CAPD: An Interdisciplinary Approach – Evidence-Based Management Approaches, in partnership with Salus University

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- [Facilitator] It is my pleasure to welcome back Dr. Jennifer Gonzalez. This course is this part two of a two-part series on CAPD. If you'd like to learn more about Dr. Gonzalez, you can read about her bio on the course registration page, and at this time I'll hand the mic over to you, Dr. Gonzalez.

- Thank you. Thank you very much. And thank you everybody for joining for this part two session. Those of you who attended last week will see some, a little touch of some review here so that way we're all on the same page as we move forward. Here are my disclosures, very similar to what you saw in the presentation last week. Here are our learning outcomes. I won't go into them word for word, but they are here for your reference. These are all the things that I would expect for you to be able to do at the end of this course. And again, hints for the presentations exam are in the top right hand corner for slides that correspond to the question.

So an outline of what we are going to review today. We're gonna start with a case review. This is a clinical case that I had actually at the end of the previous presentation, the diagnostic presentation. So you know, we weren't able to review it at that time, but it's still worthwhile to review it. So we have it to kick off the presentation today. Then we'll jump into some of the CAPD management basics, so some of the foundational information that we need to make sure that we know as we move forward to determine how to manage CAPD in the patients that we see. We'll talk about some of the actual training approaches that are deficit-specific or bottom-up and strategy-driven are also known as top-down strategies.

We'll move into some information about device-based intervention as well as accommodations. And then at the end we'll have some time for some Q and A. So the clinical case that we are going to discuss, this is a case of a 26-year-old female. She is right-handed. I did see her at Mayo Clinic in Arizona. That's where I have my salaried

position and where I see CAPD patients for evaluation and management. This patient did play the flute throughout childhood. She reportedly was very, very good at it. But unfortunately at age 15 she had to undergo surgery to remove a large posterior fossa brain tumor. It was a glial neuroma and to treat the resulting obstructive hydrocephalus through a suboccipital craniotomy.

And she also had a placement of an external ventricular drain. This is a quote that is direct from the report from the surgeon that performed the surgery. At that time, the tumor that she had was "in the superior vermis extending down to the region just above the fourth ventricle and anteriorly extended into the posterior third ventricle. The tectum, or what is known as the high brain stem, was very poorly seen on all of the films." That's imaging. "Likely the result of longstanding distortion and the tumor extended superiorly to nearly the level of the tentorium." Which is more that thalamus, the thalamic region of the central system. This, you know, the distortion as well as the surgery resulted in palsies of cranial nerve three, four, and six.

And these are our oculomotor cranial nerves. They, they're responsible for eye movement, coordination of eye movement. So you know, she was now unable to read music, which is super impactful for her because, you know, music was such a big part of her life. She could no longer read the music because she could no longer control her eyes. When I began the evaluation with her, you know, it was very evident that she was having a lot of difficulty with her eye control movement. She actually needed pieces of surgical tape to hold her eyelids open and wasn't able to coordinate her eye movement. She would have eyes, her eyes were looking in different directions. Despite all of this, she did graduate with her bachelor's degree with honors, and she did have accommodations put in place mainly because of the visual issues that she was having.

Up until this point, no one had ever addressed her auditory complaints. She said that she had been discussing or had brought that up with her physicians and they told her

that her tumor was nowhere near the auditory nerve so it was impossible for her to be experiencing auditory problems. Despite that, she does have auditory complaints. She would express that she had difficulty of course, understanding speech and noise. She was unable to follow conversation in groups, so with multiple people talking at one time, and, you know, in sequential order. She, when she was in the car, she would have to turn off the radio to hear the person who was talking with her. She also had some sound sensitivity, reporting that she was unable to tolerate moderate stimuli such as the washing machine and a dryer.

You know, this sound sensitivity or hyperacusis is something that I come across quite a bit in patients that I see with CAPD. It's not necessarily a sign that somebody has CAPD, but it's affecting the same auditory pathway. So it's not out of the realm of possibility that someone may also be experiencing sound sensitivity along with these processing problems. When a room is too loud, she's unable to hear for a while after she exits the area. So some auditory fatigue there. And she can easily become overstimulated from noise and experiences brain fatigue often. I like to administer a questionnaire called the Modified Amsterdam Inventory for Auditory Disability and Handicap Factors. It's a mouthful, but it's essentially a five part questionnaire with subcategories that are noted there at the very bottom.

Distinction of sounds, auditory localization, intelligibility in noise, intelligibility in quiet and detection of sounds. I don't actually score this for the person. What I use this for is to see where they feel their subjective difficulties are in these areas, so that way I can kind of tailor my assessment battery according to what they feel their weaknesses are. And you can see in this case, if on the left axis are the numbers of questions that the patient would respond almost never, occasionally, frequently, or almost always. All of the questions are situation based. So with the question, you know, they would say, "Oh yeah, I can almost always do that task in that situation." They can frequently do it, but not always.

So maybe more than 50% of the time, but less than a hundred or less than 90. Occasionally they can do it, but it's not very often and then almost never. And so in this case, she was really feeling as though she was having a lot of difficulty, of course in intelligibility in noise. That is like her main complaint, but was also having a lot of difficulty with telling where sound is coming from, being in spatial sound environments, being able to distinguish between sounds and some deficits in terms of intelligibility in quiet and detection of sounds. But really those weren't very high on the list. These are the scores for the tests that we administered. I administered the dichotic digits double digit version.

I completed the frequency pattern test binaurally. So that's what I mean by unspecified. It means that I administered the test with both ears. For competing sentences, we have our scores there, 90% in the right ear, 75% in the left ear. Filtered words, which is a monaural low redundancy speech test, 40% in the right ear and 4% in the left ear. She essentially got one word in the left ear and missed all of the others. We tried the masking level difference and we tried the gaps in noise test, but she just could not hear what she was supposed to be listening for. And you know, I tried to recounsel and redirect and reinstruct, but she just had such a hard time hearing the difference and hearing what she was supposed to hear, even when things were easy that it really kind of took an emotional toll on her.

So we just decided to kind of cut our losses and, you know, maybe go about testing some of those skills and those areas of the system that are targeted by those tests with electrophysiology. I also like to graph the test performance just so I can get an idea of, you know, what the performance looks like, whether there's a strength in one ear versus the other. You can see that in the dichotic digits, she did very well in both ears. We would expect her of her age to be doing 90% or better in either ear. So binaural

integration was just fine. Frequency patterns, labeled condition, she also did very well. But where we can start to see the breakdown is in competing sentences.

She has a right ear advantage, left ear deficit there. We also would expect for her to be performing 90% or better in both ears on that test. Did well on her right side, not so great on the left side. And then filtered words is particularly revealing, abnormal in both ears, but a clear difference between the ears. And recall that with monaural low redundancy speech tests in general, if the issue is, you know, high brain stem or above, we would expect to see a contralateral ear effect on the test. And if it's, you know, low brain stem before the crossing of the central auditory nervous system there, say at the superior olivary complex, that would indicate an ipsilateral deficit.

In this case, you know, we're looking at, okay, well is it a low left ear, left pathway issue or is it higher up in the system affecting the right side? This is just a graph that shows, or a chart that shows which tests were abnormal and in which ears. And she also had a very difficult time with a listening and spatialized noise sentences test. Just could not do well on it. When the task was easy, when the signal to noise ratio was pretty high, she did all right. But once we got things to be more difficult, you know, she started to not be able to hear the sentence that she needed to hear. She started to say parts of the babble that were going on in the background instead and started to kind of meld the sentence of interest along with the background babble together, which is a sign that there's a spatialized, there's a spatial, auditory spatial processing problem.

You know, because we couldn't do the masking level difference and the gaps in noise test, you know, masking level difference, that targets the low brainstem. And you know, that's information that if the person is not able to do that task, I'm curious to see, you know, what the brainstem, what the ABR would show just to see if I can localize where the issue might be. And with the gaps in noise test, that's a test of temporal resolution and you know, it's the ABR and electrophysiology is kind of getting at the same type of

information. We're looking at how the system is able to keep up with the timing of the stimuli that we're presenting to the system.

And her ABR results indicated that with the left ear stimulation, everything seemed to be fine. With the right ear being stimulated, we had poor morphology, extended wave four or five latencies, extended inner wave intervals for three to five and abnormal wave five inner oral latency difference with the right ear's being delayed. Combined with the behavioral results, you know, when we have a higher brainstem lesion, ABR abnormalities can be ipsilateral, they can be contralateral, they can be somewhat non-localizing. So combining all of this information with the behavioral results, it suggests that the deficit is in the high brainstem around the inferior colliculus on the right side. The left side's probably also impacted just based on the filtered words issues in terms of that right ear being so much stronger than the left ear, but both ears being abnormal.

And so that's really what we counseled her about and started working through our management strategies with her. Now, just so that you have an idea of what the anatomy looks like, this is a midsagittal section of the cerebellum and the brainstem. And then you can also see the fourth ventricle there. You can see the third ventricle up here at the top. And you know, just knowing where her tumor was, it started off right here around the vermis of the cerebellum and extended up into the third ventricle and kind of filled up the fourth ventricle with distension here of that corpora quadrigemina that we discussed last time last week, that four body high brainstem location of anatomy.

And hey, guess what? The two bottom parts of that corpora quadrigemina are the inferior colliculus, which is, you know, that obligatory central auditory pathway we rely on for ascending inputs, descending inputs from the auditory cortex. And it's also heavily involved in localizing and spatial processing. And so, you know, no surprise

there that there's some influence there with the test results showing what they show and her history of where her lesion was. The surgery that she underwent did leave her with cranial nerve three, four, and six palsies. Those cranial nerves actually are, their nuclei are in and around the superior colliculus. So anatomically this all makes perfect sense and I just present this so that way you all can see and understand that there is a clear connection between what we do clinically with behavioral tests and electrophysiology and where a person has a documented lesion along their system.

And that these are things that people can be experiencing for years after the damage occurs. So with her results, you know, really the interpretation, what this might look like with her, and these are the things that I would discuss when I counsel regarding results and what we found. You know, what abnormal auditory spatial processing might look like in an everyday life situation. What abnormal binaural separation may look like, what abnormal auditory closure may look like, especially those difficulties without accommodations. And even though we couldn't test temporal resolution behaviorally, the ABR findings do suggest that she likely, very likely has temporal resolution problems. And so these are some of the things that she may experience. And you know, as you can, as you go back and look at some of the auditory complaints that she was reporting, they do fall in line with this.

And this kind of last slide that I want to present to drive home what we do as audiologists every day, even if we don't do central auditory processing testing, if that's not really our subspecialty, and even if it is, this was all in the presence of a grossly normal audiogram, okay? So very clear issues with listening auditory com, auditory pieces of communication, and the audiogram just fails to pick up on all of this. So, you know, if we don't recognize that, if we don't recognize that we have patients that can still have trouble in, you know, with their, with hearing and understanding and communicating with others, especially in background noise, if we're only relying on the

audiogram, we do really run the risk of essentially almost even gaslighting some of our patients.

So, you know, most, if not all of the literature that I presented at the last presentation with the sensitivity and specificity numbers for all the tests that we reviewed last time, those are all tests that have been researched with people who have documented lesions along the central auditory nervous system, just like this patient, just like this case. Okay. So it's real, it's there. So moving right along. You know, taking that information, all right? We have all of this data, we're making a diagnosis or we're withholding and just still trying to provide accommodations if somebody has abnormal auditory perception. You know, what do we do with that information? How do we move forward to give this patient or to give our patients a way forward with their life when they have these issues?

So just some basics here. Again, central auditory processing disorder is primarily auditory driven in its disorder and it's of the central auditory nervous system. So with that, evaluation and diagnosis must be made by an audiologist and not just any audiologist, one who is trained and knowledgeable in the disorder. Challenges with perceptual processing of auditory information that are not due to peripheral auditory disorder, nor higher order cognitive and or language disorder, that's really what our focus is. We're recognizing that these challenges exist. They're not because of a peripheral auditory disorder or something higher order. How do we target this primarily auditory driven disorder and how do we try to make it better? We recognize that the hallmark complaint that individuals will present with is difficulty hearing, difficulty understanding speech, especially in noise.

And, you know, more so than is expected based on their pure tone audiogram. Sources of central auditory processing disorder include a neuromaturational lag or delay, neuroanatomical anomalies that are, you know, congenital but not frank, meaning that

a person is born with them, but they're not pathological, they're not dangerous for the person. You also have neurological disorders, which are frank, and that, you know, require, you know, referrals to other professionals if they're not already being managed for those things. And then also acquired, you know, things like TBI, stroke, demyelinating disorder. You know, we're talking about ways to manage CAPD, but some food for thought here as we go through the next few slides. What about those individuals that we're not diagnosing CAPD?

What about these individuals that were calling attention to the fact that they're not experiencing or that they are experiencing difficulty hearing in noise, but they just don't, they either don't meet the criteria for diagnosing based on their test results, or they have a higher order cognitive or language disorder? How do we still support those people? But they're still having trouble hearing and noise. They're still having trouble with hearing and communicating. How do we support them to help them do better? These are the central auditory processing skills that we reviewed last time, dichotic listening, temporal processing, sound localization, lateralization and monaural low redundancy speech. It is my perspective that it is not enough to simply apply the diagnosis when it is appropriate.

My mindset is that I wanna be able to document the areas of weakness that a person has. These areas of weakness should be clearly observed in the evaluation results. And you should be describing them in the resulting report. You say these are the areas of weakness and this is how this area of weakness may look in everyday life when somebody is doing these activities of daily living. Development of a successful treatment plan does hinge on the proper determination of areas of weakness as well as areas of strength. I've heard from so many people over the years that I've been working in this subspecialty, you know, and I think it's a mindset that we've gone through the years with and maybe we need to recalibrate our thinking about it.

You know, I've heard so many times from people, you know, "Yeah, we can diagnose the disorder, but there isn't really much we can do about it, right? So why should we be looking at it?" My hope is that you leave this presentation with information to help you just recognize that there are things that we can do. There are actual deficit-specific training activities that we can use to try to remediate the disorder. There are ways that we can help a person be able to think about what they're hearing a bit better, so that way they're able to attend and to think better about what they're hearing and to just be more aware of what's going on around them.

There are ways that we can support the person to improve the signal to noise ratio. These are all things that we can do to support people who have processing disorders and who have processing deficits. Those of you who work in pediatrics, you know, why do we provide the information or the intervention for our pediatric patients? Well, Moncrieff in 2017, this is a direct quote from her paper, basically outlining the reasons why we should care about this. "It is our job as pediatric audiologists to identify and remediate any auditory issues that might interfere with sufficient auditory access for brain development. When we identify a hearing loss, we work to correct acuity to as close to typical hearing as possible.

If we can identify an auditory processing disorder, then we should also agree that it is our job, it's our responsibility to correct that auditory process to as close to typical as possible to give that child the best chance of successfully listening, learning and communicating." She goes on to say that, "A failure to first improve auditory access may significantly impair outcomes from the cognitive and language interventions, just as a failure to appropriately address amplification requirements in a child with hearing loss would seriously limit speech and language development, even with interventions." This calls attention to the fact that we learn to read, we learn our language, we learn to communicate. Based on hearing, other people do that as we're young and as we get older.

We learn to read by hearing people read to us. We learn to speak by hearing people speak to us, and we use our language and we use our own speech and we make adjustments for our own speech compared to what we hear based on what we're hearing. So if we have not just, like just taking out of the equation of peripheral hearing loss, say we don't have a peripheral hearing loss, but we have an auditory processing delay or a lag, or a neural structural anomaly or a neurological disorder that's affecting our ability to process that's not present on the audiogram. These are things that are auditory specific that affect our ability to make use of that information and to develop these higher order cognitive and language skills.

So, you know, it can be kind of hairy as we as children get older to try to separate what auditory processing is and what the effect it is on cognitive and language and vice versa. But we still have to acknowledge the fact that if a person has these issues as they're developing, that can set the stage for cognitive and language disorder as well. And it is our responsibility to recognize that this is an issue and that there are kids who are at risk for developing CAPD and furthermore then maybe developing cognitive and language disorder and we need to provide these supports. CAPD may be diagnosed at any point in the lifespan. So we're not just dealing with kids here.

And that's another thing that I hear a lot from other practitioners is that CAPD is largely considered a pediatric problem. It really is not. And I would be able to tell you all here that, here at Mayo Clinic in Arizona, most of our population is adults. And I see lots of adults who have auditory processing deficits. You know, it can happen at any point within the lifespan. It may occur secondary to neurological disease, insult or injury, or it may be of unknown etiology. It could be that a person has been dealing with this for a very long time, even in childhood, and these issues just haven't been addressed until later. Although a large focus of CAPD service provision has been on children, it should be recognized that CAPD also occurs in adults.

It's been estimated that the prevalence of CAPD in the school age population is approximately 2% to 5%. The National Institutes of Health, they report that it's, you know, 5%. So more on the large, more on the higher end of that prevalence estimate. Whereas prevalence in the older adult population may be as high as 76%. That's really, really high. And it's possible that, you know, as we age, we start to experience what's called central presbycusis, which, you know, it progresses as we get older. And maybe as we start aging and getting older and older, our likelihood to develop processing issues or processing difficulties gets higher. I think I mentioned last time that with the census data from 2022 and looking at these, this prevalence data, these prevalence data, nationally, we're looking somewhere around a possibility of between 1 in 20 to 1 in 7 people in the country at this moment in time of any age having CAPD.

And you know, when you think about it that way, we really do have an urgency to be looking at evaluating these people and to providing intervention. "In regard to management, Whitelaw exposed the myth that since there is no cure for CAPD in adults, there is no value in assessing their central auditory processing skills or in providing adults with management." Whitelaw further highlights, "That the auditory system remains plastic for a long period of time, and that offering intervention to adults with CAPD is viable. While numerous child-focused management approaches have been developed, only few have been trialed on adults, despite the notion that most people with CAPD will potentially live with these disorders throughout their lives." All right, so, you know, we have this information.

We know that we want to do something about the CAPD for our particular patient we have here with us, in front of us. We've diagnosed it or we're, we've documented central auditory processing deficits. How do we communicate that to our patients? There are a couple of ways that we can do that. You can immediately counsel right after the evaluation about the results. You could also choose to wait maybe a week or

two, compose yourself, marinate on the results a bit so that way you have time to formulate what you wanna do and then set up a time for a follow-up appointment a little bit later. My preference is to kind of give the patient the Cliff's Notes version of what the data showed, so that way they're not leaving without knowing whether they have a diagnosis or not, or what their skills actually looked like.

But my preference also is to meet up with them in about a week or two and to give them an opportunity to hear what I have to say about the diagnosis for them to be able to ask questions and for us to come up with a plan in terms of the priorities for how to manage it moving forward. If you decide to do a post evaluation consultation or counseling appointment, you know, a dedicated time to be able to sit down with your patients to talk about the results and what they mean. My recommendation is to go into that appointment with at least two copies of your report to ask the parents or the patient whether they received the report and if they have any questions about the content, if they've had a chance to look it over.

You wanna briefly review the tests performed and what they test for. My recommendation is to always give real world examples of how that particular skill or how that test, what skill that test assesses and whether it's normal or abnormal, how it would look in everyday life. Review the results and explain your interpretation. You wanna go through the recommendations. And my recommendation, the recommendations that I have at the end of the report are a list of all of the things that I think would benefit that patient based on their results and based on their case history and what they've told me they're experiencing. My preference is, is during this counseling consultation appointment, we then discuss what are some of the things that the patient finds as being realistic with their life?

What are some of the things that I think are really important that they address? And we kind of come up with a plan together. And we come up with maybe five or six or so

bullet points of things that are the priority. You know, you don't wanna present too much to the person at once because then they'll get overwhelmed. You know, you kind of wanna prioritize and target certain things as you move forward. If you have time, you could demo devices. What I mean by devices is say, you know, a digital FM system or mild gain hearing aids. If you have the time possible, if you have the equipment there, and the patient wants to do that, go ahead and do that.

And you of course wanna check for understanding throughout the appointment. It's really easy to get caught up in the details about all of this. There is a lot of very dense information that is part of the anatomy, part of the physiology, part of the testing, interpretation, all of that. So you just wanna make sure that you're not losing the person as you're going through it all. In general, the focuses of management for CAPD involve changing the environment. So that's kind of more in terms of accommodations, communication strategies, accommodations. You wanna improve listening skills. And some of that might be more like metacognitive or top-down types of strategies. But you also want to see if you're able to remediate the disorder.

And these are those management strategies that are going to be heavily focused on your test results that you've gotten and the data that you have. Whether you have an ear weakness, whether you need to focus more on strategies to target right hemisphere skills or left hemisphere skills and things like that. Ideally, you would have a CAPD management plan that includes all three of these overlapping. You know, that way you know, you're able to target what a person needs in the moment as they're remediating the disorder and as they're improving their listening skills. You don't wanna leave any of these kind of out in the open or not addressed, I should say. Our CAPD management approach will also depend heavily on, you know, this patient-centered interpretation.

If you're thinking like, "Okay, these are the skills that are abnormal. What are some of the things that I need to be aware of that a person may need support?" You know, with

binaural interaction, you know, you may need to be aware if the person does have a hearing loss and you're still able to do the CAPD evaluation, or if the person is using mild gain hearing aids. You know, you may run into some issues with binaural hearing aid fitting that a person may perform more poorly with two hearing aids or two devices instead of one. So you just need to be prepared for that, that you may need to make some adjustments. Or maybe you need to be looking at some deficit specific training opportunities to make it so that the person does better with binaural devices.

Binaural integration, binaural separation, we've talked about this last time. What I really want to address is as we move forward with discussing these training activities, temporal ordering and sequencing, these tests are, the temporal ordering sequencing tests are really enlightening in terms of cortical issues and where the breakdown is occurring in the central auditory processing. You know, with the labeling task for these, you know, the frequency pattern test and the duration pattern test. When we originally out, when we originally test these skills, we ask a person to verbally label the patterns that they hear. And if they don't do well, my recommendation for you is to have the person hum or sing what they're trying, what their response is, instead of applying the verbal label to it.

And by doing so, you're able to sort through where in that system the breakdown is likely to be happening. And as you'll see here in the next several slides, when we talk about temporal processing remediation, some of your recommendations may hinge on whether the issue tends, whether the problem is more right hemisphere. So the actual ability to hear the difference between the sounds that they're hearing that are very similar versus whether the person is able to hear the difference, they just can't decode or can't label it the way that they need to, right? So your recommendation and your management strategies that you'll be using with those patients in those different situations may look somewhat different. In the report that I make up for the person, for each patient in general, these are the things that I include.

I'm not gonna be going over every single one of these today, but we'll be talking about devices, deficit-specific training, accommodations, maybe further referrals, I guess would be, what I would include is the speech language pathology types of management strategies. So again, we're not gonna go through all of these, but we'll go through some of the heavy hitters. All right, ASHA and AAA call out that accommodations, assisted listening devices, top-down, bottom-up and delivery of necessary services for comorbid conditions. All of these combine for a successful CAPD treatment plan. I do want to call out that if auditory training does not target specific deficits or areas of weakness, the areas of weakness just will not be effectively remediated.

And this was a finding by Cameron, Glyde and Dillon in 2012. Consequences of that could be that, hey, if we're not targeting the specific skills and we're targeting other things, it could take longer for that particular person to improve their skills. It could delay, you know, the remediation of it. It could prolong suffering of that patient and it could set them up, you know, for failure in terms of developing speech and language skills, those more cognitive strategies in kids that we rely on so much as we go throughout our life and as we learn in the classroom. So this makes the case for deficit-specific intervention. And when we talk about deficit-specific intervention, we're talking about those bottom-up strategies, those more auditory-driven strategies where we're using the data that we have from a person's evaluation, how they did on all of those behavioral tests.

And we're using that information to tell us what we need to target in our testing. It's direct skills remediation. We're using that information to tell us, okay, we need to work on this skill. And essentially what we're using for that is we're doing that improvement, or we're doing that management by using auditory stimuli to try to change the system. All right? So what does the literature say about deficit-specific intervention? I did a little

literature review using the keywords auditory, processing and training. Surprise, surprise. Those are kind of important to include in your keywords. But I also didn't want to include articles that were focusing more on like psychological disorder, peripheral hearing loss, amplification, foreign language acquisition.

I wanted to look specifically at auditory processing training itself. And the number of peer reviewed articles that came back. There were 26 of them. The year range of publication was from 2006 to 2022, with the majority of them being published over the past six, seven years. And as I cast the net out, and I looked to see what the major themes were, these were the main article themes. The articles were focused on dichotic listening training, temporal processing training, auditory spatial processing training, training for comprehensive, using a comprehensive program, even including dance and music as part of our training techniques. And then there were also some articles that reviewed the objective evidence of the effectiveness of these programs. So looking more at like electrophysiology and whether there are changes in how the system responded after, you know, pre and post training.

So training approaches, deficit-specific and strategy-driven. Top-down approaches are those metacognitive strategies. They include self-instruction, step-by-step reauditorization. Basically a person kind of talking to themselves as they're doing something or talking themselves through step-by-step of completing a task. Self-regulation and problem solving. That'll include anticipation strategies, ways to problem solve, how to plan to problem solve. And journaling activities are also helpful, kind of self-reflecting on the day and how things went and what could be done moving forward. There are also metamemory strategies, that's like creating mnemonic devices, chunking, elaboration, recoding of the information into a pictorial representation. An example of this is called auditory memory enhancement or A-M-E, essentially that involves a person working with the patient describing a visual scene to them.

And once they're done describing the visual scene, the patient has to draw it. They have to listen, they have to retain that information, and then they have to sit down and draw from memory based on what they heard. They could also set steps of a task to music or motion. And then there are some linguistic and metalinguistic strategies here, just training in the rules of language, recognizing and interpreting discourse cohesion devices, and using context or contextual schemata. All of these top-down approaches are probably going to be better approached and should potentially be the responsibility of a speech language pathologist who is really well trained in these approaches. You know, as audiologists, I would, as an audiologist, I would hesitate to actually be the person administering these training techniques as I don't feel like it's within my scope of practice.

But, you know, looking at the, you know, the interdisciplinary aspect of CAPD, these are the approaches that you still want your patients to go through, but that require that referral to the appropriate professional. So a referral to a speech language pathologist is well within your responsibility, in my opinion. The ones that we as audiologists can be more involved with are those bottom-up strategies. These are known as deficit-specific training, direct therapy techniques or direct skills remediation. And these are effective techniques. You know, the effectiveness of them, they're going to be more effective if they are frequent, intense and challenging. So somewhere between a 20% difficulty and an 80% difficulty. If, you know, if a person is getting better than 80% on their performance on a particular strategy, maybe you need to be making it more difficult.

And if a person is getting less than 20% correct, maybe you need to make it more easy. They require active engagement and participation on the part of listeners. They target the specific auditory deficits that are present. And, you know, "Teaching of deficit-specific compensatory strategies that focus on the use of these fundamental auditory processes and spoken language comprehension will help to bridge the gap

between bottom-up and top-down processing levels and enhance generalization of skills learned to real world listening environments." So really ideally, you don't just wanna focus on bottom-up strategies. You also want to include top-down strategies in your approach. Ideally, they're able to meet and bridge together to provide better outcomes than just using one of them alone.

This is from ASHA's CAPD Practice Portal, talking about direct skills remediation. Direct skills remediation may address the following and they are listed here. I'm not gonna go through each and every one of these on this slide individually, but there are strategies that can be devised. There are techniques that can be built to address all of these skills if a particular patient has a deficit in that area. We do also wanna consider whether we formally address these issues. So whether a person is actually coming into the clinic and receiving training from us formally in a booth with, you know, with us in terms of a person who's managing that or whether you wanna give the participant or the patient ways to informally address these issues.

So giving them recommendations, giving them suggestions on things that they can do at home on their own, in their own time, not using formal stimuli, but stimuli that that can be easily delivered at home. Amongst these deficit-specific training activities, we have dichotic listening training and the list of articles that was present in that literature search that I conducted are these, these six articles. And you know, before we go through dichotic listening training, I just, I know that I kind of breezed over the anatomy and the physiology involved in dichotic listening last time, so I just wanted to review this again so that way we're all on the same page. With binaural integration, we generally use the dichotic digits test.

That's probably one of the most common tests that we use to test this skill. You know, you have our right hemisphere that is responsible for our contour recognition. It's that more musical aspect of what we hear. And our left hemisphere in general, especially in

right-handed individuals is, its responsibility is the verbal processing. It's more language and linguistic focused, right? Our ability to put a label to what it is that what that we heard hinges on our left hemisphere on that speech and language side. With dichotic stimuli, we have to have two verbal stimuli presented that are perfectly aligned between the ears. So we have one verbal stimulus going into the right ear and a different one going into the left ear with their onsets perfectly aligned.

If it was a monaural situation, it wouldn't be difficult. You know, if it was monaural, we'd be focused on using our more dominant contralateral central auditory nervous system pathways. But we would also have a less dominant ipsilateral pathway that is active there as well. And like I mentioned, this should be pretty easy. A person should be able to say those numbers with no problem. If it's just a left ear monaural stimulation, the same thing would be happening. We would have a dominant contralateral pathway to the right hemisphere, but we would still have a less dominant pathway going ipsilaterally from the left ear up to the left hemisphere. When we use dichotic stimuli though, and they're perfectly aligned, we suppress those ipsilateral pathways and then we have to rely on our contralateral pathways to perform the task.

This is dichotic listening, right? So if we have the two stimuli presented, say nine four to the left ear and two five to the right ear, we have this pathway that's active from the right ear to the left hemisphere, and the information that's presented to the left hemisphere has to go to the right hemisphere because that's where it goes in a crossed system with dichotic listening. But then the information has to cross back over through the corpus callosum to the left hemisphere for the person to be able to apply a label to what it is that they heard. So in a good well, you know, healthy system, the person should be able to repeat all four numbers with no trouble.

If there's an issue with the corpus callosum, the person may guess incorrectly at what they hear in their left ear, or they may just not hear what they heard in the left ear at all.

They may not be aware of it. In that case they would say two five, but they wouldn't be able to correctly say what they heard in their left ear. The same pattern can be present if you have an issue with the right hemisphere, okay? And this is really what we call that right ear will, under normal circumstances, even without a pathology, a right-handed individual will demonstrate somewhat of a right ear advantage. That's actually a normal thing. The question is, is that right ear advantage greater than it should be to the point where the left ear then is deficient?

So in this case, it's a right ear advantage, left ear deficit. The same thing happens here with binaural separation. We have the pathways that are still active here with the perfectly timed onsets of these verbal stimuli. The right ear's stimulus should be easily repeated because it has that more direct pathway to the left hemisphere that handles verbal information. What the person hears in their left ear, this is the distractor, right? This is the side in this condition, we're asking the person to focus on what they hear on the right side and repeat what they hear. And in that, in doing so, they're suppressing their left side. In a healthy system, they should be able to do this well.

When the focus is on the left ear and we're having them to try to suppress what they hear on their right side, they should still be able to do that well. This is still a more difficult task for people who even have, well, you know, just a healthy system that's operating well. But the question is, is it abnormally low? Is that right ear advantage so high and the left ear not performing as well as it should? This is normal. But if we have a corpus callosum issue, the person would still be able to perform well with the right side, with right ear directed attention because of that direct pathway. Okay? And same thing here with the right hemisphere, if the right hemisphere is the issue.

But when we switch the task and have left ear directed attention, the person may be unaware that they even heard something in their left ear. They may mush the two sentences together. So you might hear somebody say, "Ice cream is strawberry." Or,

"We have a chocolate sundae." You know, and in that sense, it's still not normal. We also call that right ear advantage, left ear deficit, right? So when we see that we have a left ear deficit or we have an ear that's weaker than the other, and we are going through life with that weakness, we don't have really a situation that sets up the weaker ear as being the stronger ear. The person just navigates in their world with this, you know, ear asymmetry.

How do we remediate that? Because if without remediating it, the person will still have difficulty hearing in noise if they have a deficit in binaural integration or binaural separation. But one of the ways that we can go about training that is by using dichotic interaural intensity difference training, or DIID. This is training for patients who have deficits in binaural integration or binaural separation skills, or both. It involves establishing a DIID crossover point, and that's defined as the intensity of the stronger ear being decreased until the point at which the weaker ear starts to perform better than the stronger ear, okay? So in this sense, we're creating, we're simulating an auditory environment where the deficient ear becomes the stronger ear.

And we do that by giving that weaker ear a bias in intensity in the stimuli that we present. However, there are two conditions that are necessary to be able to use the DIID. The performance in the poorer ear must be at normal or near normal limits at the crossover level, okay? So we're looking at like anywhere between like 80 to 90%, okay? When the crossover point happens, they have to be able to perform that well on that side. And the intensity of the stimulus presented to the better ear cannot drop below the hearing threshold. So that that stimulus has to be audible still in that ear. So that way the person is still completing a dichotic task. It's not just a monaural task.

Because if it's a monaural task, they're still, they're gonna be doing much better than if it was dichotic. So what this looks like is, let's say that at the beginning of training, we have a 95% performance in the right ear. That's the strong ear. And we have a 40%

performance in the weaker ear. You know, clear right ear advantage, left ear deficit there. Pretty big. What, 55%, okay? So in terms of defining what the crossover point is, we have to reduce the intensity in the strong ear to try to produce better performance in the weaker ear. So with that reduction in intensity on that strong right ear stimulation, then we end up getting an 85% in the right ear and a 55% in the left ear.

We reduce it even more in the strong ear because the weaker ear still isn't in the, isn't close to normal with this bias. We just keep doing this until we find the point at which the weaker ear does better than the stronger ear to a point where it's close to being normal. Okay? That's your crossover point. At this point, this is when training begins. This is the level that you would begin training with it. You would begin increasing that strong ear stimulation, just a little bit, training there for a period of time during your session. And then at the end, you would administer the dichotic digits test or a dichotic test, a dichotic listening test to see where you're at at that point when the training stopped.

Then you would increase the stimulus again at another session and then see how you do. Then you would increase it again and see how you do, okay? And then eventually you would, your hope is that you would have both intensities for either ear being the same and both ears performing well. The ideal is for the left ear to be performing close to normal, around 10% different in terms of performance from the right ear. And at that point, you would consider your training being complete. Okay? Delphi and Abdollahi in 2018 did a, not really longitudinal, but basically a pre and post training study to see, you know, does DIID training work? And if it does, how long does it take for it to be effective and is it permanent?

The initial training began with an interaural intensity difference of 5 DB greater than the crossover point, okay? The level of the weaker ear was kept at 50 DB HL presentation level. And the tasks, the materials that they used for the training tasks included dichotic

CVs, dichotic sentences, and dichotic stories in a music background. They used free recall and directed attention or directed ear recall. So focus right, focus left. And their training protocol looked like, you know, they had their patients coming in for four sessions per week, 30 minutes for each session. And the dichotic digits test was administered at the end of each session to assess for performance. And if that performance in the weaker ear was greater than or equal to 80% training continued at that specific IID for the entire week.

If the performance in the weaker ear was less than or equal to 80%, the IID was increased in 1 DB increments until performance of the weaker ear reached 80% or until the IID level returned to the starting level. The goal, their goal, what they defined as being normal, when the training should end. Their goal was that they wanted performance to improve to normal limits, meaning that there's only a 10% interaural asymmetry with the right ear, the stronger ear performing normal. Training stopped, and then the dichotic digits test was administered two weeks later to make sure that the outcome lasted. That it wasn't just kind of a fluke at that point at the end of the training. And it did, it remained stable.

So this DIID training works, it works quickly and it lasts. There are individuals though, who either can't go through DIID training for whatever reason, or maybe there are other deficient areas of skill that was, that were noted during the behavioral evaluation that would indicate that maybe we don't wanna use the DIID. Maybe we wanna use a version of it called dichotic offset training, also known as DIID II, which essentially is not using intensity differences between the ears, but they're using timing differences between the ears to remediate the, this skill. This improves the weaker ear performance by manipulating the interaural timing differences. The weaker ear stimulus arrives slightly later in time than the better ear stimulus. And the weaker ear obtains a dichotic processing advantage or a lag effect.

And as a patient improves over time, the lag is then decreased to make the task more challenging. All right? For DOT or DIID II training, essentially this is what it looks like. With our first condition, perhaps we have that big delay stimulus one in the right ear occurs earlier than stimulus two. And this results in really, you know, good performance, normal performance on the right side and a 10% or less difference in the right ear advantage between ears. Maybe the next condition over time, right? The next session we shorten up that timing delay and we ensure that a person still is doing that well. The next session, as you can see, these stimuli are occurring quicker as I go along in this animation.

And then eventually they occur at the same time. The goal there is for the ears to maintain their performance as you shorten up that delay over time. At that point your training would be complete. They found, Delphi and Abdollahi found that DIID and DOT training is super effective. They had six cases that underwent DIID training and six cases that underwent DOT training. And in all of those cases, the right ear advantages were as significant as 50 to 60% at the start of their training. Their goal or what they found was that with DIID training, improvements of the scores were within normal limits with 10% right ear advantages in as low as 12 to 14 sessions. And when we do the math there, if they're doing four sessions per week, you know, they basically are experiencing these improvements within three and a half weeks of training.

With DOT training, it takes a little bit longer for these effects to be seen, but they are eventually realized. It takes about 20 to 22 sessions for this, you know, training goal to be reached. Which, with the math, ends up turning out to be about five and a half weeks. Dichotic listening training programs that are out there and available are listed here. Constraint-induced auditory therapy is available through Auditec. There's a central auditory processing disorder online training software or CAPDOTS. Auditory rehabilitation for interaural asymmetry or ARIA that is Moncrieff's, de Moncrieff's training program. And you know, you could use dichotic test materials through the

audiometer in a controlled environment as well. You know, you can't just use whatever stimuli you want, but you can do this training procedure as long as you're using dichotic stimuli of your choosing.

There's also on the horizon, the development of the dichotic interaural intensity difference training app through Apple. And this is through Plural Publishing with the developers Frank Musiek, Gail Chermak and Jeffrey Weihing. I'm chomping at the bit to have this available. I can hardly contain myself. The summary of binaural separation integration activities include dichotic listening training, you know, that just like we mentioned, that we discussed involves finding a crossover point, reducing the target to competition ratio over time and readjusting that target to competition ratio as needed. Localization training, this kind of gives a little preview in terms of who you might want to use dichotic offset training with. This may be effective in people who have combined dichotic listening and binaural interaction deficits.

So those individuals who may not perform very well on the MLD, or maybe they have a normal MLD but it's reduced and they also have dichotic listening difficulties. You may wanna entertain dichotic offset training for that particular person. You could also do sound room activities with speakers at various horizontal and vertical planes. And you could also do some games like Blind Man's Bluff or Marco Polo, where a person has their eyes closed and they have to local, they have to figure out where that sound is coming from. Formal DIID and DOT training, the administration for that really, I mean, we encourage that to be, to take place in the clinic in a controlled environment. It's recommended.

There are ways that you can train a person or there are ways that you can have a particular patient do these activities at home informally. It would involve the same procedure because really it's the DIID procedure and the DOT procedure. It's how the tasks are being completed. It's not necessarily, I mean we do want to make sure that

the stimuli are verbal and that they're occurring in both ears at the same time. But there are ways to leverage what a person may already have at home to do some at home informal training, say with audio books, different audio books in each ear and having them direct their attention to one side versus the other, and then putting it all together.

Temporal processing training. So, and this includes music and dance. This is a list of articles that were included in the lit review. And just to kind of review a little bit more about the anatomy, the physiology that's involved in temporal ordering and sequencing. With temporal resolution, which is the GIN, it's the approximate gap threshold, total percent score. That is a more cortical-focused test. It tends to be a little bit less localizing in terms of side of the cortex, but it's more dominant for the, for cortical deficiencies. Temporal ordering and sequencing specifically for a labeling task. We talked about this last time, that it involves basically the entire central auditory nervous system, including the pathways going up to the cortex, both cortices and the corpus callosum.

No matter whether we are testing ipsilaterally or contralateral, no matter whether we're presenting monaurally or binaurally. We're presenting monaurally to the right ear. These are the pathways that are active. In order for us to label the stimulus as say, high, low, high, in this case, that information has to first be processed in the right hemisphere. We have to be able to hear that those sounds are different and we have to be able to hear in which way they are different. Our ability to apply a label to that though requires that information to then be processed across the corpus callosum into the left hemisphere for that pattern to be decoded and for the label to be provided verbally.

Same thing happens with presentation to the left ear. It's just presented to the left ear. We still rely on the same overall process with the information having to get to the right hemisphere and then back over to the left hemisphere for the label to be applied. In general, then when we're testing the ears, either monaurally or binaurally together,

these are all of the pathways that are active. It's basically lighting up the entire system. When we have a corpus callosum issue that's preventing that crossing between the left and the right hemispheres in either direction, in this case, the person will probably get that pattern incorrect. You know, there, that information's not getting to the left hemisphere appropriately for the person to apply the label to it like they need it to be.

Same thing would happen here with stimulation of the left ear. The same pattern you might see with left hemisphere deficiencies in the auditory cortex, and as well as the right hemisphere. We just don't know, if we're having the person label it, we don't know where the issue is happening at the cortical level. Okay? So the way that we can sort through that is by having the person hum the pattern instead of applying a verbal label. And when we do that, these are the pathways that are active with right ear stimulation and these are the pathways that are active with left ear stimulation, much less. Here we are, if a person has a corpus callosum problem and the information that they, like, if they had to label it, that would prevent the information from crossing over for the label.

But hey, their pathways going to the right hemisphere are still healthy and active. So, when they are hearing the signal or the stimulus in the right ear and they have to hum it, they're able to do it well, they can hum it back to you just fine. Same thing with the left ear. However, if the issue is in the right hemisphere, not the left hemisphere, okay? This is, if the right hemisphere is still healthy, the person should still be able to do it. But if the issue's in the right hemisphere, that's when the breakdown happens. They're not really able to hum it back to you. So if you use the labeling versus the humming response task, you can kind of figure out where an area, where the area in the auditory system, in the central auditory system, is where that deficit is happening.

And based on that information, you may use that to figure out what types of musical, what types of temporal tasks you want the person to do to try to remediate the problem. So these are the articles that I included in that list earlier. You know, they

basically outline the various benefits of music training and dance training. Giacosa, specifically in 2016 found that "Dance training which is considered whole body may result in greater fanning of fibers connecting different brain regions and increase in crossing fibers or larger axon diameter." So this is indicating that maybe there's more of an interhemispheric benefit of going through dance training versus musical training. Neves and colleagues in 2022 found that, "Music training produces neural behavioral enhancements in auditory and linguistic processing.

" And Skoe and colleagues in 2021 found that, "Novice dancers who have trained continuously since childhood had enhanced temporal resolution or gap detection." Okay? Compared to untrained controls. So we come across this differentiation perhaps of maybe there are some individuals, some patients that might respond better for music training versus dance training. Temporal processing benefits may be dependent upon the site of involvement. I think this is something that perhaps should be investigated a little bit more. So I'm just kind of using that previous slide, all of those studies and kind of inferring what this might mean. This, the literature suggests that, you know, there may be differential benefits of music versus dance training depending on the site of involvement in the cortex.

Dance training or therapy may be most useful for people who have left hemisphere, right hemisphere and or corpus callosum involvement. Whereas music training, music therapy may be most useful for people who have right hemisphere involvement specifically. Temporal processing training, you know, temporal ordering sequencing activities are listed here. Prosody training could be involved there. Basic temporal patterning training. These may be delivered in clinic. However, these are probably activities, just looking here at the language dominance here that are probably best handled by a speech language pathologist. And they can be delivered formally and or informally. Auditory discrimination and temporal processing activities, non-speech discrimination activities. This involves duration, frequency, intensity, difference limens.

So basically, you know, playing two sounds and asking the patient is it different or is it the same?

Okay? And if it's different, you know, start training them in terms of being able to say which one is low, which one's high, which one is soft, which one's loud, which one's long, which one's soft or short. You could also include discrimination of tonal glides. So instead of it being too distinct tones like beep, it would be- or you know, is it going low high or high low. Okay? And you know, those tonal glides, that influences our perception of glide phonemes, ow, oy, right? And so there is that connection there between these non-speech discrimination activities and training someone to be able to recognize those phonemes a little bit better. Temporal gap detection tasks, flutter fusion, backward masking, two-tone ordering are all in that boat as well.

Phoneme discrimination and speech to print skills. Okay? These may be delivered in clinic formally and or by an SLP. There are tasks that are specific to interhemispheric training. Interhemispheric transfer training, of course, you know, DIID training, dichotic training really also targets this as well, so I can't not mention that. But there are other things that can help as well. Grab bag verbal to motor transfers, grab bag motor to verbal, verbal to motor transfers. This basically involves, you know, verbal to motor transfers means that, hey, maybe there's, there are a bunch of objects in a bag, an opaque bag that you can't see into, and the person you're working with is telling you, "Okay, find the bear.

" And the person has to use their hand. They put their hand in the bag and they have to feel around and find which one's the bear, okay? Grab bag motor to verbal transfers is also interesting. And I would say, you know, you'd probably leverage using your left hand, for example, going into the bag. And you're not asking a person to find a specific object, you're asking them to feel around in the bag and to tell you what it is that they're feeling. Okay? In that sense, they're having to feel with their left hand the motor

piece goes up and then they're having to apply a label to what they feel. And that's a spatial type of a thing.

It definitely promotes the training activities for not just recognizing what the person is feeling, but they're also having to put that linguistic label to it. So you're also exercising those interhemispheric transfer connections that aren't necessarily always auditory, right? Music lessons, listening to songs and answering questions about lyrics, video games requiring auditory visual integration and maybe bimanual coordination. So using both hands at one time doing different things. And sports games, dance activities requiring two feet or two hands being coordinated. And these are things that are more likely to be delivered informally. Auditory spatial processing, there are six articles here that are listed. Listen, LiSN and Learn, which is now called Sound Storm. Training with that has led to significant improvements in spatial processing and speech in noise skills.

Sound Storm is geared more towards children. So you know, that doesn't mean you can't still recommend it for adults, but just keep in mind that it's more geared, its target population is pediatrics. Lateralization training led to improvements in monaural selective and auditory attention task tests and spatial word recognition scores in noise. Lateralization training under headphones using ITDs performed as a game, that has led to latency decreases on the MLR, binaural interaction component and significant increases in binaural interaction component amplitude. Post training, interaural timing difference thresholds are significantly better compared to pre-training ITD thresholds with a virtual acoustic space training. And, you know, dichotic listening training can improve sound localization skills. And this is what I was alluding to with the dichotic offset training.

Comprehensive training. That just means that, you know, if are we, you know, is this, are we, these are training programs that aren't just focused on a single skill but focused

on multiple skills at once. In Schochat, Musiek, Alonso and Ogata in 2010, the experimental group had 30 children aged 8 to 14 years. The control group was 22 children aged 8 to 14 years, and that's without CAPD. And they did pre and post intervention MLR measurements and the intervention that they used was eight weeks long. One formal session per week for 50 minutes and informal training with their parents at home for 15 minutes every day. The formal training when they came into the clinic for this, they did temporal training tasks for frequency, intensity, temporal training, okay?

And they did DIID training and localization and speech perception and informal training techniques were story time, listening to a story and sketching the paragraph. That's kind of like that auditory memory enhancement or AME that we talked about earlier. You could select a topic and the subject was asked to add a word, taking turns while adding more words. So that's like an auditory memory span. So adding a piece and having to remember everything else kind of adding to that chain. And then also listening to songs and repeating lyrics. Training significantly improved the behavioral test scores in the CAPD experimental group. And that's with the PSI speech and noise tests, nonverbal dichotic tests and the SSW and digits.

And they also found that training significantly changed MLR amplitudes, making them bigger, specifically when they're measured at the C3 electrode site. And what's interesting about this is that the C3 electrode site is that electrode site that's above the left hemisphere on the left, basically on the left hemisphere around the left temporal lobe. And when we think about the left hemisphere, the left hemisphere is more involved in those linguistic tasks. So this suggests that the training significantly improved and resulted in greater amplitudes, greater response of the left hemisphere linguistic hemisphere in the system. Tawfik, Hassan, and Mesallamy in 2015, they administered a training program using a combined bottom-up and top-down approach using these training methods. And they found that behavioral testing after 7 to 42

months demonstrated significant improvements in the dichotic digits for single digits and double digits, pitch pattern sequence test in the GIN, the approximate gap threshold.

But that they also demonstrated improvements in those strategy-driven skills, which is not necessarily surprising considering that they didn't just do bottom-up strategies, they did top-down strategies as well. And so the improvements in those strategy-driven skills were recognition memory, memory for content and memory for sequence. Here are some auditory closure training activities. You know, some suggestions on things that can be recommended. And you know, a lot of these, these are somewhat more likely to be delivered by a speech language pathologist or for you to recommend for the person to do informally at home on their own. So possibilities for in booth or formal training include kind of this list of things that you can do that involves DIID training, DOT training, gap detection training, lateralization training and frequency, intensity, duration difference limens, tonal glides, two plus tone discrimination and ordering and sequencing.

And I also have the articles, some articles listed here that are able to show you kind of the effectiveness of this and whether they can be administered unilaterally or bilaterally. So some key takeaways there for deficit-specific training, or I guess management training strategies in general is that central auditory training is efficient and it's also effective when the training task is matched appropriately with a deficient skill. Improvements in performance can occur within weeks. As early as three and a half weeks of targeted intervention. And that's with the DIID program. Improvements in performance are long lasting. They're also observed on behavioral and electrophysiological measures. So not just subjective results, but also those that are objective. And while deficit-specific or bottom-up training is effective and efficient, it is made even more so when it is part of a multi-dimensional treatment plan.

We're just gonna breeze through some of this deficit device-based interventions. I think a lot of us are well aware of the technologies that are available. So I'm not gonna focus a ton on each of these slides, but I just want to call attention that there is literature out there that supports the use of an FM system in children as well as in adults. But mild gain hearing aids as well, with one of the more recent articles coming out by Roup, Post and Lewis. Looking at individuals, adults who have self-reported listening difficulties or hearing difficulties and whether they felt like they experienced improvements by using mild gain hearing aids and the results were favorable. They were definitely, they were significant in terms of subjective findings as well as objective findings.

The types of device-based strategies include ear-level FM, I say digital versus true FM because true FM uses radio waves and now we've kind of moved away from that. We use more of a digital form of the technology. You could use hearing aids alone, you could use hearing aids and FM together, hearing aids with remote microphone, sound field systems and live listen technology. This is just kind of an overview of some of the things that would be available for people who have CAPD. I mean, in general, the goal for using devices in individuals with CAPD or just hearing and listening complaints in general is to boost the signal to noise ratio. And one of the ways that we're able to do that is by providing a more direct stimulus closer to the eardrum.

That way the signal of interest doesn't dampen by the time it gets to the ear. It's less influenced by noise, it's less influenced by echo, reverberation. Okay? And because there's a boost in the signal intensity up closer to the eardrum, you may experience better attention effects. You know, someone might be able to focus on what they're hearing a little bit better than they would otherwise. The question too is, is this a temporary fix or can it permanently change the central auditory nervous system? Well, Hornickel and colleagues in 2012, their article on the use of FM with children with

dyslexia suggests that this, that the changes that happen with the use of an FM system are supporting an improvement in the underlying representation neurally for speech.

And that it actually does fundamentally change the system. Things to consider though, of course, are associated cost and that includes, you know, whether the devices that we recommend are covered by insurance, whether a person can private pay and whether a person or a child has availability for these devices through their school system, through the IEP or 504 plan. Hearing assistive technology, these are devices that help people hear in loud or busy places. We talked about these conditions with distance, noise, reverberation and context. FM stands for frequency modulation, operates like a tiny radio station with its own frequency. And it has two parts, which is a microphone and a receiver. The microphone, the speaker wears it and the person who is receiving the information in their ears wears receivers.

And those receivers can be dedicated ear-level receivers. They can also be located in hearing aids or on hearing aids and in the sound field. Ear-level devices are the preferred recommendation for CAPD. There might be situations where that's just not feasible and having a sound field system might also be beneficial. It's better than not having anything at all. There are devices that are manufactured by hearing aid companies, but there are also devices that are manufactured by non-hearing aid companies. The ones that are ear-level quote unquote FM systems that are actually digital now. The main ones that are available are through Phonak. It's the Roger Focus II. This is what it looks like and these are the current colors that are available.

I love that they added Caribbean Pirate, 'cause that's one of my faves. They are used with transmitter microphones and these are the examples that Phonak has for them. Non-hearing aid manufacturers. Williams Sound has headphone-based devices that are for single users. They also have multiple receiver systems for multiple people to use in a big area. There are also infrared systems that can be available as well. This uses

light waves instead of FM radio waves to send sounds across a room. And when we talk about infrared, that's that wavelength of light, that is, you know, very long to the point where we can no longer see the light. It's usually used at home with a TV, but can be used in larger places like theaters.

And one that we all very are probably very familiar with is the induction loop system, also known as telecoil. The loop wire goes under carpet or in the ceiling and the wire connects to a microphone, and then the electrical current goes through the wire and a person has a receiver that they're able to plug in and hear from that. And we're well aware of the sign that indicates that a telecoil is available. There are sound field systems. Basically the receiver takes the form of a big speaker and the speaker can be put close to the person who needs it, or it can be in the room itself, just anywhere. And these are the microphones that generally plug in to, or are connected to those sound field speakers.

I mean, there are some pros and some cons to sound field systems. You know, they're not at the ear level, so the signal to noise ratio may still be affected by them not being so close. But there are some pros. I mean, if it's a cost issue and you know, you wanna create a universal design system in a classroom, perhaps every child could benefit from having a sound field system and not just the person who has a CAPD. What I think is probably the coolest development is that we now have FM or digital FM receivers in hearing aids themselves. So we don't have to have, we don't have to choose one way or the other or to put a boot on a hearing aid anymore.

And so Phonak has options for that. Oticon has their ConnectClip and their EduMic that they're able to use there with that. And these are the microphone options for Phonak. And then options without hearing aids, using AirPods and through Google, using, you know, Google bluetooth headphones. You know, there are ways that we can leverage our phone, turn our phone into using, into it being a microphone itself and

creating that boost in signal to noise ratio using these pieces of equipment and not having to go with actual hearing aids or, you know, hearing-specific technologies. Accommodations. These are just lists of things to consider. Okay? In meetings, trainings and classroom activities, so accommodations are not just for people who are, for kids who are in school.

We also wanna provide accommodations for people who are working and who are older and need these supports. And then in overall communication, we wanna consider the environment and background noise, minimize distractions, use clear speech and so on and so forth. And of course the last one is be patient. The last slide that I have here talks about CAPD and the IEP, individualized education plan eligibility. This is kind of a big hangup, you know, with kids a lot of times it's kind of like, yeah, we're able to, identify that CAPD is there, but how are we able to support these kids in the classroom? Well, in starting with a filing in 2014, you know, there was a Ninth Circuit Court, United States Court of Appeals ruling that found that CAPD qualifies on its own as being eligible for services through IEP by qualifying CAPD as an other health impairment.

And so me, I live in the Ninth Circuit, in that region of the Ninth Circuit. So I, whenever I see a pediatric patient, I definitely call attention to this and that, you know, this is definitely something that needs to be addressed. But you know, there, we definitely have a lot of room to grow here with this. And, you know, it's, it can be challenging for kids to get the things that, or the support that they need. And we have to continue being their best advocates. All right. We covered a lot of information. What questions do you have for me?

- [Facilitator] Thank you, Dr. Gonzalez.

- You're welcome.

- We have a very nice comment here from Demetra. Demetra just says, "Thank you so much for the thorough literature review and those articles she will find very helpful in supporting the recommendations that she makes." So thank you Demetra. And we just have one last question here if you have the time, Dr. Gonzalez.

- Yeah.

- A member asks, "What are recommendations for programming mild gain aids for adults with CAPD?

- Oh, yeah, that's a good question. Okay, so Francis Cook's article goes through how you would program them for kids. Christina Roup and her colleagues when they came out with their article in 2018, what they did was they programmed the hearing aids, they're open fit, okay? So they're Rick hearing aids with open domes. And what they did was they provided insertion gain between, they provided about 5 to 10 DB of insertion gain for the frequencies of 1000 hertz through 4,000 hertz for soft inputs and conversational inputs. They didn't provide any gain improvement or any boost in gain and insertion gain for loud inputs. So loud inputs, no in, no gain. And a between a 5 to 10 DB insertion gain from 1000 to 4,000 hertz for soft and conversational inputs.

You do wanna be really conservative with your MPO. I mean, when I fit hearing aids for people who have CAPD, I actually limit it. I put it as low as I possibly can to the limits of what the software will allow me to do. And that's just because, like, these are patients that aren't having trouble with hearing loud inputs. Like that's not what our goal is for using hearing aids in this case. We are essentially leveraging the technology to try to improve clarity and to leverage the noise management features in the hearing aids to clean up the signal a bit better. We're not focusing on trying to, you know, restore

audibility for soft, average, and loud inputs, like that's what we would be using for hear, for peripheral hearing loss.

It's somewhat of a different way of going about providing amplification for these patients. Great question.

- [Facilitator] Thank you so much, Dr. Gonzalez. Well, I think that concludes all of the questions in the queue, and we wanna thank you again for your time and your expertise. I know you put together just three hours of excellent content on this topic, so we appreciate that. And I have a big thank you to those at Salus for coordinating the series as well. We hope you all enjoyed this presentation. If you missed part one, please log into Audiology Online and take a peek at the library. That's where you'll find it. And we hope you have a wonderful day. Thank you again, Dr. Gonzalez.

- [Jennifer] Oh, you are so very welcome. Thank you to everybody who's here and to everyone who's listening to this. Much appreciated. Thank you.