Hearing Aid Technologies for Supporting Teenagers' Unique Listening Needs

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

It's my pleasure to welcome back Dr. Erin Picou. Dr. Picou comes to us from the Vanderbilt University Medical Center. If you'd like to learn more about our speaker today, you can read their bio on the course registration page.

But at this time, I'll hand the mic over to you. Thank you, Christy, for the introduction and thank you for the opportunity to be here. Super honored to be part of this innovation summit and to be here to talk about hearing aid technologies and teenagers today.

These are my disclosures. This is a list of some limitations and risks that are inherent to participating in today's webinar. And these are my stated learning outcomes. And I do think or hope that by the end of today's talk, I will have achieved all these, but we'll revisit them at the end just to make sure. So I also do want to take just a minute to acknowledge and thank a whole group of people who have been really instrumental in the work that I'm going to talk about.

And most of what I'm going to talk about has been funded by Phonak or Synova. So I'd like to thank them for that. So I do want to contextualize my talk and my, my slides. Today I am talking about teenagers. So I've been working really hard to use the word teenager when I talk about this particular patient population.

So they're not children. They, at least my teenagers don't like to be called children and they're not yet adults. So they have this really interesting and diverse kinds of listening needs at which we'll talk about. But I just want to contextualize today's talk and show you what teenagers might look like. These are some teenagers.

They might have been in my study, they might not. And I do want to talk about today we are going to talk about teenagers. So thinking about that teen age group. And today I am going to specifically focus on teenagers who have bilateral hearing loss and who are using hearing aids. So we're not talking

about cochlear implant users and we are going to talk a lot about the kinds of hearing aid technologies that could be appropriate for for teenagers.

So if none of those things are interesting to you, or sorry, hopefully some of those things are interesting to you and you can stay with me for the next hour. So before we dive into the hearing aid technology for teenagers, I want to take a step back and talk about and think about the kinds of listening needs that teenagers have, because as I mentioned, at least for me, I think they have a they represent a unique population So I want to talk about that a little bit. So what's unique about teenagers? If you've worked with teenagers, you might already know what I'm going to say. But you know the adage, if you've seen one, you've seen them all.

I think that absolutely doesn't apply to teenagers and it doesn't apply to most of the populations that we work with. So I have heard people update this adage with something like, if you've seen one, you've seen one. So you can't. The idea being that you can't generalize from one person to the next in a particular population. And with teenagers, I'd say it's probably more appropriate to say something like, if you've seen one, you've seen one side of one.

Right? So this teenage year is. Teenage years are marked by lots of variability and diversity and rapid changes in growth and development and mood and listening environment. So I'm going to talk about some of those things today when I think about teenagers, at least in the school, classroom, school context, we talk a lot about classroom listening needs. And I love the focus on classroom listening needs because in classrooms, that's where students and teenagers are learning content and they're acquiring knowledge and they're growing and developing.

So we talk a lot, and I think a lot about classrooms. But I also recognize that classrooms are only part of the story, right? Teenagers spend a lot of time in schools, and schools are not only classrooms. Schools involve playgrounds or foot or fields, sports fields, hallways, gymnasiums, cafeterias. So really

diverse, changing listening needs.

And that's just at school. Teenagers have a life outside of school, believe it or not. So teenagers like to, many of them like to socialize, they have hobbies, they might work. And all of those have a unique set of listening needs and listening challenges. So that's one of the reasons that I think studying teenagers and working with teenagers is so interesting.

And let's talk about that a little bit more. So let's just dive into a case study. So this is Lillian. She's 13. She has bilater sensorineural hearing loss.

And just for context, she lives in a suburban town with her parents and her brother. And I mention that just because I recognize that Lillian represents Lillian and not all teenagers. But a typical day for Lillian, she might get the bus, catch the bus at 6:45, arrive at school at 7:10, come back home on the bus 2:55, do some homework, go to trombone practice, have dinner with her family, go to soccer practice, come home, do homework and maybe have some screen time, watch some TV or YouTube or something. So this is a typical day for Lillian. And you might imagine that each one of these activities has a really unique and distinct listening hallmark.

The bus is probably noisy. Road noise, noise from other students, lots of conversations happening, kind of chaotic acoustic scene. The school day we'll talk about in just a minute. The bus, again, is chaotic. Homework might be quiet, but she might also be streaming music or listening to music.

She might be watching videos to acquire content to do the homework. Trombone practice requires listening to music and hearing through her own trombone and maybe others. If she has a tutor family dinner, this is conversations might also have music in the background, maybe some chaos. Soccer practice involves listening to people who are close to her, like other people on the soccer team, or maybe people who are far away yelling at her, like coaches or something. So we've got lots of different

talkers kind of coming at her from different distances.

And then at the end of the day, she returns to this homework or screen time again, streaming or listening to music. So you see just a wide range of kinds of listening demands that Lillian has. And I'd like to add that it's probably punctuated. If Lillian is anything like my own teenagers, it's punctuated by things that are happening, arriving in her pocket on her phone. Right.

She might get texts from friends periodically throughout the day. That draws her attention. Her friends might be sending her videos, she might just be watching videos. So all of this diversity in listening is punctuated and interrupted by other things that require a rapid shift from what she was doing to this new thing and back to what she was doing before. And if we were to examine the school day itself, we might see the same or a similar kind of pattern.

Right. So this is her class day. We see a couple of different classes. The classes might be a combination of lecture where she's trying to listen to the teacher, and then group work where she's trying to listen to her friends or classmates. Group work.

And then also we have lunch there at 11:04, where we know that cafeterias tend to be really noisy and chaotic. P.E. also, let's say they're doing something inside the gym. So you've got noise and reverberation and yelling and people who are far away and people who are close, and then again, the musicality. So lots of different things happening in one school day that require lots of different kinds of listening for Lillian.

And then, of course, in the school day, we also have. It's punctuated by these four minute passing periods. So they're pretty short, but lots of important conversations happen in these hallways during this four minutes. And in those hallways, you've got noise and reverberation and just. Yeah.

So this just shows how much switching and how much diversity is in the kinds of listening demands for a teenager. I use this example, and I've said it already, but one of the themes or two of the themes about teenagers and listening is diversity. Right. In our case, we saw music, we saw stream signals, we saw speech and quiet, we saw speech and noise, we saw speech from a distance, we saw speech and music and reverberation. And that diversity comes with lots of quick transitions.

So we need whatever our hearing aid technology is, it needs to address both the breadth of listening needs and also do it really quickly. Then all of that is within the context of teenagers who have growing autonomy. They're no longer in elementary school where somebody's telling them what to do and doing all these things for them as they are moving to the teenage years, they want and deserve and need more control. So these rapid speed of transitions and this diversity of listening needs needs to happen within the umbrella of giving teenagers autonomy.

So we're going to see this slide a couple of times through the rest of the talk, but these are the implications, I think, for hearing technology in teenagers. So we know that teenagers need autonomy, and one of the things we can do to achieve that is give them control of their hearing technology. We also see that they have these really diverse listening situations. So in order to address that, we need to give them flexible technology that addresses lots of. Right.

Noise, distance, music, reverberation, again with the rapid transition. So there are a couple of ways, a couple of hearing aid technology features that we can address these rapid transitions. Transitions. Yeah. So I'll talk about how those might work in teenagers in just a minute.

And then finally, as I mentioned, Lillian is just one example. But we see variability in listening needs within Lillian's school day. And then Lillian doesn't represent all of the teenagers. So we also know that we have diversity across teenagers in the kinds of listening situations that they need. So how we address that variability and that diversity both within and across teenagers isn't necessarily a hearing

technology feature, but it could be really useful for us to get their perspective about what their listening needs are for an individual teenager, because it will vary across teenagers.

So that's actually where I want to start is looking at how do we address the variability within and across teenagers. And as I mentioned, one of the good ways to do that would be to ask, get Their perspective, get their insights, what are they listening to? What are their listening needs? So I think this might be an age old question. How do you solicit a teenager's perspective?

One way is to catch them at the right time. So if you ask them a question and they're in the mood, they might tell you. And if they're not in the mood, they might not tell you.

Another or in addition to that would be to use teen focused counseling techniques. So there's this really nice paper in 2012 by Chris English published in the Journal of Educational Audio Audiology that talks about counseling teenagers specifically. So if you are working with this population or maybe just getting started or thinking about it, I highly recommend this article. In that article there are a couple of. Well, there's lots of great information in there.

But two teen focused counseling techniques are to keep the conversation going and make sure the conversation is open so that you're giving the teenager space to talk to you when they're ready.

We can also use questionnaires to solicit teenagers perspective. Also within that article I just mentioned, they mentioned the Self Assessment for Communication Adolescent Scale. So it's a way to get to and solicit a teenager's perspective about their listening needs. I will also add my own questionnaire to this. So we have recently developed and published a study called the Vanderbilt Classroom Assessment Short Survey or the VCLASS for short.

And I want to talk about that questionnaire in a little bit more detail. The idea here behind the V class or the Vanderbilt Classroom Assessment Short Survey was to elicit teenagers and younger students perspective about the kinds of school based listening challenges they face. So we used questions for a scale that Todd Ricketts had highlighted and we put together a list of questions. Each question had a has a picture associated with it. So we're really trying to describe listening situations that children might face.

I'm sorry, see I did it. That teenagers might face in school based listening environments and get their perspective about how easy or difficult it is to listen in these situations. So for example, a person taking the questionnaire would see a picture and they'd be instructed to pretend they don't have any hearing devices and they'd say okay, so this picture shows somebody who's eating lunch with a friend in the cafeteria. If you were in that situation, would that be very easy? A little easy, not easy or hard?

A little hard, Very hard or it doesn't apply. I never eat in cafeteria, at tables, in a cafeteria. So we have 15 questions on the next three slides. I've got a list of the questions.

So for example, the one I gave you is I'm eating lunch at school, my friend is across the table telling story. And then the person taking the questionnaire would say that was really easy or not easy or not easy or difficult, for example, so, and so on. So we've got one in the cafeteria, we've got a couple in the classrooms. We've got situations that reflect quiet places, we've got situations that reflect loud places like a lunchroom or playing outside or also listening situations where the talker of interest isn't always in front. So for example, this question on the bottom of the slide says my teacher asked me a question while standing behind me in the classroom.

So we're trying to get, trying to capture somehow the kinds of diversity in classroom and school based listening situations that teenagers might face. Also trying to think about some other skills besides just listening to or understanding speech. So we have questions in there about auditory localization. So I'm

in a noisy gym and I hear someone say my name. How easy?

And I want to find out where they are. So how easy or difficult is that?

So here are three examples. So I've got three pictures here and underneath each of them is the prompt and just reminder. For every question we get a rating of 1 to 5 where 1 means that was really difficult, 5 is that's really easy, and a score of 3 means neutral. So our first foray into this was to test it with children, children who have unilateral hearing loss. So hearing loss in just one ear.

We used a broad distribution of, yeah, we used a broad, we distributed it broadly so we could get lots and lots of responses. So we ended up with children age 9 to 17 who have hearing loss in just one ear. We have over 1100 responses for these children who took the survey. And what I'm showing you here is just the distribution of the self reported degree of hearing loss. We've got a little loss, some people had a little loss, most of them had some loss or significant loss and some had total hearing loss in just that one ear.

Because we had so many data points, we were able to do some psychometric testing and subscale analysis. And what we ended up with are three subscales, each of which have pretty good internal reliability and they reflect three different kinds of listening situations. So one is listening situations where the talker and the listener are far apart. So for example, on the bottom left of the screen here you'll see that the student is in the back row and the teacher is in the front row. So there's a pretty big distance between the talker and the.

The listener. So we've got several questions like that. We've got several questions that have a small distance between the talker and the listener, but they're all inside. So in the middle picture here on the bottom, this is an example of a question from the near inside scale. So the talker and the listener are close together, but they're inside the building.

Other examples of this are like doing group work or listening in a cafeteria.

Finally, we have this subscale about listening near but outside. So this is an example on the bottom right, we've got two people who are talking to each other, and they're outside. So the difference between the near inside and near outside subscales are the. The kinds of room acoustics. Right in inside, we're facing noise and reverberation.

Outside, we just have open air, less reverberation, and probably less noise.

I think that the difference between the subscales is important and interesting, and it gives us some information about listening challenges that teenagers might be facing at school. So in this figure, what I'm showing you are average median responses, actually, to the three subscales for the participants who had four different degrees of hearing loss. A couple of things I want you to note first, if we look just at a little loss, so the light yellow bars, we see that scores are lower for the far subscale than either of the two near subscales. That means that listening to talkers who are further away from the listener is more challenging, because on this scale, lower means more difficult. We see that those far talkers are situations that are more challenging.

And we see that across the board. Regardless of whether or not the participant had a little loss, some loss, significant loss, or total loss, their responses to that far subscale are lower, meaning it was more difficult. That's one thing I want you to notice. The other one is we see progressively more lower scores as we see more hearing loss. People respond as teenagers who have total loss have lower scores than those who have a little bit loss.

That indicates that, in general, overall listening in classrooms is more difficult for children who have significant or total unilateral hearing loss than if they just have a little bit of unilateral hearing loss.

Now, a question you might be asking is, how does that compare to children in the same age range who have normal hearing in both ears? So what I'm showing you here is the figure you just looked at. So we've got a little Loss, some loss, significant loss, total loss in the facets. And I've added on the left scores from children who have verified normal hearing in both ears. What we see is overall and in general that they're doing a lot better.

So they think that those listening situations are generally really easy and much easier compared to the children who have unilateral hearing loss. Even though listening is generally much easier for the children who have normal hearing than unilateral hearing loss, we still see that those far talker questions are more difficult. So for all, all children, regardless of unilateral hearing loss or normal hearing in both ears, we see that those far talker listening situations are the most challenging.

Fortunately, the hearing aids, hearing devices, sorry, seem to help. So this is again children who have unilateral hearing loss and we ask them to repeat the questionnaire considering what their listening environment, listening experiences are like with the same questionnaire when they're using their personal listen devices. And so that everybody, well, not everybody, but we have different kinds of hearing devices that the children in this population were using. But across the board what you see is those scores are well above that middle line. So listening is much easier for these children when they're using their hearing devices.

And their scores, sorry, their scores look a lot similar to the children who have normal hearing.

But I said at the beginning that I was going to talk about teenagers who have bilateral hearing loss. So let me show you. We did look at, at questionnaire scores on the V class for teenagers who have bilateral hearing loss. We had 17 teenagers who are all existing hearing aid users and they completed the V class as if they were not wearing their hearing aids and then as if they were wearing their hearing

aids. You can see their average audiometric information here.

And what I did is I grouped the children who have, or, sorry, the teenagers who have bilateral hearing loss into a mild to moderate group and a moderate or greater group. So that's the mild to moderate is the light green and then the more significant is the teal. So a couple of things I want you to notice. One, I have replotted the scores for the children who have normal hearing on the left, so they're still in purple. So we see that children with normal hearing are still reporting that classroom school based listening environments are pretty easy.

And we see that the children who have bilateral hearing loss don't. So their scores are lower, meaning that those listening situations are more difficult and they're more difficult for children who have more significant hearing loss. And we continue to see the far subscale questions have the lowest scores. So those listening situations that are the most difficult are the ones where the talker and the listener are far away. Very similar to the pattern of results that we saw for children who have unilateral hearing loss.

Fortunately, we do see that the hearing aids seem to be helping. So in our sample of 17 teenagers anyway, we see that their scores with their hearing aids are well above that middle line for the most part. So they report that with their hearing aids they're able to hear pretty well in those school based listening situations and they look more similar to the children who have normal hearing in both ears. Yet we still see these far talker scores are the lowest. So regardless of whether the children have heard normal hearing in both ears, bilateral hearing loss or unilateral hearing loss, or whether or not they're wearing devices, listening to a talker who's far away is the most challenging kind of listening situation that our teenagers report facing based on this questionnaire.

So just to summarize that VClass, I think we have this validated, empirically derived and internally consistent questionnaire that I think we could use to help evaluate and monitor school based listening situations for teenagers and maybe pre teenagers. And the data suggest that. The data that we have so

far suggests that listening to a talker who's far away is the most challenging kind of listening situation that we asked about. And again, that was true regardless of the degree or configuration of the hearing loss of the participants who took our survey. So I see the VClass as being useful in a couple of ways.

One, I would love to keep using it in research, so that's what I'm going to do. But I think clinically we could use it to identify students who are having difficulties. We might be able to use the VClass to pick up children who are having or teenagers who are having trouble in classroom situations that maybe didn't show up in another kind of way. If we did that, we could use the V class to identify specific listening situations that are challenging. So is it just things when reverberation and background background noise are playing a role, or is it when the talker and the listener are far away, or is it really just all listening situations?

And then also I think we could use it to monitor device success. So we know that with hearing aids, both children with bilateral and unilateral hearing loss tend to do better with their devices. So if we are fitting devices and we're not seeing that they're doing better, maybe we need to go in and reevaluate the hearing technology that our teenagers are using. So if you're interested, this feels like a little bit of a plug and it is. But if you're interested in using it or checking it out, I have a version of the VClass linked here.

We've set it up to be in RedCap so you can deliver it electronically and then download the scores. We also ask for some demographic information at the beginning. You can skip all of that if you just want to get straight to the questions. But if you did put in some of that demographic information, it would help us to continue to work on the questionnaire.

So I want to just. Let's return to Lillian. So let's say that we gave Lillian a V class and she had a score on average of three and a half. So her total V class score was three and a half. That indicates that listening is just a little bit easy in school based environments, but it's really just, just above the, the

neutral line.

So listening for her generally is pretty easy. But we see that her near Inside subscale is 2. So that means that in those listening situations where she's close to a talker but they're inside, like in the cafeteria or doing group work where there's noise and reverberation, her score is a 2, which means she's having listening difficulties in this specific kind of listening situation. That gives us an insight into what kind of technology we might use to help her. So in this case, I would think about using more advanced noise cleaning algorithms to really address the background noise and the reverberation that might be affecting her near inside subscale score.

Okay, so when we're thinking about teenagers, we've talked about autonomy, diversity of listening situations, rapid transitions, and what I just got done talking about is how to get their perspective and measure the variability within and across teenagers. And now I want to move on to thinking about. I'm going to switch to thinking about rapid transitions. So we know that with Lillian, she's moving back and forth between a bunch of different. She's got a lot of texts coming in and she's a teenager, so she needs some control.

How do we get her that? And one solution that we have available currently is tap control. So remember, Lillian is. She's got this really pretty busy day. She's very active and her active day is punctuated by texts and video and streaming and, and music.

And so it would be nice to have a way for her to move in and out of these streamed signals. So she wears bilateral hearing aids. She has an iPhone. She loves streaming. She does have a YouTube account, but she uses it responsibly.

And because she wears hearing aids that are controlled by her smartphone, she's allowed to use it in the classroom. So what kind of options do we have for giving her control for rapidly changing? One is a

program button or a remote control, so she could use it to change to a streamed program. Program buttons and remote controls are available in most form factors. They have lots of options for control.

So as an audiologist, you could program the kind of control and the way that she can interact with it. And you can do, right, one hearing aid, that one button that programs both hearing aids, so it's less work. The downside of program buttons and remote controls is that at least for noise cleaning, most teenagers don't use it, so they don't press the button. So another option would be control on the smartphone. Right?

So it's easy to open your phone and make adjustments. The downside is it does require the smartphone to be there. And often smartphone controls offer many options for control. And it does require interaction with the phone. So you have to pull it out, look at it, and, and do stuff.

So that's not always ideal. So tap control is a possible third solution. So with tap control, at least the way that Phonak is implementing tap control, you can double tap the pinna to start, stop streaming or start and stop or answer a phone call, or activate a voice assistant like Siri or Alexa. And within the programming software, you can control the strength necessary for the double tap. So you, depending on the person and they're tapping, you can adjust it so it's not too sensitive or it's not too hard to double tap it.

We wanted to know if this would be good for teenagers. So we fit participants in a study with Audeo L90RS. We trained them on tap control and we encouraged them to use tap control for about a week while they were at home. You'll recognize these audios as the same teenagers who took the A to B class. After they took the tap control and they wore it at home, we asked them to tell us what they thought.

Was it easy? Did you like it? Would you keep using it? So one of the major findings from this study was that everybody was able to demonstrate that they could use tap control. So it was very, very easy to train our teenage participants to double tap.

And they were very quick to pick up that you could double tap on one side and that would start and stop streaming, double tap the other side. And it enables voice assist and Then either side answers the phone. So they, they figured out and were very easily trained. It didn't take very much work and they were able to demonstrate these skills immediately after training and then after some amount of time after they were at home, then they told us what they thought. Most teenagers said that TAP was easy to use.

So in this figure, this little donut figure, we see that almost everybody said that that TAP was easy, either very easy or a little easy to start and stop streaming. It was also most of them said that it was easy to answer phone calls and very easy to start and stop or to call their voice assistant. So their Alexa or their Siri.

And we asked them what they thought about TAP control and why they might like it. And these are the kinds of responses we got. So the TAP was just cool, just a simple tap would do the trick. Well, when I got a call and I was busy, it was very easy just to tap my ear instead of stop what I was doing, pull out the phone, answer the call. So that was nice.

And it was faster than taking out the phone and pressing pause. So it really. These kinds of comments highlight what I was saying earlier about how we need some kind of technology that is able to rapidly adjust to the kinds of listening demands that our teenagers are facing. And it's nice not to have to pull up the phone and interact with it in order to make those changes. We asked our participants if they preferred TAP to the alternative so interacting on the smartphone.

For the most part, most of them said they liked TAP better for streaming. Most of them said they liked TAP better for answering the phone calls, and most of them said they liked TAP better than calling voice assistant. I will say that most of the free response questions that we got about why they don't like TAP control was related to voice assistant. So for example, the last comment here on the slide says it was easy, but when I was putting my hair behind my ear it would call Siri. So I think that the voice assistants were inserting themselves into the teenagers lives in a way that maybe they didn't like, but otherwise for the most part they found TAP to be easier.

And some of these things, some of these negative comments about tap, we could readdress with training, right? So sometimes when I tapped it it didn't work. So we could bring them back and then adjust that sensitivity of the TAP in the programming software so that it always worked when they did tap. Also we could address this comment about it being confusing sometimes because I would accidentally hang up on a call. So that would probably Be a little bit more training and just some experience with tap and I think it would be more reliable, more robust.

So let's return to this question about options for hearing aid control. So thinking about rapid transitions and diversity of listening needs, we talked about why, or I talked about why a program, button or remote control might not be optimal for addressing the kinds of like streaming phone call content. A smartphone app could work, but TAP control does a nice job of addressing the kinds of phone based streaming transitions. So our training was easy and successful. Everybody right away was able to demonstrate that it worked and they knew which ear did which function.

Most of the teenagers in our study reported liking to use it, use it especially for the phone and streaming. So I think this is a nice solution that addresses the kind of autonomy and need for rapid transition that we've talked about for our teenagers.

So we just did this. We talked about the need for autonomy. We're giving them control, and in this case we can give them control to the streaming through tap.

So the next thing I want to talk about is diversity of listening situations specifically addressing noise. So many of those listening situations that I walked through with Lillian included some kind of noise, right? Lillian's in noise, in the bus, at soccer practice, in pe, in the lunch room, in the hallways. Lots of different kinds of noisy listening situations.

So what kinds of hearing aid technologies do we have available for children to. I'm sorry, see, I did it again. What kinds of noise cleaning algorithms do we have available for teenagers that could help address listening in noise?

And actually, let's move away from Lillian and talk about Hunter. So Hunter has bilateral hearing loss and he wears RIC devices mostly full time. He is a teenager now, but a couple of years, many years ago, his audiologist deactivated advanced features, including most of the noise reduction options, and hasn't revisited that decision since then. Hunter reports being tired at the end of the day. He loves mountain biking.

He loves being on the mountain biking team. It's also a nice quiet sport for the most part. But he has trouble making it to practices after school because he just feels so tired at the end of the day. So this kind of report is consistent with what we see in the literature. We know that listening in noise is difficult for everybody.

It's not specific to teenagers, but we do know that listening in noise can interfere with learning and so it can be harder to learn. When you're listening in noise, you're using more cognitive resources to hear, so you have fewer available for other things. Like learning can be effortful to listen in noise, so that, like I said, they're working harder, they've got more cognitive resources devoted to listening. And as a

result, listening and noise can be very fatiguing. So we did a study a couple of years ago in the lab where we were looking at speech recognition testing in noise and reverberation.

And you can find the details of that in that paper that I've got referenced. But the important point that I want to make here is that after only 25 minutes of listening, adolescents, teenagers reported a 56% increase in fatigue when they were listening in noise. So they get really tired really fast. It doesn't have to be just an end of the day kind of thing. It can be.

It's not even the end of one period, right? 25 minutes isn't very long. And if you're listening in noise, that can be really fatiguing, especially if you have hearing loss. So you know as well as I do that we'd like to do something to address listening noise for teenagers. The kinds of things that we have in our arsenal currently include directional microphones, digital noise reduction, and then advanced digital noise reduction.

So I want to go through some of these. So directional microphones are the first one I want to go through. So we know, and we've known for a while that in adults directional microphones can improve speech recognition under the right circumstances. So if reverberation is low, there's spatial separation between the talker of interest and the background noise and the listener is pointed their nose at who they're listening to. So all of those things can maximize directional benefits.

We also see directional benefits in teenagers. So there's nothing unique about teenagers here. As long as they're in those listening situations where they are in low reverberation facing the talker of interest and there's spatial separation between the speech and the noise, then we would also expect directional bike directional microphone benefits for teenagers.

So that's specific to speech recognition. We've also seen some evidence in the literature to support directional microphones reducing listening effort. We see it in adults, particularly in complex listening

environments. We have seen some evidence of directional microphones reducing listening effort in teenagers, particularly the teenagers who are struggling the most or have the highest listening effort without the directional microphones. So we know that fitting directional microphones on teenagers can improve speech recognition performance and reduce listening effort.

And we would also hope that the combination of those things would reduce listening related fatigue at the end of the day. So directional microphones are a great option for teenagers. Another option is in addition to Directional microphones would be digital noise reduction. So what I mean here is this single microphone, acoustic based or modulation based digital noise reduction. So we've seen in the literature lots and lots of evidence that suggests that digital noise reduction can has robust subjective benefits of improving listening comfort and maybe also reducing listening effort for adults and also school age children, at least in terms of subjective preference.

The listening effort benefits I've only seen in adults, but we would imagine that those would also translate down to teenagers.

The benefits of digital noise reduction for adults and teenagers however, are specific to those subjective and also listening effort based benefits. So we don't see any changes in speech recognition performance generally with digital noise reduction. But those are both great options, right? Directional microphones and digital noise reduction can both be used in combination to support listening in noise for adults and teenagers.

Now I want to move to advanced digital noise reduction. So one example of an advanced digital noise reduction is called dynamic noise cancellation. So this is a digital noise reduction that works in combination with the directional microphone to further improve the signal to noise ratio in challenging listening situations. So it does a really good job of reducing noise specifically from behind or beside the listener. So in this example here, I've got a person who's listening to a speech in green in front of them,

they've got noise surrounding them.

And then we would expect that activating dynamic noise cancellation or this advanced digital noise reduction would reduce the level even further of the sounds that are coming from behind.

So we tested advanced digital noise reduction again with the same population of teenagers who were in the TAP control study. There are a couple, we did a whole bunch of tests with them using this advanced digital noise reduction feature. But I want to talk about just a couple. So one would is the double blinded paired comparison testing and the other one was sentence recognition in noise testing. So we wanted to see if teenagers preferred to have this feature active.

We also wanted to make sure that, well, we wanted to see if there were speech recognition benefits and also to make sure that this advanced digital noise reduction wasn't interfering with sentence recognition and noise. Because if the digital noise reduction is too aggressive or is too active, it has the potential to interfere with sentence recognition or speech recognition performance. So we wanted to make sure that that wasn't the case.

So for our laboratory study, we fit participants to, we fit them with these hearing aids, but we fit the hearing aids to match the same frequency response of their own hearing aids. So what I'm showing you here is the DSL target in dark like black. And then what they were using and what we programmed them to in the laboratory in yellow and green, so you can see that relative to DSL targets, they were all underfoot. But we made our hearing aids, our research hearing aids match what they were used to. And we programmed these hearing aids with three manually accessible programs.

And we did it in a double blind way in that the person who programmed the hearing aids and assigned the manual programs was not the same person who did the testing. So the experimenter doing the testing didn't know which of the programs was which. Advanced Noise reduction setting. Those three

manually programs all had the same frequency response, but they varied by the strength of the advanced digital noise reduction. So it was off, weak or strong.

And we did double blind paired comparison testing. They were sitting in the lab and they had speech coming from in front and they had noise coming from all around, had two sentences that we just played on repeat. So they listened to two sentences in one program and then they listened to the same two sentences in another program. And then the experimenter asked them, which of those programs did you like better, the first one or the second one? And then how much better did you like it?

So, well, were they the same? So you get a score of one if they're the same. A score of one means, well, you made me pick, but I really can't tell the difference. And a score of five means, oh, it was a lot better. That was a lot easier to listen with the one that I chose.

So we compared, we did this round robin approach where we compared every program to every other program and we did it in both directions so that every program was in both the A and the B spot the same number of times. And what we did is we looked at those which program they preferred and we came up with their favorite program or the program they picked the most often. So if they picked each program 50% of the time, then they picked no program, basically because that's just random variability in their picking. Or if they picked the mild setting or the weak setting more often than anything else or the strong setting. Then we assign each participant to one of these categories.

So they had no preference. So no preference is the one participant we had who picked everything exactly the same number of times. We had two participants who preferred it to be off. So their preferred hearing aid advanced digital noise reduction setting was off. They did not prefer it to be on or active in either the mild or the strong case.

But you can see here, most of the participants preferred mild or strong advanced digital noise reduction. And importantly, there was no change in sentence recognition performance. For off, mild and strong. So there's nothing about this advanced digital noise reduction that is negatively affecting speech recognition performance.

So my interpretation and my summary of these data are that we see no downside to advanced digital noise reduction and most of the teenagers preferred it to be active. 80% of them preferred it to be active, either in the mild or the strong case. And I'm not, I. We looked at some predictive variables. I can't tell you what about those 20% who didn't like it.

I don't know why it wasn't based on like age or audiometric information, but there are some people who don't prefer it.

So Hunter, we could expect that activating advanced features like directional microphones, digital noise reduction and this advanced digital noise reduction might support school based listening, particularly in noise. It might reduce his listening effort and listening related fatigue. And certainly at least the advanced digital noise reduction. He might really like it. But what if he doesn't like it?

And do we need to give him control over advanced digital noise reduction? That's a good question. So we just talked about how we can address noise through a bunch of different noise cleaning algorithms. But now let's talk about this control piece. So how do we give him, and can we give him control of this advanced digital noise reduction?

Let's talk about control. Can we give him control? How should we do it? So I have already mentioned that when we have fit teenagers in the past with hearing aids that have a button or remote control and we train them on how to activate noise cleaning algorithms in schools. In this Ricketts et al.

2017 paper, none of the teenagers who are in our study use the program button or the remote control in a way that was. Oh no.

Appropriate. Oh no. I'm so sorry. Okay, so program button on the hearing aid or remote control is probably not going to be used widely by most teenagers. We did look at tap control.

Tap control has some benefits and everybody was able to use it. Everybody demonstrated that they could use it. But it's really specifically focused on streaming, stopping and starting streaming, answering phone calls and activating voice assistants. So that's really not going to help us here. Here we might think about smartphone applications.

So the downside of a smartphone application is that it does require access to a smartphone. And there is some concern among some professionals that if we give a teenager some control, they might overuse it. So they might go in and make too many adjustments and mess everything up or they might not use it or use it appropriately. So we wanted to know if we could Trust teenagers to use the smartphone app to adjust their advanced noise reduction and if they would like doing it. So we, the same teenagers, we trained them on the smartphone application, and we sent them home with a smartphone application and said, okay, use this on either your smartphone or our smartphone.

If they didn't have one, then they came back to the lab and we asked them what they thought. So what I'm showing you here are the number of participants who said that they didn't like the app to control digital noise reduction. They didn't like the app up a lot. They didn't like it very much. They liked it okay, or they liked it a lot.

And you can see that our most common answer is that they liked it okay, which to me sounds like a very teenager response. But most of them liked using it. However, the most common frequency of use was that they would use it several times a week. So some of our participants said they would never use

it, or maybe they might use it a couple times a month. Some said they'd use it many times a day.

Some said they'd use it once a day. But mostly they're using it several. They said they would use it several times a week. Now, if you think about Lillian's day, where she goes in and out of noisy situations really fast and she might want to control the degree of noise that she's experiencing, or cutting out several times a week probably isn't fast enough of a repetition, a transition to address Lillian's needs.

But several times a week is better than not at all. These last two kinds of questions that we asked were about confidence and anxiety. So we asked them if having access to the app increased their confidence for listening in noise. So if we give them control and autonomy and they can change the degree to which their noise reduction is active, do they feel better, more confident listening in noise? And most of them said, yeah, they feel at least a little bit more confident.

And some of them also said it didn't change their confidence. Mostly that's because they were plenty confident in noise already and they didn't need the app. And then finally, we looked at just participants or teenagers who reported feeling anxious in noise. So not confident, but anxious. Most of the ones who report feeling anxious in noise feel less anxious because they have the smartphone control.

So even though they're not going to use it very often, knowing that they can use it and having the ability to use it and control it makes them feel generally more confident and less anxious. So just returning to this thought about noise reduction controls, tap control works for Controlling streaming and phone calls and maybe a voice assistant. But a smartphone application can be useful for changing the strength of advanced digital noise reduction. So that's a really nice skill. What I didn't talk about and I didn't show you the data for is that teenagers are internally consistent with their controls and their preference.

So one of the things we did in the laboratory, so we did that blind, double blind paired comparison testing where we had this round robin approach and we asked participants to tell us which one they liked and then the one that they liked the most, we assigned them their favorite. And it's based on those data that I say that 80% of teenagers reported liking advanced digital noise reduction. The other thing we did in the lab is we played them speech from the front, noise from around, and we gave them the app. So part of the training was to train them on how to use the app. And we played speech for them and we showed them how to use the app and we asked them to adjust the app to their favorite place.

So we gave them some experience and some time and some training and we asked them to adjust the app. And the participants who in that double blinded study reported liking digital noise reduction also use the app and set the digital noise reduction strength to be moderate or strong. So that's important and relevant because the data, the preference testing was double blind. So they didn't know that they were choosing noise reduction to be on. And in the app they knew they were choosing noise reduction to be on.

But that says to me that internal reliability and that internal consistency means that we can trust teenagers to set their noise reduction strength in the app with what they would choose in a double blinded study. So them being internally consistent with the controls and preference makes me feel pretty confident in giving them this autonomy and this control over the noise reduction setting.

And that being said, most of the participants said they would report using it several times a week. So that's maybe not as frequently as their noise needs are going to change, but it might be enough for them because they know they have access to it. The ones who like it can use it. And they report feeling more confident when they have access to it, and they report feeling less anxious if they're anxious to start with in noise. So giving them access to this app in order to change digital noise reduction can be, yeah, they can be trusted and it can be one way to address the, the noise listening needs that they're

experiencing in schools and outside of schools.

So these are the things that we talked about. So if you remember, we used or I used Lillian as an example to provide some context for the kinds of listening needs and challenges that I think that teenagers face. So they are teenagers. They're transitioning from childhood where they're being told what to do and things are being done for them into adulthood where they totally autonomous. So they're transitioning into this need for autonomy.

What we can do as audiologists is give them control.

We talked about giving them control, for example, through the smartphone app and also through TAP Control. These are just two examples, two ways to give them control of their hearing aid technologies. When we looked at Lillian, we looked at just the high number of listening situations she was in. If you recall, Lillian was on the bus, she went to school, she had trombone lessons, she did homework. That homework probably involved some asynchronous learning where she's watching videos and doing homework assignments based on that asynchronous learning.

And then she goes to soccer. At soccer practice, you've got coaches and teammates yelling from far and close and near. So Lillian at least is an example of a teenager needs the kinds of flexible technology that can, can address noise, distance streaming, music, lots and lots of different things, and lots and lots of different things that change pretty rapidly. So we've got rapid transitions across her day. And then also because we live in a smartphone era, we've got these smartphones that are alerting us and she' accepting phone calls and turning on streaming and turning off streaming.

So that's one way that tap Control can really come in handy. We were able to train or show that tap control can be useful. And also the smartphone app coming back to that autonomy. And then finally I did talk about how teenagers are variable and diverse. So we looked at Lillian, but that's just Lillian.

So other teenagers are going to have different perspective, different listening needs, different challenges. And so it's really important that we, we ask them, we get their perspective of what their listening needs are and what kinds of challenges they're facing. And I showed you and talked to you about the VClass, which is a questionnaire that we've developed to look at school based listening needs for teenagers. And in that school based listening questionnaire, we saw some interesting pattern of results that I think that we can use clinically and I hope that I have addressed my learning outcomes. So my learning outcomes are listed here.

So I said that we would summarize the unique listening needs of adolescents and hopefully I have highlighted this. You're probably tired of me saying it already, but teenagers, adolescents have diverse, rapidly changing listening needs. It's Diverse within a person and across people. Using that VClass or that questionnaire that we developed, I've shown you some data today to suggest that in school based environments, listening to a talker far away is probably the most challenging kinds of listening situation, at least among the ones that we queried or the ones that we came up with.

No matter who you were, those faraway talkers were the most challenging. If the teenagers had normal hearing in both ears, unilateral hearing loss, bilateral hearing loss, with and without hearing technologies, those faraway talkers were the most challenging. We looked at tap control as a way to handle some of the rapid transitions, particularly as they relate to streamed content. So phones, streaming and voice assistants. I showed you data that suggests that we trained everybody very successfully and it works really well for phone calls and streaming.

And teenagers reported mostly liking it and being able to use it. And then finally I talked about benefits and limitations of noise reduction for adolescents. The benefits being these robust subjective preferences. So 80% of the teenagers that we worked with preferred having this advanced digital noise reduction active. The downside, I guess, is that it doesn't improve speech recognition performance and

noise.

A not downside is that it doesn't interfere with or interrupt with speech recognition performance, performance and noise. But it's this kind of hearing aid technology, this noise cleaning that I think can really help teenagers who are in these noisy, complex, difficult listening situations. So one solution would be just to set it and another solution would be to set it in the programming software and give teenagers the app. We saw that the teenagers we tested were internally consistent. So I feel like they're trustworthy with the app, but they're not going to use it as many times a day as might be necessary to adjust to all of the kinds of diverse listening and noise situations they might encounter.

Okay, well that is what I wanted to say about teenagers at this point. I would be happy to take some questions. Paul has a question. If digital noise reduction does not reduce speech recognition, but does not improve speech recognition either, then is the digital noise reduction only for reducing fatigue? I would say that, yeah, the digital noise reduction has the real potential to reduce listening related fatigue, which I think is a huge issue and would be a huge benefit for quality of life and participating, active participation in.

Right in life. So Hunter might be able to get back to more mountain biking practices, but also. So fatigue is kind of a longer term thing. Our patients, our teenagers also reported liking the quality of the speech better. So they felt like it was easier to understand and they preferred the sound quality with it active so it not interfering or sorry, it not providing speech recognition benefits.

Yeah. So even though it doesn't provide speech recognition benefits, the quality is better and it might make listening less fatiguing.

Do anonymous attending, do you have any data regarding how well teenagers with lower level technology like Audeo L50 or Sky Lumity 50 do? I do not, but this is a question that we are actively

looking into. So recognizing that not all teenagers are going to be fit with the, with the 90s, so we would like to move into investigating the 50s as well.

Is there a paper version of the scale available from an anonymous attendee? There will be one very soon, I promise. We're just doing a little bit of tweaking to make it fit and look pretty. So it's 15 questions and every question has a picture. So as you might imagine, it requires some organization and graphic design in a way that I'm not good at.

So I've got some help and it, it is the downside of having pictures on the questionnaire is that it, it will end up being I think eight pages because there's 15 questions and I think there are two questions on each page. So it is pretty, pretty paper. Heavy pretty paper. Hey, I support a deaf ed program for high school, so this would be really helpful. Super.

Are you okay if I recommend them using the form for a program? Yeah, absolutely. Despite the absence of a paper form right now, I would be more than happy to see the B class or anything that we talked about today be disseminated beyond just this group of people who are here today. So. So, yeah, thank you for asking.

Thank you, Dr. Baku. I think that concludes all the questions that we have in our queue currently. We'd like to thank you for your time and your expertise in coming back on audiology online and presenting as part of the summit. We'll go ahead and close the classroom today.

Dr. Picou, thank you for advancing. That's just a reminder for our members to complete the multiple choice exam should they wish to earn the CE credit. It and we hope you all have a wonderful day. Thank you.

Thank you.