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How Hearing Aid Sound Quality Can Improve Patients' Moods

Presenter: Erin Margaret Picou, AuD, PhD, CCC-A

At this time, it's my pleasure to welcome back to Audiology Online Dr. Erin Picou. She is a professor in the Department of Hearing and Speech Sciences at Vanderbilt University Medical Center. She directs the Hearing and Affect Perception Interest Laboratory, which focuses on speech recognition, listening effort, and emotional perception for adults and school age children. She's also active teaching and mentoring clinical and research graduates, among other things. Please Read more about Dr. Picou on our course page.

And Erin, at this time I'll turn over to you. Thank you Carolyn. Thank you for the opportunity to be here today and thank you all for logging in. I'm very excited to talk about my favorite research topic. Well, we're probably not supposed to have favorites, but this would be high on my list if we were.

Specifically, I'm going to talk about hearing aid, sound quality and patient's mood. So I do have some disclosures. The most important one I want to mention is that this work I'm going to talk about was funded by wsa WS Audiology. There are of course, some limitations and risks to participating in a webinar like this, so please recognize those. And specific to today's topic, I did come up with some learning outcomes which are also available in your course materials, I believe.

So before we get into it, I do want to make sure that I thank the team that's been working on this line of research, so specifically Laura Balling and Eric Branda at WS Audiology. We have a great team of research audiologists and students at Vanderbilt Health without whom this would not be possible. So you might not see them online today, but if you do see them around at a conference or something, please say hello and thank you.

So before we get into the science a little bit, I want to take just a minute and do a little introspection. So I want to know how you you're feeling. So in general, how is your mood right now? And I believe you should be able to use the reactions in the zoom feature. So if you're feeling really good, why don't you give me a little heart or a smiley face.

If you're feeling kind of okay, maybe a thumbs up. And if you're not really in a good mood, you're kind of in a bad mood, give me a thumbs down. So I'm seeing lots of hearts and smiley faces, a couple of thumbs ups, thumbs up, thumb ups. So anyway, lots of good or okay moods and of course one cat, because I'm afraid that my cat might make an appearance in today's presentation. So it's Exactly.

Thank you all for responding. It's exactly this kind of task that we are asking our patients to do. Our research participants is to do some introspection and tell us how they're feeling. And we're working from the overarching idea or the overarching premise that if we optimize hearing aid sound quality, we can change and specifically improve mood. So that's kind of a bold idea, actually, that by getting hearing aid sound quality right for a patient, their mood is better.

And I hope over the course of the next, I don't know, 50 something minutes, I'll be able to convince you that that is probably true. So to do that, I want to first talk a little bit about mood, make sure we're all on the same page. I want to talk briefly about sound quality. And then I'm going to spend most of my time talking about a couple of studies that we've done recently looking at how hearing aid gain and hearing aid sound design can affect mood. And then finally, I've got some practical tips for ways I think that we might be able to really individualize and optimize hearing aid sound quality to have those mood benefits.

So what is mood? The mood seems like it's a relatively intuitive thing, right? I've already asked you, you've told me how you're feeling, and most of you are in a good or at least an okay mood, and that's great. But the word mood is sometimes could be confused with other kinds of affective phenomenon. In fact, I've done it myself already when asking you how you're feeling.

So let's get some definitions here. So we're all on the same page. For me and for the rest of this course, mood refers to a diffuse affective state. So it's a low intensity kind of emotion, might not have a specific cause. You can just be generally in a good mood and it lasts.

The time course is hours or maybe days or maybe weeks. And that's in direct contrast to something like an emotional response. So an emotion is quick. It's directed in response to something, an object or an event, and it can come on really quickly. So we've seen emotional response happen within 50 milliseconds and they take one or two seconds to dissipate or dissolve.

So they're really fast and they could be more intense than something like a mood. Feeling here is just the word that we're using to describe those emotions and moods. So it's just the label that we're putting on the emotions and mood and These three things that are lower on the list are more very long term, more like personality kinds of things. So they're ways that we shape and think about and interpret the world. So you can have an attitude like long enduring belief, like I love cats.

For example. An effective style might be the disposition, the way that I emote. And temperament is like an effective style, but you may be born with it. So you've maybe heard of, you know, difficult babies or easy babies, those sorts of things. So I promised that the cats would make an appearance and to just kind of give you some examples about these different kinds of affective words.

Let's take Oakley and Apollo. So these are eat teen 19 pound cats. I think about 5 of the pounds are fur. But they are going to be our subjects for thinking about and interpreting these affective words.

So we could think about mood as being, well, I'm sitting near this cat and I feel confident and content because. Or not not because, but this cat is near me and I feel confident and content. And that's different from I feel happy because I saw these cats or I feel happy because I got to play with these cats. And. And in this case, happy is just the word that we're putting onto that emotion.

And the attitude would be something like I love cats. Or maybe you're not a cat person, I apologize, your attitude might be I don't love cats, why is she talking about cats? And that's fine, but it's not mood. And then effective style and temperament could be things like I approach life with humor, or I've always been easygoing like these cats because I didn't tell you. But in addition to being £20, they're also very easygoing anyway, so that is mood.

We're not going to continue to talk about effective style and temperament. We're going to specifically focus on mood for the rest of this presentation. And we've already had this experience of rating our mood. So in the example I gave at the top of the hour, I asked you to rate your mood on a scale of kind of like good to bad. And that's a very natural thing to do.

But we could also think about mood in specific mood states. So I've got a list here of five mood states that we've been studying. So a seam related affect, vigor, fatigue, anger and tension. So these are states, mood states that you can be high or low in.

So just to give you some definitions, esteem related affect is maybe the one with the least interpretable name. But this relates to moods being or adjectives in this mood would be like confident or competent, satisfied, not ashamed or proud. Vigor and fatigue are related to each other, but not exactly inversely so. So vigor is being lively, active or energetic. Fatigue is mostly the opposite.

So being worn out or bushed and anger and tension, I think are sort of intuitive. But there are some adjectives here that also could describe the mood states of anger or tension.

So we know that there are. We know some things that do affect mood. So I said that it's not like this quick response to a specific thing, but there are factors that can affect mood. We know that mood is related to basic needs. So you might have experienced or heard somebody talk about experiencing

hangry.

So that's the feeling of being angry because you're hungry or thirsty. If you're physically fatigued, you might also have a mood state that is less vigorous and more fatigued. But it's not just these basic needs that can affect mood. We also see evidence in literature that sensory experiences can affect mood. Specifically sensory experiences that are tied highly personal.

So this example of light, we've seen in the literature that when people are working in an office space that has light that they prefer, their mood is better. So if they are people who prefer natural light and task lighting, their mood is better than if you put them in a room with those fluorescent ugly lights. You can see my light preference is coming through. My bias is coming through. Anyway, when you people are in the light that they like, their mood is better.

Probably you have experienced your mood being affected by temperature. So when the temperature is too hot or too cold, your mood is likely to be affected. I know here in Nashville we've had a very hot summer. It's still pretty hot today. And that has for sure affected my mood over the course of the last couple of months.

But also something like clothing. So if clothing is itchy or too tight, that can also affect mood. Or if you get clothing that you feel you is stylish and you like and you feel like you feel good in, that can make you feel confident. So it's not just negative sensory experiences. You can also have positive sensory experiences that positively impact your mood.

So specific to hearing loss, there have been a couple of studies looking at mood and hearing loss in general. So not specific to device use. There's a study that suggests that people who have hearing loss have similar general mood states than people who have normal hearing. And then there are a couple of studies looking at the effect of hearing loss or comparing group differences between people who have

hearing loss and people who don't. In terms of mood and vigor.

So there is some evidence in the literature to suggest that people who have hearing loss are more likely to report low vigor and increased fatigue than are people who have normal hearing, particularly if they are employed and they're working and they need to listen. We don't see much else in the literature about these other mood states. So anger, tension or esteem related affect. So it's really so far in the literature just specific to vigor and fatigue.

More recently there's this specific kind of fatigue that's been discussed a lot more. My colleague Ben Hornsby is doing a lot of this work looking at listening related fatigue, which is in itself a negative mood state. So this is the experience of fatigue that's specific to listening or having sustained levels of high listening effort. So for example, if you're listening for a long time in background noise and reverberation and it's really important for you to be able to hear what's being said and you're putting in a lot of effort, you might feel tired from listening and have high listening related fatigue as a result. So high listening related fatigue is a negative mood state.

And we know that people who have hearing loss are at increased risk of reporting listening related fatigue, in part because hearing loss increases the need for listening effort and listening is just more challenging and demanding. In terms of device technologies, hearing related device technologies, we see some. The evidence is more is complicated. So we have scientific evidence to suggest that hearing aid use compared to non use or cochlear implant use compared to non cochlear implant use. This is confusing.

Let me start again. We have evidence to suggest that device use reduces listening related fatigue. So if you weren't wearing a hearing aid and you start wearing a hearing aid, or you didn't have a cochlear implant and you start using a cochlear implant, your hearing listening related fatigue decreases. It's a little bit more complicated than that because anecdotally we might have experienced. I know that I have

met patients and friends who wear hearing aids and report that they're more tired when they're wearing hearing aids.

They have to work harder and they just are desperate at the end of the day to take out their hearing aids because their listening related fatigue is so high.

Now I want to segue here because those studies have all focused specifically on listening related fatigue and device use compared to non use. But what about differences in hearing aid sound quality, which is the purpose of today's talk, of course, but we believe that it might be not just Hearing aid use versus non use. But getting the hearing aids right for people might be explaining some of the effects that we're seeing in the literature related to mood and hearing aid use. So let's talk just briefly about sound quality. It turns out sound quality is intuitive, but maybe complicated even to describe.

So coming up with the definition of sound quality was a little bit challenging. It's something kind of like mood maybe, where we feel like we know what it is when we hear it. And we can rate sound quality on a scale, but the contributors vary by person. So what's good sound quality to one person might be bad sound quality to somebody else. And we know that words that people use to describe sound quality include things like naturalness, clarity, loudness, specifically the loudness being the right comfort level, noisiness, specifically, not being too noisy, not having much distortion, distortion or having a broad bandwidth are all things that are related to good sound quality.

But as I mentioned, there are listener characteristics that define sound quality. So those characteristics are based on the person's preferences, what they've listened to in the past, what parts of sound quality are most important. Right? So some people maybe are more tolerant of noise as long as there's little distortion, for example.

So as I mentioned, we know that sound quality is highly personal. So there's considerable inter individual variability in sound quality preferences. And predicting sound quality preferences based on aspects of a person is really difficult. So it's hard to predict sound quality based on an audiogram or sound quality preferences based on an audiogram or age or gender or I don't know whether or not they like cats. We don't, we don't know how to predict hearing aid sound quality.

So the approaches that optimize hearing aid sound quality have to be individualized. We have to rely on letting people tell us what sound quality is good, what sound quality is not so good. And we know that if we do that, there's huge reward. So perceived sound quality is one of the things that shows up over and over again in ratings of hearing aid benefit and hearing aid satisfaction and whether or not people actually use their hearing aids. So optimizing sound quality has, for individual patients has big benefits.

And I would like to add to that list benefits related to mood. So, as I promised, we're going to get into a couple of studies where we looked at how sound quality can affect mood. And I want to talk you through first the general approach that we're using for measuring sound quality in mood, and then get into the details of a couple of studies. So this is the general approach that we use. So we bring patients in and we do, you know, the consent and the hearing test and all that stuff.

And we fit them in the lab with two different settings or two different kinds of hearing aids. And these settings or hearing aids vary in their expected sound quality. Then they wear one of those hearing aids home and at the end of the day they rate how good their sound quality is of that day, of that hearing aid and what their mood is at the end of the day. Then they come back, they answer a question, a questionnaire about listening related fatigue. We trade hearing aids, so we trade the settings or we trade out the hearing aid sound design.

They wear the second hearing aid home. And every day at the end of the day they rate their mood and their perceived sound quality. Then they come back, they do listening related fatigue again in the lab, thinking about their last week, and they give us the hearing aids to measure hearing aid sound quality. It's just a single question where we ask them to rate the sound quality of the hearing aids in the situations they've been in throughout the day. And they just get a slider scale and ranging from poor to excellent.

And the middle is acceptable. And behind the scenes here they don't see the numbers, but behind the scenes these slider scales get assigned to scores of 0 to 10 where 10 means the sound quality is excellent and 0 means the sound quality is very poor. To measure mood, we've been using a subset of the profile of mood states. So it has three subscales that I mentioned already. So related to seam, related affect, fatigue and vigor.

And participants see a list of these adjectives and they rate the degree to which they feel that adjective right now. So options are not at all, a little, moderately, quite fit, quite a lot and extremely. And as you'll see here, some of these words have asterisks. So we reverse scored them. So when I'm going to show you data in just a minute, all of those data, higher scores indicate better.

Better mood, less, less fatigue, more vigor, more esteem related affect, higher esteem related affect, doesn't matter.

And then as I mentioned, we're also using or measuring listening related fatigue retrospectively thinking about the last week when they come back to the lab and to use to measure listening related fatigue, we're using the Vanderbilt Fatigue scale for adults, the 10 item version. And I'm biased, but I really like the scale because it only has 10 items and it captures things like related to mood. So I feel worn out from everyday listening, but also the consequences of that listening and being tired from listening. So feeling tired from listening causes strain on my relationships. So the 10 items like that, those are just

two items.

And then they rate on a scale of zero to four, is that never or almost never true? All the way up to always or almost always. So we just sum those scores and higher scores means more frequent listening related fatigue. So A score of 40 means that they're almost always worn out at the end of the day from listening.

So we've taken this approach and we've done it twice in two different studies. So there's two different types of sound quality manipulation. I want to talk about one where we changed hearing aid gain settings and another where we compared two different brands. And these two brands are expected to vary based have different sound quality because they have different sound designs.

So I want to talk about the first one first. So looking at comparing hearing aid gain settings, so how does hearing aid gain setting affect mood?

This is just to reiterate that we're going to focus on hearing aid gain settings. And what we're doing is comparing hearing aids that are the same hearing aid and they just have two different programs. In one program, the hearing aid has optimal sound quality and the other, the hearing aid program program has worse but tolerable sound quality. So to achieve optimal sound quality and worse but tolerable sound quality, we had this rather extensive protocol in the lab where we played. We put participants in a sound booth and fit them to now NL2 targets.

And we gave them the app for the Widex app. So they're fit with moment 440 receiver in the canal hearing aids fit them to NL2 and we played them through a loudspeaker, speech, non speech, classical music, non classical music, animal sounds, laughter. And we kind of looped through all of these different sounds and we asked them to adjust using the app to find a hearing aid sound quality that was best for them. And this hearing aid sound quality had to work for all of these different types of stimuli.

So they couldn't have a different sound quality for speech and non speech or music and so on.

Then we did the same thing, but we asked them to create this worse, noticeably worse but tolerable program. So they knew when they were doing this task, they knew that they were going to wear the hearing aids home for two weeks. And we wanted them to make the hearing aid sound quality worse, but something that they could live with. Then we took them out. Our research audiologist took them out, walked down around the hospital to the cafeteria, switched between these two programs, made sure that they liked the good one and they could tolerate the bad one.

They came back to the lab and we did a blinded paired comparison to make sure they could still identify their good one or hear the difference between the good and the bad and identify which one was the good one. So we wanted really to have different hearing aid programs and made sure that they liked the good one and didn't like the not one.

The participants were 30 adults with they all had hearing aid experience. They were older adults between the ages of 50 and 80. They all to be in the study. They all rated hearing aids or I'm sorry, they all rated sound quality as being important to them. So in our first pass of this, we were thinking we would recruit musicians and audio engineers.

We we are in Nashville and we thought we'd have a pretty big pool of that sort of really attuned critical listener. It turns out that people say that sound quality is important them important to them for a whole host of reasons. And all of our 30 participants did report that sound quality is important to them. They were not all musicians and sound engineers, but you can see their individual and main audiograms here.

So these are the gain profiles of the good and the tolerable hearing aid program. So throughout today's presentation, whenever you see green, it means that somebody is that that's the good program. And

the red means the less good program. And you might not be able to see unless you're paying close attention, but the hearing aid gain for the good and the prescribed NAL NL2 targets are very similar. So the now NL2 is the black line here.

And you can see that the prescribed now NL2 targets and the good hearing aid program overlap really nicely. And then the tolerable hearing aid program has less gain. It's about 5 to 10dB of less gain in those mid and high frequencies. Importantly, these gain differences didn't affect speech and noise score. So they had the same quicksand scores in both hearing aid programs.

And they both used the hearing aids for the same amount of time they use in both programs. So these differences in gain weren't enough to affect speech intelligibility, but they were enough to affect perceived sound quality.

So the first thing I want to show you is this correlation between ratings of mood and ratings of sound quality. So what you're looking at is ratings of sound quality on the x axis. So left to right, higher scores indicate better ratings of sound quality at the end of the day for those hearing aids. And top to bottom, better mood is higher and worse mood is lower. So you can see this upward trend where hearing aid ratings of mood were better on days that they were using the sound quality of the hearing aid was better.

So this supports the idea that hearing aid sound quality is related to mood at the end of the day.

Then I also wanted to show you average ratings of mood at the end of the week for those good and tolerable programs. So here we're just seeing mean actually median ratings of mood at the end of the day for tolerable in red and good programs in green. And we can see this little boost for ratings of mood in the good program. So ratings of mood were higher when they were wearing the good program than the not good program. So I just want to pause here and get a reaction.

Is this finding surprising to anybody? Is this intuitive? If it's, I don't know what your options are. But if this finding is surprising, can, can I see some surprising faces if this makes sense? Maybe give me a thumbs up or a heart or something so I'm seeing some thumbs up.

I will just be very honest. I was surprised that something like hearing aid sound quality could affect ratings of mood at the end of the day. And I'm, well, you're probably not surprised because I set it up that way, but I was surprised. And I'm glad that. I'm glad to see this finding.

But I do want to add a little bit of a complication here. So we also, at the end of the day when they're rating their moods, we asked for feedback. So we wanted to know if something was weird that day or, you know, what, what kind of. Tell us a little bit about your hearing aid experiences. It wasn't required, but we wanted to give them the opportunity to tell us about their day in case something stood out or something was weird and something stood out and something was weird to us.

So 19 of our 30 participants made comments when they were wearing their good program about that were consistent with the idea that this would be their good program. I should say, before I move forward that they didn't know when they went home which was their good program and which was their tolerable program. So they, they had this cooling off period. They were blinded, so they just went home and they didn't know if their hearing aid was supposed to be good sound quality or not good sound quality. So they were blinded to that.

So most participants said that when they were wearing their good program or the comments from their good program week were consistent with them liking their program. So for example, somebody said they were amazed at how Clear they were hearing somebody else said the sound quality was good, better than my own hearing aid. So these are all comments that made us think that we did, we got it right, their good program was good for them. 11 out of our 30 participants made comments during what

was supposed to be their good week that made us think that maybe that wasn't actually their good week. So, for example, one participant said nothing was enjoyable and another participant said, it's not been a good week and it felt like torture.

So it feels unfair for me to stand in front of you and say, look, we made hearing aid sound quality better and their mood was better because their sound quality wasn't actually better. So I want to show you what happens if we separate the people who had consistent preferences so they actually liked their good program at home versus people who had inconsistent preferences, which is they didn't like their good program at home. So we had about this two thirds, one third split, and you can see that the trend is kind of in the same direction. So when people are wearing hearing aids with the sound quality that they actually liked when they got home, their mood was better. At the end of the day, we had a small sample size of people who were inconsistent.

So that didn't reach significance. But you can see that it's going in that in the right direction in that their ratings of mood were better when they were using the hearing aid, sound hearing aids with sound quality that they preferred while they were at home.

So to interpret those data, just to reiterate this, when they were in their preferred program, their mood at the end of the day was better. Their preferred program for most people was the one that they set while they were in the lab. And for most people, it was pretty similar to now. Some people actually preferred the version that had now slightly less than now gain. So remember, that tolerable program was on average 5 to 10dB lower than now in the mid to high frequencies.

And that's the one that some people preferred. But in order to know they preferred it, they needed to go home and wear it at home and see what it felt like. So at the end of the day, their mood was better when they were in the hearing aid program that they liked, not the one that was closer to now, not the one that was further from now, not the one that they necessarily the one that they programmed in the

lab, but the one that they liked while they were at home listening to their everyday, normal, typical sounds.

So first before we. Well, not first because we're halfway into this, but here, pause here for a Minute and just say that I will add to the list that I showed you at the beginning that auditory experiences can affect mood at the end of the day. So in addition to light, temperature and clothing, we can add auditory experiences. And specifically getting that personalized hearing aid sound quality is, is how we can affect mood at the end of the day. So for most people we were able to see that this individualized gain settings improved mood at the end of the day.

Some people needed a trial period at home to figure out which hearing aid sound quality they liked. But regardless which camp they were in, we've shown that auditory experiences can affect mood at the end of the day and auditory experiences can affect listening related fatigue at the end of the week. So remember they did this Vanderbilt fatigue scale at the end of each week thinking about in retrospect their prior week. And here higher is actually worse. So on this scale, higher means that they had more frequent fatigue and lower means they had less frequent fatigue.

And we have these two groups again, people who had the consistent laboratory and home based preferences and the people who the 11 people who switched whether which program they liked better when they were at home. Also on this figure I'm showing the median score for people who have normal hearing. So that's a score of five. That's that dash line. So we can see kind of interestingly, people when they're using their preferred hearing aid gain profile, their on average ratings of fatigue are similar to people who have normal hearing.

But if we take them away from their preferred hearing aid gain profile, we put them in that tolerable program, their ratings of listening related fatigue increase and they're no longer similar to adults who have hearing loss. So we're increasing listening related fatigue by putting them in a non preferred

hearing aid program.

So this just summarizes exactly what I've just said, which is that auditory experiences can affect not only mood but also listening related fatigue. At the end of the week, listening with their preferred program reduced listening related fatigue to levels that were similar to adults who have normal hearing. And using a non preferred program increased listening related fatigue. Now as a reminder, these effects aren't driven by audibility or speech and noise performance in the way that we measured it. Because we don't have differences in quick sense scores or hearing aid use time or SII values between these good and bad good and tolerable programs.

It's about the hearing aid preference for sound quality, not audibility or changes in speech performance.

Okay, so the second study I want to talk about is looking at instead of gain Differences looking at hearing aid sound design. So the reason we wanted to do this is it seems unlikely that as a clinician, you or I would ask somebody to manipulate hearing aid sound quality so that they could just barely tolerate it right already. Our goal is to make hearing aid sound the best that we can and to optimize sound quality and user experience for our patients. So we're very unlikely to naturally set up this good versus tolerable sound quality comparison. But we do know, and we do suspect that hearing aids, which vary in sound design, also vary in ratings of sound quality.

So we're going to leverage some of these natural differences in hearing aid sound design and inherent differences in sound quality to again address this question about hearing aid sound quality and mood. So we're using the same general approach. Remember, they've got two different, in this case, two different hearing aid brands. So they go home with one, they rate sound quality and mood. At the end of the day, they come back, they answer questions about listening related fatigue, they switch hearing aid sound designs, they go home, they rate sound quality and mood.

At the end of the day, they come back, they rate listening related fatigue, and they give us the hearing aids. So they're not keeping any of the hearing aids, we're not selling them to them. This is all just part of the the research experience.

The other thing that I wanted to do is increase our scope about measures of mood. So in that first study, we only measured a scene related affect, vigor and fatigue. And we know that anger and tension are also moods that exist and they feel somewhat intuitive. They felt intuitive to me at the end of the day, if I say I'm in a bad mood, it usually means it's because I'm angry and tense and maybe hangry. So I wanted to see if we could expand our study of mood by including ratings of anger and tension.

We included 40 adults with hearing aid experience. Most of them also reported that sound quality is important to them. Only two of them didn't. Mostly people rated that or said that sound quality is important to them because they like to hear, they like to communicate, they like music. Similar age ranges before we added.

An additional exclusion here is that what we're going to do, and you'll see in a minute, is compare two different brands from wsa. And we wanted to make sure that nobody had experience with WSA brands. So all of our patients were using hearing aids, but none of them had experience with WSA brands. So they're mostly Phonak and Oticon hearing aid users.

So we fit everybody with two premium level hearing aids and we tried to match colors so that if, you know, they, they picked a silver white X they were also fit with a sil silver Signia and we fit them using their proprietary first fit gain algorithms and send people home.

Now the reason that this, we thought this might work is because these two brands have different sound designs and two different sound design philosophi. So Widex philosophy is generally a less is more approach. They're focused on natural sounds and they have this time domain processing, whereas

Signia is really focused more on noise management, making the speech come to the forefront and getting rid of as much background noise as possible. And they're using, also using frequency domain processing. So naturally you might have experienced, I have experienced patients who really, really like Widex hearing aids or really don't like Widex hearing aids.

And so there are, within that company, they know that there are people who have these preferences for one hearing aid sound design versus another. As I mentioned at the beginning, it's difficult to know beforehand who's going to like what. So it's hard to predict based on an audiogram or an age or so on who's going to like which sound design. And importantly, we know that these sound designs differ in ratings of sound quality on an individual level.

So I probably shouldn't admit this, but I'm going to show you anyway. So these are ratings of, these are distributions of ratings of each type of mood. So steam related affect, vigor, fatigue, anger and tension. So in all of these higher scores are better. So you can see if we look at the green ones, so affect, vigor and fatigue, you can see that we have ratings kind of across the board.

We have some ratings down at zero and we have them all the way up at four. And those distributions are kind of flat. Our anger intention distributions are very, very skewed. So we have lots and lots and lots of ratings of 4. So our patients in our study reported very, very little anger and tension.

So that's great for them, but it means maybe they're less, they spend less time being hangry than I do. So I will leave aside for now the anger and tension scores and continue to focus on a seam related affect, vigor and fatigue. But also feel pretty good that our patients are not angry or tense. Oh, those are animations. So first thing I want to show you is correlations between ratings of sound quality and ratings of mood.

So again we have on the x axis ratings of sound quality. Higher or to the right means ratings were of sound quality were better and higher means ratings of mood were better. So we see for all three subscales seem related affect, vigor and fatigue. Higher ratings of sound quality were related to better mood at the end of the day. This was only statistically significant for ratings of vigor, but we can see kind of the same trend for for all three.

And I think that's just because we have more variability in ratings of vigor. In general, our patients had pretty high ratings of esteem related affect and pretty good ratings of fatigue. So this is reverse scored. So higher is better. So in general they're not fatigued and they feel pretty confident.

And their vigor varies more day to day. And on days when their hearing aid sound quality was better, their vigor was also more likely to be higher.

Now the next thing I would like to show you is the remember in that first study we had the good and the tolerable program. So it'd be nice to group and look at mean data for mood at the end of the day using a good and or a tolerable hearing aid sound quality. But we don't have good and tolerable because we, in this case, because we think we know that both of these are premium level devices that have presumably good sound quality. They just vary in their sound design. So this, because sound quality is so individualized, we know that the preferences for these brands will vary.

So what we did is went into the daily ratings of sound quality and looked to see which patients preferred Signia versus widex. And we assigned them preference categories based on their sound quality ratings. So what you'll see, these are just six participants. And so I just want to use them as an example. These first two had ratings of sound quality that were higher with Signia as indicated by the red boxes than with widex, as indicated by the purple.

So these two people and any patients whose data looked like them would be assigned to this Signia category. We preferred Signia category. We also had the reverse. So we had participants whose ratings of sound quality were higher with the WIDEX than with Signia. So these bottom two participants are examples of patients who preferred based on sound quality judgments, widex than Signia.

We also had a bunch of people in the middle whose ratings of sound quality were similar between the Signia and the widex. So those two in the middle were assigned to a no preference or an either category.

This figure is showing the distribution of those preference assignments. So you can see about half of our participants didn't have a difference between sound quality ratings between the two brands or between the two sound designs. So they have ratings of sound quality that were the same. Same enough for Signia and Widex. Among those that had differences between brands, we had about half, maybe a little bit more than half, preferred Signia and about half, maybe a little bit less than half, preferred Widex.

So this again suggests that sound quality is highly personal, right? There are people who preferred Widex and there are people who preferred Cinea. And we couldn't predict based on age or gender or audiogram who is going to prefer which, but we have assigned them to these preference categories based on their sound quality ratings.

So now we can, using the sound preference assignments, look at mood at the end of the day, average across the week. So what we're seeing here, the no preference participants are in gray. The when they had a preference and they were not using their preferred brand, they're in red. And when they were had a preference and were using their preferred brand, they were in green. So again we see hearing aid sound quality using the preferred brand results in better mood at the end of the day.

So this is maybe by now old hat because I've been talking for, I don't know, 40 something minutes. But remember that this is a comparison between two great brands. These are premium level devices whose sound quality is expected to be great. And even still we see differences in sound and mood when we look at people's preferences and whether or not they were using their preferred brand or their preferred sound design based on sound quality.

So thinking about listening related fatigue, the other thing we did in the study is we didn't want to just let listening related fatigue look at just listening related fatigue and sound quality. We wanted to look at listening related fatigue and other things that we know affect listening related fatigue like social participation, listening efforts. So what I'm showing you here are correlations between listening related fatigue. So higher on the score means more frequent fatigue. And then I've z scaled these three different kinds of questionnaires we gave people and what you can see is when they were more socially connected, when they had better listening effort.

No, sorry. When they were less socially connected, had more listening effort and had worse hearing aid sound quality, Their ratings of listening related fatigue were.

I think I've said this wrong. Doesn't matter. Hearing, listening related fatigue and sound quality were significantly related even when taking into consideration listening effort and social participation, which also affect listening related fatigue.

So to summarize where we are and where we've we've been so far, we've seen that sound quality is related to mood at the end of the day. And I've shown you that in two different ways. One, we in the correlations between ratings of mood and ratings of sound quality. So on days when the hearing aid sound quality was better to them, ratings of mood were also better.

Yep. And during weeks when hearing aid sound quality was better, ratings of listening related fatigue were better. We've also seen that ratings of mood average over the week are better when they're using a preferred hearing aid setting. So we saw that in that first study when they're using the good hearing aid frequency shaping that they individually set and preferred, they individually set in the lab and then preferred at home. And then we also saw it in this most recent study that I talked about where we've got them.

Participants are using their preferred hearing aid sound design. The ratings of mood are also better at the end of the day. So this combination of results and data to me says that sound quality can affect mood and listening related fatigue. And the importance of sound quality exists even when we're talking about well fit premium level devices. So it's about, it's not about the, in these studies, it's not necessarily about the quality of the device and it's about pairing the sound quality to the person's personal preferences.

And I would like to reiterate that we have done the things that would be necessary to make sure that this is. These relationships hold and are specific to sound quality and mood. So we've looked at things that could potentially be driving mood or interacting with sound quality and mood like age or degree of hearing loss or speech intelligibility or how far away were they from now targets.

None of those things seem to matter. We also looked at, I didn't mention it, but in the daily ratings we looked at social participation to make sure that they just weren't in a better mood because they were more socially active. And that didn't contribute either. And we've seen not only these relationships exist when we make these unrealistic gain setting changes, but also when we compare premium level devices.

So a natural question that you might be asking yourself is what how can I, what do I do with this information? How do I improve mood at the end of the day for my patients? And my main message here

is that I would like to reiterate the importance of optimizing sound quality for individual patients. So it's about matching preference to matching the hearing aid to the preference of the patient. So you could take the same sound design and hearing a gain and give it to everybody.

So one brand, one gain setting and give it to everybody using a uniform approach. If you remember from graduate school, this was an approach that was popular back in the 30s and 40s. And I don't think I need to say much more about it because that is the opposite of individually optimizing sound quality for patients. We could also take an adjustment approach or where we start with something more uniform or individually tailored based on an audiogram and then adjust it. We could try a predictive approach where we're trying to decide which patients are going to prefer which brand or which sound quality.

Or we could try a combination of approaches. So this uniform approach, as I've already mentioned, probably not the best approach to individually tailoring hearing aid sound quality for each patient, but examples of uniform approaches that you might see might be using a first fit approach and never changing from it, matching to a prescriptive fitting and never changing from it, fitting only one brand and only one prescriptive target. We know that this approach won't work for everybody. I probably don't need to belabor this point, but I've already shown you that there's not a one size fits all approach to hearing aids. And this is probably intuitive and you know it.

You could try an adjustment approach where we take, we start with a prescription or a first fit and then we make adjustments in the clinic. How does it sound? How does my voice sound In a clinical setting? This is tough if this is your only approach to adjusting. As I've shown you in our mood study, we had this pretty robust, long, complicated procedure and still when they went home, about a third of patients didn't prefer what they'd set in the lab.

And this is consistent with other research in this area. We know that in clinical settings it can be tough to hear differences between gain settings. Patient descriptions might be difficult to interpret and that experience can be frustrating if you're just trying to do it only in a clinical setting. You could try a predictive approach which would be to select a hearing aid brand and or gain settings before you fit to a patient and that be it. We know that sound preferences and preferences for sound design aren't easy to predict based on age or gender, degree of hearing loss.

So this approach by itself is probably not sufficient. So all of this to say that my suggestion today would be a combination approach where you maybe pre select the most appropriate device and gain adjust it and fit to targets or a first fit adjust it based on their feedback in the, in the clinic, encourage a field trial, let them try it at home, come back and then make adjustments. These adjustments could be things that audiologists are Doing could also be adjustments with the app. But this kind of iterative process where you're really tailoring and targeting hearing aid settings to optimize sound quality has the potential to have really great benefits. So these home trials offer exposures to typical soundscapes.

They have the time and the space to try out a variety of different settings. You get the, the patient invested in the process and you have, if you're successful, matched sound quality for an individual so you've got the preference to the patient. Again, individualization is key. I think I have, I don't want to belabor this point too much, but the data that I've shown you suggests that this personalization is really important. So the person, the personalization based on their own experiences in their own life, with the opportunity to adjust and optimize hearing aid sound quality individually for themselves, has the potential to really improve mood at the end of the day and listening related fatigue.

So in my last, I don't know, minute, I want to just highlight this with a couple of case examples, I guess. So in this follow up study where we compared two hearing aid sound designs, we also asked them to give us some information about their, their day or the listening experiences in part so we could see if

they, you know, liked the hearing aid settings. Also so we could exclude people who had things like oh, I've got Covid or I'm in the hospital or whatever. We wanted to make sure that we're capturing data that really just exhibit or focus on their normal routine kinds of life. So we've got all these free text comments and reading through those free text comments really has highlighted for me the importance and the benefit of matching the sound quality to a patient's preferences and also might offer some mechanistic explanations here.

So, for example, this patient is a, I can't remember how old he is, but he's a gentleman. And he said while wearing his Signia hearing aids that at dinner outdoors he was able to hear better than he's generally used to. He realized through this experience that he's picked up the habit of assuming he's not going to be involved in the conversation. So he's an existing established hearing aid user, has worn hearing aids for a long time and now with the Signia devices, which by the way, Signia was his preferred brand. So his sound quality ratings were higher with Signia than with Widex.

And with these Signia devices he feels like he's able to participate more in conversations and more than he used to be able to participate more. So this is an example of the importance and the benefit of matching the person with the sound quality.

And as I mentioned might offer a mechanistic explanation because it might be that his mood is better because now he gets to participate more. He doesn't feel left out. The sound quality of the instrument is really helping him participate fully in his life. But it's not that Signia is a better brand. That's not what I'm saying.

Because we see the same kind of thing on the widex side. So this particular patient was assigned to the widex preference category. So she plays a mountain dulcimer. I didn't know what it was, I had to look it up. But it's a guitar like instrument that is common's not quite the right word, but we see it in Appalachia.

You can play folk music on it. And she is a mountain dulcimer player and she describes the experience of with the Widex hearing aids being able to hear the warm tone and that playing this mountain dulcimer was a pleasure where before with her old hearing aids she felt like she had to convince herself and just trust that this instrument makes a nice warm sound because she couldn't hear the warmth and the pleasantness and the niceness in this instrument that she presumably loves to play. So again, she's an established hearing aid user. But the switch to this brand that has a better sound quality for her lets her participate in and interact more fully with the things that she loves to do. So again, more potential insight into this relationship between sound quality and mood.

Because probably her mood at the end of the day is better because she can, it's a better sensory experience and she can more fully, fully participate in the things that she wants to do and the things that she enjoys doing.

So key takeaway points here. Just to reiterate what I want you to remember because I've talked about a lot of things and I've shown you a lot of things. I hope that I have shown you evidence to convince you that hearing aid sound quality can improve mood both at the end of the day in ratings of vigor, esteem and fatigue and then at the end over the course of about a week. So in terms of listening related fatigue, getting the right hearing aid sound quality for a patient can improve their mood at the end of the day and at the end of the week. I've also talked about at length how the personalization piece is important that we need to pair the sound quality with the patient and get something that they prefer.

There's no approach, no gain configuration, no sound design that works for everyone. We've seen that, at least in that first study, their preferences change between the clinic lab setting and at home. So it wasn't something that we could do in the lab. For some people the things that we were doing in the lab or the clinic weren't being successful at home for them. So it required both a lab and a field trial to get the settings right for them.

But when the sound quality was right for them, they were. They had better mood and better listening related fatigue. So with that I will take some. I have a couple of minutes for questions I think. So I'm just going to leave up on this slide while I answer questions some of the key findings and also again my great team at Vanderbilt nwsa.

The data slides that you're looking at are related to listening related fatigue and mood in that gain study.

So let me see if I can find some questions. Ah, so somebody says I may have missed this, but are these new users or previous users? Yeah, I probably didn't say it very often.

They are all established hearing aid users. So we definitely focus on people who were existing hearing aid users. In the second study they didn't have any Widex experience. We didn't have that. Widex or Signia, we didn't have that in the first study.

But when we did compare the brands they were existing hearing aid users but not of Widex or Signia.

Other I don't see any other questions.

It's fine if you don't have questions, but if you learn something today, can I. I'd love to see an emoji, a fun emoji. The cat's gone. But I did see some cat emojis earlier. That was fun. I appreciate that.

Dr. Picou, one question actually came in through the chat. Oh, I can read that one. It says what? And I was actually curious about this one as well. What's your experience about letting a patient try different brands versus what you recommend as best is the best brand for the patient?

Yeah, I now I think what works in your clinic workflow would be great. So if you are in a kind of place where you can train try different brands, I think that's a great, that's a great option. If you're not in a place where that works, then obviously don't do that. But I one of the things that's been really surprising to me especially about this brand comparison, is just how much of a difference we saw for some people between the Signia and the Widex brands and and they didn't come into it. Nobody came into it thinking, oh, I really need a Signia or a Widex hearing aid.

But some of them really loved a different brand than the brand that they were used to. So if you have that option, I think it's great. I fully, fully recommend it.

Thank you. Then I was thinking, like, how many brands do we need to offer? Because they'll notice a difference. And the person said thank you to that. But that's just rhetorical.

So, yeah, I don't know. I feel like there's a right answer to that question. I'm going to go with five.

Last question before we wrap. What's next? Where are you going to go with this mood research now, do you think? I love that question. My dream would be to see if we could get more into a cause and effect.

So I want to bring people in and change their mood in the lab and, you know, play around with the sound quality while we change the mood in the lab. So there are nice ways to do that. Like, we can stress them. That's not a nice way we could stress them. I don't like that one.

I'm trying to. I'm thinking about designing a study where they come in and we try to make their mood better. And we do it with different hearing aids. Different hearing aids. Different hearing aid gain settings.

So I love that. Well, if. If it happens, please come back and tell us about it. I will. All right.

Thank you so much. It's always great having you on. When I saw a post about this research a while ago, I was like, I never thought about this. And I love just hearing you explain your research. We have one comment that says, thank you for your time today.

This was an excellent presentation. Lots of thank yous in the chat. So thanks from the participants as well. And that wraps today's webinar. Hope to see everybody again soon in another audiology online webinar.

Have a great afternoon. Thank you, everybody.