk about normal hearing, that just because you're getting all the words, that doesn't mean you're not working to get those words. With sensorineural hearing loss, the effect is probably even bigger. And for some patients, they're always working hard at the task or harder than than automatic, even when their speech and noise score might be at a very high level, 100% correct but they still are working hard to get to that level. Some might start getting to the point where it's absolutely effortless but other people just because of the nature of their hearing loss still have to put in more effort than normal in order to get to that point. So, effort is not a direct reflection of your word recognition

score. Effort is something that you may need to put into the task more even if you're getting all the words. And sometimes you don't see those effects until you start testing using more complex paradigms. It all relates back to the basic observation that we only have a certain amount of cognitive resources that we have available to us and because of that, you have to use a cognitive resources to do a variety of different tasks at any moment in time. So as you're listening to me you're using a certain amount of cognitive effort to just identify the words that I'm saying. And again, I'm talking at a relatively fast pace and so you need to kind of keep up with that. But you also need cognitive resources to do something with the information that I'm presenting. In other words, if you're really getting any value out of this, you're remembering it, you're reflecting on it, you're deciding whether you agree or disagree, maybe you're learning something new, you're developing a different perception, whatever it is, you're doing something with it but you're using the same pool of cognitive resources to do that.

The more cognitive resources you have to put into just basically decoding the words, the less you have available to do something with that information. And so you're not processing it as deeply if you're using a lot of effort simply to decode the words that I'm saying. The question is what gets sacrificed and you can't do anything with information you don't understand. So at baseline, you have to understand the words that I'm saying. But once you understand the words I'm saying, how many resources you have available to do anything with it? Just basically remember what I said, let alone incorporated into your thinking as a clinician or whatever it is that you're going to do and then that's what we're very interested in at Oticon specifically in terms of what gets sacrificed in the process. It also relates to an observation I made earlier is that, you know, if you want to measure cognitive efforts, you need to put the system under stress. And using typical speech and noise testing, we don't really put the system even under time stress, let alone a depth of processing stress. And so if you're going to measure cognitive effort, you really need to kind of push the envelope to sort of replicate what it's like to understand in more complex situations that have just

identifying individual words or individual words and sentences without any real depth of the processing being necessary for a test like that. If you're going to measure effort there's a couple things to remember. You can measure listening effort in terms of either an immediate or long-term measure. In other words, how much effort are you putting in when you listen to individual sentence? Ways of testing it that way versus long-term like how fatigued you are at the end of the day, that sort of thing. So there's different ways you can approach it. The other thing to remember is that listening effort is a little bit of a misnomer because effort is under the control of the listener. It probably should be better talked about in terms of processing demands to do a task because effort is how much effort you put in as a listener to meet the requirements of the task. And so it's not just how hard the task is, is how willing you are to meet those demands. And so we always throw around the term listening effort as if it is some sort of fixed element of the task and it's really not a fixed element of the task, it's related to how much effort the person wants to put in to meet the demands of the task.

So it's just a little bit of a wordplay but I think it's important to remember that that is something that we have to tease out is whether or not the person is actually putting in 100% effort. So if you want to measure processing demands, so I'm using that in terms of kind of substitute for listening effort. You can do it from different ways. You do it using ratings, patient rate, you know, kind of long term, how hard is it? You know, how much effort do you think you have to put in throughout the course of the day to listen or how much effort do you have to put under this condition? You could play sounds to them and have them say, oh, this one is over eight, this one is eight out of 10 in terms of how much effort I have to put in sort of thing. So you can the ratings and there's different rating scales that are available to do something like that at least experimentally. You can make physiological measures. There's a variety of different ways that that has been done. Even doing things like cortisol levels in saliva, that's been noted as a way of measuring kind of long-term effort or fatigue throughout the course of a longer period of time, like throughout the course of a day. You can

measure those things. We've been very interested in a few different other ways of measuring effort physiologically that we'll talk about in a few moments. You do things like reaction time, how long does it take for a person to give a response on a test? That's usually a sign that whether or not they're having to do extra sort of cognitive churn to even identify the words or not, that's the way you do it. One of the ways you also do it is dual task or multiple task testing where not only is the person trying to identify individual words or individual words and sentences but they're also having to do other things at the same time. And the whole idea is with dual task is if the primary task that the patient is to recognize the words, you give them a second or a third task that they also have to do at the same time. And normally what ends up happening if you try to hold their performance at a fixed level on the primary tasks then you'll see variability in terms of how well they can do the secondary task. And the amount that you get a fall off on the secondary task is usually an indication of how hard they have to work at the primary test. So that's been used in a variety of different ways, dual task testing as a way of really tracking what are the processing demands of the primary task.

It's a very interesting study that was done by Andrew Pittman and her colleagues about five, six years ago out at Arizona State University. And so they were testing an adaptive compression concept we have in our hearing aids called Speech Guard that we've had around now for a good 10 plus years and our hearing aids that is a very specific way that we go about doing nonlinear processing that's designed to keep more information in the speech signal. And we were having trouble finding a way to really show the effect and she was using a very nice, complex testing parameters in order to do that sort of multiple task testing and it gave us some very good information. So the the basic job of the person was to hear a word and categorize that word as either a person or food or an animal. And right before the sound, the word occurred, they would get some sort of extraneous sound, just kind of throw them off a little bit. In this case, sometimes they were overlapped with the word they were listening to,

sometimes they were separated in time a little bit. But again, it was a way of kind of creating some cognitive distraction in the ear. There was background noise going on, it was noise from a playground because this testing routine was used for both children and adults and so they had to be relevant to the children. They also had to do a visual match test. So if you notice down in the bottom, the squares and the stars and circles, they basically had to follow that sequence across and circle the next item that would occur in that sequence. So in the first one, we see square, star and circle, square, star and circle then you would see the last two are square star and so you'll be circling the circle 'cause that's the next one that would come up. So they're trying to fill up the person's card resources by doing a visual match test at the same time. And one of the things that she found was comparing our adaptive procedure to both traditional slow versus fast compression systems is when she tested under these very complex situations, especially when there was overlap between the competition sound and the word that they had to categorize that you saw some real benefit of the adaptive approach that we're using under those conditions.

But it was only when she sort of loaded up their cognitive system to do that but it's just a really good example how you can really if you need to can load up the cognition to really tease out what you need to about what's going on in the person's perception. A couple other ways that we've done it, we've also test it using pupillometry which is another physiological measure. Pupillometry has been shown to be a good way of measuring cognitive effort that when a person puts more effort into a task, that their pupils dilate to a certain degree. And that you can measure that across a group of patients. It's hard to measure on individual patients and get stable results but you can measure it across a group of patients in a experimental setup. And one of the things that we noticed is that that relates very interestingly to the way we perceive speech. So here in this situation what you notice is OSN on and off is the speech and noise routine that we have in our advanced products OpenSound Navigator. And what you notice is across signal to noise ratios, OpenSound Navigator when activated improves signal to

noise ratio performance by about five to 7dB depending on what level on the input output function that you're testing. But the point being that it is an effective speech and noise test or speech noise circuit. We also under the same conditions measured pupillometry and pupillometer like I said, your pupils will change in size over time depending on how much effort you're putting into the cognitive tasks. And the pupils get bigger when you're at a point where you're really doing the most effort in terms of the presentation which is a couple seconds into the presentation. And this is what the data looks like. With OpenSound Navigator off, if you follow along here is the species noise performance for the patient going up there. And when you notice when you turn on OpenSound Navigator the pupil dilation gets very high at about this point where you're starting to get some information that you can start to put together the message but you have to work really hard at it. And then you see that the pupils are at peak dilation. You also see a kind of fall off here when the signal to noise ratio is very poor because a person just basically gives up trying. And like I said, effort is under the control of the listener. So here's a good example of where that's the case. When we turn OpenSound Navigator on what you notice is that not only was the overall effort lower as reflected by pupillometry but the give up point moved farther into the negative signal to noise ratio area. Meaning that because we improve the signal to noise ratio by using OpenSound Navigator then the person was willing to put effort into the task under poor listening conditions 'cause they're still getting good benefit out of putting that effort in. So again it was using pupillometry this way gave us a nice different way of seeing the way people use their cognitive resources.

Again, it is from experimental purpose, it really allows us to understand better how the brain processes information on a complex listening environments. Another way that we've been using recently another approach is using the EEG as a measure of the ability to perform selective attention. One of the things that we know, as humans we naturally attend to more than one set of stimuli in our environment if we feel that it's relevant. For example, we don't totally get into tunnel vision or tunnel hearing except

under very extreme situations. And most of the time when we're going throughout the course of our normal life, we will attend to multiple sources of information but will change how much attention we apply to one source of information versus another and we want to see how hearing aids can affect that. And so basically, what we did was we had the listener listening to two different voices, two different people talking at the same time and they're told whether or not they should be listening to the male or the female or the male talker. And also, there's a background of multiple talkers also going on at the same time. The way we do the EEG is a very, very precise sort of correlational analysis about the details of the EEG waveform compared to the details of the speech waveform. And if you do some very precise correlational measures, you could see what part of the EEG was related to what part of the input auditory stimulus and how well they are correlated. And so that really gives you an indication physiologically of what the brain is paying attention to. And like I said, this idea of paying attention to more than one thing at a time is what normal conversation is typically like.

We normally will allow ourselves to monitor more than one thing in the environment will modulate how much we attend. We listen to one thing versus another but we will kind of keep multiple things sort of aware in our consciousness. And so if you think of some kind of typical sort of environments that we used to be allowed to go into and hopefully we're starting to go a lot into these days, we should update this picture to put masks on everybody at this point in time, I guess. But the idea being that in an environment like this, that person, let's say the person with a hearing loss is that woman in the tan blouse, kind of in the left center, in a situation like that there's multiple sources of sound that are probably relevant and interesting to her, some more than others and that she can decide if she wants to pay attention to individual talkers but also sort of kind of sort of be enjoying the music in the background or noticing other things that are going on in the environment is the way we normally work. And what we're able to see in this work was that yes, indeed that if you did the correlational analysis of the EEG what we notice is that the basic hearing aid effect was at the drop the noise compared

to the two talkers which means that OpenSound Navigator was doing what it was supposed to do. But we're also able to see that the individual could decide if they're gonna listen to one talker more than the other. That under conditions when the person was told to pay attention to the female talker that the correlation to the female speech was higher, there's still some correlation to the male talker but it was higher to the female talker or vice versa when they were told to pay attention to the male talker, that correlation got very strong to the male talker and weaker to the female talker. But the background noise babble is put even farther into the background, you know based on the EEG. So is a very interesting set of work that we've started, we're continuing to do at Oticon to really show you that you can start to take a look at the way hearing aids work in very different ways. Just a few procedural issues to wrap up this conversation. If you're going to test hearing aids under different conditions, whether it's traditional testing or more advanced testing, you need to know your device, you need to know how the automatic systems work in the device so that you are testing it under situations that really makes sense for the automatic systems.

For example, activation levels are very important thing. I've seen people test speech and noise that like 60, 65dB and not see any effect of from adaptive noise reduction or adaptive directionality which makes sense because oftentimes those systems are set up so they don't start activating until 70, 75, sometimes even 80 dB SPL. So if you're testing under conditions that are much lower than these systems are designed to activate then of course you're not gonna see the effect in those situations. So you have to understand the activation levels of these products and talk to your sales reps 'cause they should be able to tell you where it is. You need to decide if you wanna test under automatic or fixed conditions. In other words, if you wanna see the effect of directionality and it is adaptive and you're not sure of the level, sometimes you could just set the hearing aid in a fixed mode so that you're sure that it's in a directional mode and then you can see the core effect of the directionality. That doesn't tell you how it's going to work in the real world environment but at least it can tell you whether

or not the directionality is doing something for the patient if it's active. Speaker position, I talked about that early, it's kind of in relation to the question you asked, for example, if you wanna see the effect of directionality, you have to get the speakers apart from each other and zero 45 for most situations is not gonna be good enough, zero 90 might be more important. However, if you wanna test the effect of the noise reduction, separate from the directionality then you probably need to put the speech in noise coming from the same speaker because then it's not directionality that's solving the problem but then it's noise reduction. So again, you have to think through what you're trying to test and decide whether or not your clinical setup is set up to do that. So it's really to ask the question about what you wanna test and understand how your device works. So the final thought is basically, again, it gets back to this question I started at the beginning. Why are you assessing? Why you're spending your time and the patient's time doing this? And make sure that that is clear in your mind. And I went through that whole list at the beginning of the reasons why you might wanna do it.

But once you set up that reason that you might wanna do it then that'll give you guidance about what sort of testing you wanna do, whether it's objective or subjective, how you're gonna use it in your counseling? How are you gonna do record keeping on and all those sorts of things that you might feel important. And it could be obviously, you can do multiple different things to meet multiple purposes. But it's just very important that you have a clear idea in your mind about why you're doing it. Some of these more advanced deeper level testing that are not really ready for primetime yet, in terms of clinical testing, you know, that's the sort of thing that as we move forward in our field you may very well see that type of approach, those sorts of approaches become more clinically realistic. Like I said, adapt the speech and noise testing, when it was first out there for about 10 years it was just for only for an experimental reasons because it was tricky equipment, device to get it set up. Nowadays it's pretty routine but it took a while to become clinical routine. So anyway, hopefully you found a few good ideas out of this discussion of measuring the effect of a hearing aid. If you ever

have any questions or comments, you can always feel free to contact me via email, my email's on the screen. With that I wanna thank you for the time and hope you have a very good day.