Clinically-Relevant Hearing Aid Research, in partnership with Vanderbilt University

Presenters: Erin Margaret Picou, AuD, PhD, CCC-A, Todd Ricketts, PhD

Erin. It's my pleasure to welcome back Dr. Erin Picou and Dr. Todd Ricketts. This course is part of our annual partnership with Vanderbilt University.

If you haven't had a chance to check out some of the other partnership courses that are available in our library on demand, if you'd like to learn more about Dr. Paku or Dr. Ricketts, you can read their bio on the course registration page. But at this time, I'll hand the mic over to you, Dr. Ricketts.

Thanks so much, Christy, and welcome everyone. Here are disclosures, here are the limitations and risk, and here are our learning outcomes.

What we are trying to do today, as we typically do in these sessions, is look at some of the recent research over the last year and try to identify studies that we hope are relevant to clinical practice, particularly hearing aid research in adults. We do sometimes poke into younger kids as well, but I think that most of our focus is typically on adults. Today we've got studies looking at bilateral beamforming, relayer measurements, feature selection questionnaires, experienced emotion in everyday listening situations, and the importance of nature sounds. And so the first study I'm going to review is out of Northwestern University that was published in Ear and Hearing. And this is a study that's really focused on the idea that working memory ability in individuals might have some association with with how people perform.

And so just a little background, there's been work done for over a decade or so showing that working memory seems to have an association with performance differences related to compression, particularly compression time constants. And what has been shown repeatedly is that there are some performance differences that are speech recognition and noise associates associated that seem to be at least somewhat predictable based on working memory. But one of the limitations of this work is the majority of it has been done in conditions where speech and noise are co located and the hearing aids are using an omnidirectional microphone. And so they're really not including conditions that are very

common for our patients, which include beamformers, in this case, bilateral beamforming processing and speech in noise that are separated. In the case of this study, they're really going to a rather extreme version of this where speech is presented in front and noise from behind, and they're using bilateral beamformers in commercial products.

So in retrospect, if you kind of look at this at a slightly different way, what they're asking is, is the association between an individual's working memory ability and speech recognition and noise through various signal processing levels kind of predictable from the temporal distortions that the processing interact introduces. What they used as a measure of temporal distortion was the HASI and this is the hearing aid Sound quality index which has been around for a little more than a decade. And it is an acoustic measure looking at short term time frequency modulation in the hearing aid compared to linearly amplified referent. This model also includes some of the differences that we expect to be introduced by hearing loss.

So when we look at those those sorts of temporal distortions, we do know that hearing aids increase audibility, they provide some real benefits. But the listening environment and some of the hearing aid features may also affect the temporal envelope. For this particular study what they're really focused on is the fact that fast acting compression flattens the temp temporal envelope and that can be detrimental to speech understanding in some cases, particularly when there is positive signal to noise ratios. We also know that noise in the environment and reverberation can act to smooth or flatten the temporal envelope, but that the negative effects of the noise flattening the temporal envelope can be offset at least partially by directional microphones and beam forming.

The reason I thought this was an particularly interesting study is that most modern hearing aids do include microphone based SNR improvements like directional microphones. And so this study really looks at a research question that's been looked at multiple times, but introduces modern hearing aids

and modern hearing aid processing in the form of beamforming. For this particular study they looked at 21 older adults with bilateral mild to moderately severe sensorineural hearing loss and they were all fitted with commercial BTE RIC hearing aids fitted to now NL2. As I mentioned before, this really did kind of take a kind of an extreme example of the effects of beamforming. And so for most of these individuals they're using double domes, they're using very limited venting to really increase the potential impact of beam forming.

The speech recognition that they did for these individuals were low context sentences with male and female talkers all presented at 65 DBA in the presence of four talker babble, that Babel level was varied so that the signal to noise ratio varied from seven to 10dB in two decibels steps. And for the non beamforming conditions the speech was co located and spatially separated. But in the beam forming conditions they only evaluated with the speech and noise spatially separated with speech in front and noise directly behind. The microphone mode for these BTRIC devices was set to be either omnidirectional or binaural beam. And these devices were capable of two different sets of time constants.

One of the things that I think it's important when we talk about this. I know we used to talk about compression a whole lot. We don't talk about it as much certainly anymore. But when we talk about variance and time constants, we're really talking about mainly release times. And so these hearing aids were capable of a pretty fast release time, what we used to call syllabic, of around 70 to 120 milliseconds or a slow release time in the neighborhood of a second to a second and a half.

In both cases, the attack times are relatively fast, ranging from around 5 milliseconds to about 70 to 90 milliseconds attack time. So in total there were 24 conditions for omni. Those six different signal noise ratios, co located or separated speech and noise and the two time constants. And for the beam forming conditions it was the same signal to noise ratios, but there was only the conditions of spatial separation

and the two different time constants. Individuals also had their working memory assessed with the abbreviated reading span test.

Excuse me. What they found in terms of signal distortion, this is temporal distortion as measured by the Haski were all effects that were expected. And that is there's less temporal distortion with a good signal to noise ratio than the poor signal to noise ratio. Less temporal distortion with beam forming than omnidirectional, less temporal distortion with slow time constants comparatively to fast time constants. However, they didn't notice very many interactions except for one of the statistical models in which they showed that the SNR related distortion was slightly smaller per DB change in signal noise ratio for the beam forming conditions comparatively to the omnidirectional conditions.

What I've done is just pulled out a little subset of their data which is really related to their main question. And these are just the mean data. Looking at different signal to noise ratio presentations from 0 to plus 10 across the bottom and looking at the patient's percent correct scores for the four different conditions in the CO located conditions. And so let's look first at the zero dB signal noise ratio and you see the same pat for the signal noise ratios until they get really positive. If we look at the two bars in the left hand part of the group, we see very little difference across the performance for the slow versus fast time constants in Omni.

If we look at the two bars on the right hand group, we also see very little difference between the slow and fast time constants when in beam forming. However, when we look at those pairs of conditions, we see a pretty large and strong and significant effect of the beamformer. This is really consistent with past research in that beamforming can very significantly improve speech recognition in the lab for speech and noise that are spatially separated and we see a pretty big effect. However, unlike what this group is found in previous studies and others have found, there really wasn't a significant effect of compression time constants. Again, this is only co located, but they also didn't find a significant effect.

Or this is only spatially separated. They also didn't find a significant effect when the speech and noise were co located.

So, contrary to the author's hypothesis, the spatially separated speech recognition and noise for slow and fast time constants didn't really depend on working memory either in the beam or omni conditions. And in fact, there was no clear evidence that the time constants significantly affected speech recognition at all. They did find, consistent with our hypothesis, that speech recognition increased at a faster rate for the same decrease in distortion for individuals with better working memory. And so they found this increase in speech recognition to be about 27% versus about 33.5% for those with better working memory, given the same change in distortion. And so another way to say that is individuals with better working memory were more likely to benefit from the reduced signal distortions.

And so when we look at the importance of this, I think that this is clearly more evidence of the positive benefits of beamforming in optimal lab conditions, more evidence that individuals with better working memory gain more benefits from a reduction in signal distortion.

But also some evidence that signal distortion differences due to compression time constants, at least in this one commercial hearing aid, may not be great enough to significantly affect speech recognition, at least at these conversational speech levels. So when we break that down, the clinical implications, I think are pretty strongly related to what I just said. And that is, I think there is more to learn theoretically regarding how amplitude compression interacts with working memory. But I think when we're looking at kind of at least optimal laboratory conditions, when we're beam forming, these compression differences may be small enough in current commercial products that it might not really affect clinical decision making related to compression. Importantly, I don't think this conclusion does extend to other considerations around compression, such as sound quality.

And there's other work showing that there is some clinical decision making around compression related to sound quality, but it just may not be related to performance and interactions for working memory. I also think clinically, this is another example of how our patients with less impairment, in this case those with better cognitive working memory, kind of achieve the greatest Benefits from technology. And those that struggle a little bit more, in this case those with lower working memory may need additional technologies such as remote mics for acceptable performance out in the real world.

All right, the second study I want to introduce, I just want to introduce this briefly. This is a study out of Western University in Ontario. And they were interested in patient attitudes and importance ratings for some modern hearing aid features. And they examined this question through the development of a novel questionnaire that they call the Hearing Aid Attribute and Feature Importance Evaluation, which is really aimed at improving hearing aid selection by identifying the hearing aid characteristics most important to the patient. As I'm sure all of you know, there are many current hearing aid benefit performance and satisfaction questionnaires.

I list just a few of them here. However, most of these were not generally developed as selection tools other than the hasp, but even the hasp, most of the tools that are out there were developed at a time where modern hearing aid features were not really present yet.

So I think that there are many modern hearing aid features that have effectiveness data now, at least in the lab. However, we don't have a lot of evidence based selection guidance for us clinically. And so what they did is construct a questionnaire based on a published concept map and then did focus groups and interviews with clinicians to ask them about the importance of different questions related to hearing aid features and modern hearing aid features and how they work. They then did a revision based on the focus group input and then distributed the revision to 218 individuals with with hearing difficulty, 84 of which were hearing aid users. They analyzed the results of this distribution looking at

item evaluation, internal factor structure and internal consistency, and did a final revision based on this analysis.

That final questionnaire includes 28 items in three subscales. One of those subscales is really advanced connectivity and streaming, which we have in all of our modern hearing aids. A second subscale is the physical attributes and usability of the hearing aid. And a third subscale is focused on sound quality and intelligibility. What they found is within each of these subscales, the average inner item correlation is pretty good and the subscales had high internal consistency.

And so what these authors point out, and I want to point out as well, is this tool really may help clinicians track features and potentially inform patients about the available options and provide evidence to justify hearing aid selections related to technology.

I do think further work is needed. However, this tool has the potential to really be useful as part of an evidence based needs assessment for adult hearing aid Candidates. However, we don't yet have data on whether this tool can potentially improve hearing aid outcomes, such as patient satisfaction, clinical efficiency or other outcomes that are clinical. Once we do have those data, however, we might find this tool even more impactful.

All right, lastly, I wanted to talk about a study that I think has been talked about a fair bit out of the UK and it's really looking at real ear measures. And I think it's important to note that this study is really focused on individuals with mild to moderate hearing loss. What this study did is compare the deviation from target before and after fine tuning using probe tube or real ear measurements. Another way to kind of generally describe what the study is looking at is whether these initial fits, what we sometimes call first fits, that is programming the hearing aid with the manufacturer software, clicking on now NL2 and looking at our fit to target, are more accurate comparatively to verification, as we typically do it clinically with real ear measures than they used to be. So real ear measurements are typically

recommended to verify prescriptive hearing aid gain and output targets.

And it's important for us to recognize this has been recommended historically for two separate reasons. One that I think is really important important is that we have seen in several past studies that hearing aid manufacturers versions of specific amplification targets, I.e. you go into the manufacturer's software, click now and do a first fit. Typically on average these weren't accurate and oftentimes considerably underfit patients, particularly in the high frequencies. I do want to point out there's a second reason for that we do real ear measurements, however, and that is individual patient acoustics, including hearing aid coupling, mic location effects really vary across individuals and there's a fairly large amount of individual variability in these acoustic coupling differences.

So why does this study matter? A recent other study found that unlike in earlier studies, that the manufacturer's initial fits seem to be pretty close on average to being accurate. And they found this in one manufacturer and they found it to be accurate on average within about 2 or 3 decibels. And so the authors concluded that there's the potential that manufacturers and initial fits might be a better starting place than they have been in the past. And they also question whether completing real ear measurements might be less critical than previously thought in patients with mild moderate hearing loss.

And I'll give an opinion on that particular conclusion a little later. So what they did was a retrospective analysis of data from the Royal Survey NIH or NHS Foundation Trust, which is a group of clinics in South England. It was 256 new adult hearing aid users mostly fitted in 2022 and they examined fittings using Phonak branded instruments. I do want to point out that this group and other groups had previously shown that initial fits from Oticon seem to be more accurate. And so they wanted to go with a different brand than they had found in, in the previous study and, and targeted Phonak.

They evaluated the RMS error of the deviation, that is what the recorded responses versus the targets and then they log transformed. And, and I do want to point out that they did a, this second manipulation to normalize the results and reduce the effects of outliers. And so what this study is really focusing on is how accurate are these fits on average after doing this normalization.

So here is the main finding from this study. The violin plots that they provided and, and what you see is the deviation from target in the initial fit in the blue violins after clinician fit using standard techniques and real ear measures, which are the yellow violins, and then finally after some fine tuning, which are the purple violins. If you look at the median data across all of these, what you can see is the average match to target across all these frequencies in those initial fits is pretty comparable to what you get from real ear measurements both before and after fine tuning. There's a little bit couple of db greater variation at 4k but, but on average all these fits are, are, are pretty close. And I think that's, that's a, a really important finding.

I do want to point out there is a small difference here in the figures that's I think most evident out at 2 and 4k. And that is kind of look at the thickness of the violin and you can see for the initial fits the violins are a little bit longer and thinner. And for the relayer measure and the real ear measure after final they're a little bit thicker and narrower. And what this shows is in fact that there's less variability in the accuracy comparatively to targets in the real ear measures both before and after fine tuning than these initial fits. And I would propose that's expected because of those individual differences in acoustics.

And so one important finding, at least a subset of manufacturers initial fit values now appear to be correct on average. And this is consistent with other recent studies. And I think that minimally this is great clinically because being right on average should reduce the time it takes to fit an individual to prescriptive targets. We can now in at least some cases put in our patients hearing thresholds, select the appropriate target in the fitting software and expect that what we measure in the real ear on

average will be close to correct.

I do want to point out however that deviations for initial fits were significantly higher then deviations for real ear measured and real ear measured fittings after after fine tuning. But this is expected given that real ear measured fittings really allow the clinician to adjust to targets considering individual acoustics and coupling. They're not guessing about that we've actually got the patient's real acoustics. They also point out in their data that deviations for open fits were significantly higher than closed fits. This is also expected because what we're bringing in then is with open fits you've got all the variation in individual ears really or unaided gain that's present in the open fittings.

And so I would suggest that, that this study doesn't really address the second main reason for completing real ear measures and that is individual patients acoustics including hearing aid coupling and mic location effects having quite a bit of variability across fine tuning. I would also suggest that perhaps it's a little bit of a jump in logic going from the idea that hey, when we're fine tuning we're really only adjusting things a couple of db and fine tuning really doesn't seem to affect outcomes very much, which is true. I think that's a little bit of a jump to there. Then go to, well, maybe we don't really need to do the real ear measures to begin with. Maybe we can just default to the manufacturer first fit.

Because I don't think that study has really been done yet.

So in terms of clinical implications, I think manufacturer's initial fits are accurate now on average. And therefore if you can't do real ear measures, at least you're going to be right on the average patient. But I'll continue to point out that we don't know whether all patients are average. In fact we know that they aren't. And what we don't know yet, and we need further study on, is whether individual differences in coupling, mic location effects and acoustics really matter.

Because those deviations aren't just a few DB, they can be greater than 10 decibels even in individuals with mild to moderate hearing loss. And so we don't yet know how wrong is wrong and we may need some follow up work. But at least we've got a better starting place minimally. Finally, I wanted to end by pointing out that there actually are some clinical data supporting what audiologists do related to find or related to doing real ear and or related to selecting hearing aids through a needs assessment. And so this is a study that we recently published.

This is a study completed over the last several years by Yu Sheng wu's group at Iowa in collaboration with with my group here in Vanderbilt where we compared an AUD fitting to an over the counter fitting and also to a fitting where which we called over the counter plus where clinicians selected a pre fit gain configuration that was appropriate for patients and then did just a little bit of follow up. This happens to be the satisfaction data from the saddle but we found the same pattern of outcomes in both an EMA based and a after the fact measure of hearing aid benefit in which there was a significant benefit for all the different delivery models for over the counter, for over the counter plus and for aud. However, outcomes were clinically significantly higher for the AUD model. We don't yet know exactly why those outcomes were better, but one possibility is that there was some additional benefit from an individualized hearing aids need assessment and so a measure like the HAFI could be useful. There could also be some additional benefit from individual individualized real ear measurements because that was only done in this study in the AUD model comparatively to patient selected pre fit which is our OTC model where even a clinician selected appropriate preface prefit which it was done in our OTC plus model.

So with that I have used my time and I will turn it over to Dr. Baku to talk about the next study. Thank you Dr. Ricketts. That was.

Your timing was perfect. I am indeed going to talk about a couple of studies and I'm going to switch gears a little bit and talk about some of the maybe softer side of hearing aids and hearing aid fittings. So emotion perception and the importance of natural or nature sounds for people who wear hearing aids and who have hearing loss. So the first thing I'm going to talk about is was published by Jack Hallman and Graham Naylor. The title is called the Influence of Hearing Loss and Hearing Aid Use on Experience, Emotion and Everyday Listening Situations.

And it was published Ray very recently in a journal called Clinical Rehabilitation.

So in this study they had two questions. So they asked are there differences between the emotional states reported by people with and without hearing loss? And if there are group differences, do these differences vary by listening situation? So does it matter what you're doing in terms of your emotional response to that situation? And then the other question was in what situations do hearing aids have effects and are those effects positive or negative?

The reason I picked this study is because I think it is related to some of the work that I'm doing and that we're doing in the lab at Vanderbilt. So we have seen based on laboratory data that people who have hearing loss and who wear hearing aids have a disrupted emotional response to sounds. So the approach that I'm using in the laboratory is to play non speech sounds for people and have them rate the degree to which they feel pleasant or unpleasant about the sound that they just heard. So we have been focused primarily on non speech sounds, like I mentioned. So some music, some bird songs, maybe cows, body noises.

So just heterogeneous, heterogeneous measurements, corpus of sounds. So, and what we found time and time again is that people who have hearing loss have a reduced range of emotional responses. So they don't feel as pleasant or happy in response to those pleasant, happy sounds as do their peers with normal hearing. And they don't feel as unhappy or as unpleasant in response to unpleasant sounds as

do their peers with normal hearing. So the result is a squished range of emotional responses to sounds.

The figure I've got on the slide right now is one example of that kind of work where we're looking at among people who have normal hearing, wear hearing aids, or have cochlear implants, the relationship between ratings of pleasantness or happiness as a function of PTA for each of those panels, as we go further to the right, we see this is increased pta. If we look at the left panel, for example, these are responses to things that we think should be pleasant. So music, laughter, birdsong. What we see is that as people have higher degrees of hearing loss, they have lower ratings of pleasantness, so they don't feel as happy listening to those happy, pleasant sounds, as do people who have lower or better pure tone averages. If we look at the far right panel, we see this.

The, the inverse is true for unpleasant sounds. So people have, who have more hearing loss don't feel as unpleasant or as unhappy when they're listening to those unhappy, unpleasant sounds. So all of this, these data that I'm showing you and all of the related studies that we've done have all been in the laboratory. And one of the reasons that I was really excited to read this paper by Holloman Naylor is because they went out into the field. So they were looking at emotional responses to things that people encounter in their everyday life and seeing how hearing loss and hearing aids affected the emotional responses in daily life more generally.

One of the reasons that I'm interested in emotion in daily life and in the laboratory is that most of the work that we have for hearing aids and how we set hearing aids and hearing aid outcomes are focused on signal processing and speech understanding, particularly noise. And that's understandable because speech and noise and speech and quiet are really, really important outcomes. But we're seeing this emerging or growing trend for people to be interested in also how hearing loss and hearing aids affect overall well being and the way that somebody feels about the sounds that they've they're hearing and on the way they can appreciate and listen to music. So that's generally why I'm interested in this kind of

study and I'm interested specifically in this study because it is, as I mentioned, out in the real world. So we don't really have good data on, until now, on how people respond emotionally in the real world, particularly in real time.

So in the study they had two groups of participants. They had experienced hearing aid users and adults who have normal hearing. And what they did was an EMA study. So ecological momentary assessment. They went out in the world with an app and rated their, among other things, their experienced emotion.

And so they rated the degree to which they felt pleasant. So that's valence, the degree to which they felt excited, that's arousal. And they also categorized their emotions with, with word labels, so happy, sad, angry, etc. So everybody did that. The hearing aid users did that with and without the hearing aids.

So I'm only going to talk about the valence fit or the degree to which they felt pleasant. But I just want to give you a study overview here. So in the baseline, baseline appointment, they complete, everybody completed questionnaires and they got their app installed and they were shown how to use it. And then at home over the sequence of 10 days, they completed EMA surveys. So for the hearing aid users who were doing this with and without their hearing aids, they traded days.

So you can see in this figure, they do EMA surveys one day without a hearing aid, the next day they'd wear their hearing aids and do their surveys. When they're doing their surveys, they get about six surveys per day over the course of about 10 study days and they're reading or providing information about the situation, type, what the purpose of the conversation was, what kind of background noise is there, where are they, and then also their valence and arousal in terms of what they found. I want to comment on the common listening situation. So participants were rating or describing where they were most of the time, they were doing one on one conversations or listening to the television. So by far those were the two most common listening situations.

So both of these do contain speech and so they're speech focused kinds of conversations. We also see that they were in some group conversations, they did some music listening and then there were some situations where they weren't listening too much.

What they found is the participants who have hearing loss when they weren't wearing their hearing aids had lower ratings of valence than did their peers, peers with normal hearing. So I don't have data on this slide to show you that, you'll just have to take my word for it. But the people who were without hearing aids, their ratings of valence were lower than their peers who have normal hearing. But the hearing aids improved ratings of valence. So we can see that here in the left panel where we have ratings of valence with the hearing aid as a function of ratings of valence without the hearing aid.

So if the hearing aid didn't make a difference for ratings of valence, all of those points would be on the diagonal line. But instead what you see is most of those points are above the diagonal line, which means that the hearing aid is increasing ratings of valence. Interestingly, these ratings, the benefits of hearing aids for ratings of valence weren't situation dependent. So it didn't matter what kinds of listening situations they were in. Just overall, the hearing aids are improving ratings of valence.

And with the hearing aids, the people who were had hearing loss had ratings of valence that were similar to their peers with normal hearing. So combined, this suggests that the hearing aids are improving emotion perception and improving the way that people feel about the sounds in their environment.

It also means that without hearing aids, people with hearing loss have a negative emotion perception. So they don't feel as happy in those listening situations as they do with their hearing aids and compared to peers who have normal hearing. This means, for me anyway, that I'd like to make sure that we're continuing to think about and focus on factors besides just straight speech intelligibility when thinking

about the evaluation and management of hearing loss, especially for adults. Fortunately, we do have something in our arsenal that seems to improve emotional responses, and in this case it was hearing aids. So in my own work, we haven't yet seen this in the laboratory.

So this is really nice and reassuring and exciting to see that hearing aids in everyday settings could improve emotion perception for adults who have hearing loss.

Clinically, what this might mean is that the patients that you're seeing and meeting with without their hearing aids, they're having this emotional, they could be having an emotional response that's negatively affected by not being able to hear and reduce audibility and they might not even realize it or mention it. So it might be something that you know and maybe want to talk about because it might be something that's happening that they don't know it. Fortunately, we do have hearing aids that can help, or hearing aids do help. So we do have something in our toolkit to help improve emotional responses for adults who have hearing loss. And sort of excitingly, the hearing aid benefits might be bigger than what we might expect based on laboratory data that we've seen so far.

Okay, so the next and final two studies I want to talk about focus on nature sounds. So this is a study that was published in the American Journal of Audiology pretty recently and it's called the Effects of Hearing Loss and Hearing Aids on the Perception of Nature Sounds and Soundscapes. A survey of hearing care professionals, care professional opinions. So they wanted to know how hearing care professionals feel about the importance of nature sounds to their patients. So they're trying to get to this idea about how do patients feel about nature sounds by asking hearing care professionals, why is this important?

Well, I've already mentioned that traditionally hearing aids have done or the hearing aid research has focused really heavily on speech, communication and quiet noise. We're starting to see the this growing movement towards emotion, perception, music appreciation. And one of those kinds of sounds that

people are exposed to that might affect their emotion and their well being is just nature sounds. There is some evidence outside of audiology that hearing natural sounds can be important for overall well being and overall quality of life. So this is an example of that kind of work.

This is a study that was published by Rachel Buxton looking at Canadians and the factors that affect and are related to self reported mental health. So they looked at lots and lots of things in a really big sample size of people all across Canada. And what I'm showing you here are factors that do improve are related to better self reported mental health and factors that are related to less good self reported mental health. So on that vertical line there, anything that falls right on the vertical line doesn't affect self reported mental health. Anything to the right means that it increases the likelihood of good self reported mental health.

And everything to the left of that horizontal line means that the factor is not related is related to less good mental health. So if we look at just the things that are really driving good outcomes at the top, we see things like being a non smoker, being employed and having post secondary education really increase the possibility that somebody's going to have better mental health. And if we skip all the Way to the bottom. And we look at some factors to the left of that line. What we see are that being widowed or being an active smoker are both related to having less good self reported mental health.

So controlling for all those variables that can affect mental health, in this study, they're also interested in nature sounds, which is why I'm talking about it. But in this figure, they've zoomed in on the gray box, which has three things I want to talk about. So they have smaller effects than the other factors that I mentioned, but they are significantly related to mental health. So one is daily fruit and vegetable consumption. So people who eat daily fruits and vegetables daily are more likely to have better mental health.

But also living in a place where you have diverse birds and diverse trees improves your odds of having better mental health almost as good, almost as strongly as eating fruits and vegetables. So this is one piece of data to suggest or one set of studies to suggest that being near, having access to, being exposed to diverse bird sounds and diverse trees can improve mental health and is, and almost as good as eating your fruits and veggies. So the question is then, what about people who have hearing loss? What if having restricted access to those natural sound reduces the chance of good mental health? So let's just talk about natural sounds for a second.

So natural sound is any sound that has a biological origin or a geophysical origin. So this could come from animals or birds or insects making noises, or also geophysical things like wind, rain, streams. And we can label these natural sounds or we could think about them in a whole soundscape. So a soundscape, a natural soundscape would be the whole whole environment that includes some animal noises, some geophony, some a little bit of human activity. So those, those kinds of combined things would be a natural soundscape.

And previously in the literature, what we've seen is that people who have hearing loss are not as good at hearing those natural soundscapes, so they're less good at discriminating between am I listening to a forest or a meadow? The people who have normal hearing can hear moment of the day pretty well, like dawn, midday or dusk, Whereas people who have hearing loss have a little bit more trouble hearing moment of the day or even season. This suggests that having hearing loss and having restricted audibility is contributing to a lack of, or contributing to difficulties hearing out those natural sounds and those natural soundscapes.

It's not clear if this is important or how well hearing aids might affect the ability to hear natural sounds. So this survey, the authors were thinking, and I tend to agree that the survey of hearing care professionals to get at how they think patients feel about natural sounds and the importance of those

natural sounds is a good next step.

So they also wanted to be mindful about the kinds of natural sounds that, that patients and hearing care professionals might be exposed to. So they had a wide sample of people who lived in rural and suburban and urban environments, because these are going to differ in their complexity and composition. So in terms of the biophony, so sounds produced by animals, geophony sounds produced by wind and rain and water, and also sounds produced by human made things. So they ask hearing care professionals about their patients listening situation and hearing demands. In terms of how well hearing care professionals think that the patients can accurately perceive nature sounds, how pleasant the patients think the natural sounds are, and they ask these questions before and after hearing aids.

So thinking about patients who have not had hearing aids versus thinking about patients who have had hearing aids.

One of the cool things about this study is they did it in France. So they're looking at French hearing care professionals. And France has five temperate climates. So they've got lots of different kinds of ecosystems in France. So by sampling French hearing care professionals, they're able to look at lots of different kinds of natural sounds.

So they asked, they use a questionnaire of these hearing care professionals, again, before or after hearing aids, about how many of your patients report that natural sounds is important to them, how many of them do you think can accurately identify natural sounds? How many of your patients report that natural sounds are pleasant and how important do you think that your patients think natural sounds are? So I'm afraid I might run out of time, but I thought that we could really quickly go through this exercise for yourself. So you probably are seeing patients and our hearing care professionals. So if you were to be in this survey, just on a scratch piece of paper or thinking out loud about how what percentage of patients do you think mention natural natural sounds before they're fit with a hearing aid?

100%. 50%? 0%. And then after they're fit with a hearing aid, how many of your patients mention natural sounds? 100%, 50%, 0%, et cetera.

Similarly, new question. So if you're taking notes, you should have two numbers on your piece of paper. New question though.

What percent of your patients do you think can accurately identify natural sounds without hearing aids? And then what percent of your patients do you think can accurately identify natural sounds with their hearing aids?

What percent of patients do you think find natural sounds pleasant without their hearing aids? And what percent of Patients do you think find natural sounds pleasant with hearing aids?

And then finally, what percent of patients do you think find natural sounds important to listen to without hearing aids? And then what percent of patients do you think find natural sounds important with hearing aids? So if you've been playing along, you should, you would have some numbers and I want to show you the numbers that came out of this study in France.

So they had 290 hearing care professionals with an average of 15 years of practice with the range being from 0 to 56. So probably this, the everybody here in the audience falls somewhere in that range. Also, with zero to 56 years of experience, 58% of their patients lived in not rural areas.

And in terms of how often do patients report hearing natural sounds before hearing aids? Only 7% of providers thought only 7% of patients say something about natural sounds before they get hearing aids and that number jumps up to 45% after hearing aids. So this suggests that patients are more likely to report, at least according to hearing care professionals, that natural sounds report something about

natural sounds after their hearing aids.

Do patients with hearing loss perceive natural sounds correctly before hearing aids? Providers think that about 42% of their patients are accurate in perceiving natural sounds correctly and that number jumps up to 91% after their hearing aids. So that, that means that hearing care professionals in France think that most of their patients are good at recognizing nature sounds and identifying nature sounds while they're wearing hearing aids.

Are natural sounds pleasant for patients with hearing loss?

These pie chart looking at just the degree to which hearing care providers think that the patients find the sounds pleasant, they don't mention it or maybe neutral before the hearing aid fitting. We see the white part of the pie means that most lots of people don't talk about it. And the ones that do find sounds pleasant after hearing aid, we see a lot more people talking about the pleasantness of nature sounds and a lot more people finding hearing nature sounds to be pleasant. But we also see a small increase in the unpleasantness of nature sounds. This is probably like wind, microphone, wind noise on the hearing aid.

How important are natural sounds for patients with hearing loss before hearing aids? So that's a pie chart on the left. The red means not important at all and the white means nobody talks about it before hearing aids. We don't really see natural sounds as being particularly important. That changes quite a bit after patients get hearing aids where natural sounds become a lot more important and more people are talking about it.

They found people in rural areas were more likely to find natural Sounds as important and otherwise didn't find a big effect of those climate zones.

So this is important because it suggests that maybe before hearing aids, people aren't aware of natural sounds, they don't find them important and maybe don't find them very pleasant. Probably because they don't give very much feedback from missing nature sounds. Right. So if you are missing speech sounds, somebody's you're going to have to ask them to repeat, you're going to miss out on communication. But if you aren't hearing the birds, nobody's telling you that you're not hearing the birds.

So what this also means is that hearing aids can improve the recognition of natural sounds and hopefully can facilitate this relationship between hearing natural sounds and overall well being. What this means for you, I think is that natural sounds might be something that you could be talking about post hearing aid fitting if you aren't already, particularly for people who live in rural environments. And that we should also be doing what we can to make sure that those natural sounds are audible, maybe even in just specific listening situations. Okay. And the last study I want to talk about is very related.

So this is looking at nature sounds and hearing loss. Also this is published in Ear and Hearing this year. So we're interested in whether individuals with hearing loss lose their connection to natural sounds without realizing it and can hearing aids make things better? So I just reviewed this study from 2025. We don't need to go over it again.

I'll also say there's not a lot of literature looking at environmental sounds or natural sounds. So this is contributing to a kind of a sparse field. And we know that natural sounds are important for overall well being and people may not realize that they're missing it. So this study is actually reanalysis of a paper I think we talked about last year looking at the role of positive focus for hearing aid outcomes. And in case you haven't read that study, the the point of that study is to take people who are first time hearing aid users and have them make journal entries in an app about the positive things that they're listening to, the positive things they heard that day.

And it turns out that that exercise of having people focus on positive things can improve hearing aid benefit and satisfaction, but also is a nice opportunity to look at the kinds of things that people find pleasant or positive in their listening world. So in this study we did a reanalysis of those positive the kinds of things that people mentioned before they came in for their hearing aid, before they got a hearing aid, at their hearing aid consultation Appointment. Everybody said that listening to speech is important and they wanted to, they wanted help to understand speech. Most of them also reported they wanted help on the television, and only 22% said they wanted to hear nature sounds. But after the hearing aid fitting, 15 of 18 of the participants in that study noted positive experiences related to nature.

So even though they didn't mention it before they got their hearing aid, many or most of them mentioned it after. And the kinds of things they mentioned is in this pie chart here. But bird songs, geophony, and the rustle of wind in the rustle of leaves in the trees were the most common kinds of listening situations that people really appreciated in that positive focus exercise. There are some quotes here I think I will skip in the interest of time, but they do highlight the kinds of things that people recognize that they were missing before they had hearing aids, like the sound of rain, birds and birds going to bed in the evening.

So this is important for me because I do think that nature sounds and having the ability to hear them is important, but also because it means that people probably aren't talking about natural sounds in the hearing aid consultation appointment, but it is something that we could be addressing either at the consultation appointment or at the hearing aid fitting in that follow up trial period because they might not know that they're missing it or might not realize how important natural sounds are to them until they go out in the world with their hearing aids. And making sure that natural sounds sound pleasant and good is probably important in that trial period. And I would be thinking about ways to encourage people to go out in the world and listen to their hearing aids and try to find those natural sounds, see if they like the way their hearing aid sounds. Now that they have audible, their audibility has improved for those. Okay,

so I just want to summarize that we've talked about six studies.

So I have just on these last two slides single statements to try to capture all of the things we talked about. So for me, the three studies I talked about, the important conclusions I think are that hearing unaided hearing loss is associated with negative impact on emotion. But fortunately, hearing aids can restore emotion experience in everyday listening situations. Without hearing aids, natural sounds might be ignored or difficult to recognize. But with hearing aids, natural sounds are easily recognized by most patients, at least according to the survey of hearing care professionals.

So not asking patients themselves. But when you do look at the kinds of listening situations that patients appreciate, post hearing aid fitting, natural sounds comes up a lot. So before hearing aid fitting, only 25% of patients reported wanting help hearing sounds of nature. But 80% of them reported that nature was one of the positive listening experiences they had after the hearing aid fitting. And then in terms of the three studies that Dr.

Ricketts talked about, he reviewed a study where they showed clear evidence of positives for beam forming in optimal lab conditions for everybody. But individuals with better working memory had more beam former benefits than people who had lower working memory. He also talked about the study where they saw that the accuracy of initial manufacturers first fit of NAL NL targets compared to measured real ear responses was pretty good on average. And then finally, he talked about the H, the hafe, the hearing aid attribute and feature importance evaluation as a potentially useful questionnaire for improving hearing aid selection.

So we have a couple of minutes for questions, so I would be happy to answer them. I believe Dr. Ricketts is also around if you have questions for him. And this is a picture of us in our natural environment, which also happens to be a lab.

And if we don't have questions. Dr. Ricketts, I have a question for you. Could you remind me, in that study looking at probe microphone verification, what kind of coupling did they use?

These were clinical fits. And so there was a really wide range of coupling. Everything from open tips. They did some analysis based on on closed versus open tips, and there was some differences, but there was a fairly wide range. The vast majority, I think more than half, were open.

Wow. Okay, super. Thank you. So they were clinical fits. They're clinical fits and they're all mild to moderate loss.

Got it. Cool.

Unless I'm hitting the wrong button, I don't see any other questions, which means, Dr. Ricketts, I think we were super clear. And I could have read those patient quotes about how important listening to rain and birdsong was.

Thank you, doctor. Thank you, Dr. Ricketts. There's no other questions in the queue, but let me go ahead and have you advance that Next slide there. Dr.

This is just to remind the participants that as we prepare to close, just to take the exam if they wish to earn CE credit. And I'll hand it back over to you, Dr. Wicketts, for any closing comments. Thank you all.