Understanding Central Auditory Processing Disorder and Treatment Recommendations

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My name is Janette Mongelli. I am a member of Starkey's Regional Education and Training Team and I'm based in Southern Arizona. Well, today we are going to go through our course here called Understanding Central Auditory Processing Disorder and Treatment recommendations. Now, I would love to have questions and all you are going to go ahead and type your question into the chat box and I'm going to hold those questions until the end just to make sure that we get through our content. But rest assured, I will be looking at those.

There's also a handout available of today's presentation. So that will be a PDF handout. It should be able to be accessed through your pending courses on Audiology Online. And I believe sometimes it also is available in the chat in the classroom. Now, if you do have a paid membership to Audiology Online, this is available to earn a ceu.

So after completing today's course, you'll go to your pending courses on Audiology Online and you'll just pass that multiple choice exam. If you do have any trouble during today's talk, you can absolutely reach out via email or phone number which I have listed here.

Now, I always like to kind of touch on the risks and benefits. Anytime we're providing this type of content, we just want our participants to know that, you know, typically we can't cover every single, possible, you know, risk factor or presentation of a disorder. We also know that new evidence is becoming available all the time and so recommendations can change fairly quickly. We also want to make sure that of course, you're using your clinic clinical judgment when putting any of these recommendations into practice. And of course, you want to make sure you are applying your knowledge of cultural competence and in general, your sensitivity to your patients before you make any treatment recommendations.

Now, the learning outcomes for today's course are that after today's course, participants will be able to define a Central Auditory Processing Disorder, that participants will be able to list the deficits

associated with Central Auditory Processing Disorder, and that you'll be able to describe recommended treatments for patients with Central Auditory Processing Disorder.

Now, just a reminder, all of our courses on Audiology Online are evidence based. So we do strive to provide the most current and best available evidence to support any recommendation or guidelines here.

So let us go onward with today's course. So I wanted to give just a little bit of the history of capd. It is certainly a very large topic and in fact, I think even the nomenclature varies sometimes. When I was in grad school, I remember that it was often listed as this app, but again, because our discipline advances and changes with new information, the way that we use language is certainly going to change as well. Research really began in 1954 with neurological patients, both Voca et al and Sparing Gazaniga.

Now, these patients presented with difficulty understanding auditory, no stimuli, but they had normal hearing. In the 1980s, doctors began research on hemispheric specialization. So which either the right or left hemisphere was responsible for some of these different processes. And they began this research working with split brain patients. Now, if you've not heard of a split brain patient, this is someone who has undergone a surgical severing of the corpus co callosum.

That's that very dense neuronal tract that connects the right and the left hemisphere. Now, typically this type of operation was done on patients who had intractable epilepsy, where, you know, they had these seizures that were located in one half of the brain. And unfortunately, that seizure activity was so strong that that activity would move into the other hemisphere of the brain. So, so one of the only treatments for this was to sever that corpus callosum. And researchers found that for the most part, folks who had had this surgery function normally, but there were some very particular deficits that were seen.

Okay, so I don't know how many times have you heard or seen talk, you know, folks talk about being right brained or left brained? Right, like our left brain is more artistic, more language based. Our right brain is more analytical, deals with math patterns, those kinds of things. Well, that, you know, kind of colloquial understanding of the brain actually came from this research that was done on split brain patients. So in the 1990s, early screening measures were, you know, came out, including the Buffalo model and, you know, the CHAPS questionnaire.

Additionally, auditory integration training became popular early on, but it was later shown to have, you know, to lack reliable evidence. Now in the 2000 Bellis and Trmac's work really established these key dichotic and temporal battery tests that are widely used in clinical diagnosis. We are going to be going through some of those in just a little bit here and then, you know, in the 2000 and tens and now even through the present, we've done some systematic reviews, right. Of the literature and those have been completed really to assess diagnostic variants. So what are the diagnostic criteria that people are using and efficacy of intervention?

So, so what types of interventions are being put in place for folks who do have capd and are they helpful? Are they useful? Right. So that kind of brings us to the present, I will say, at least in the Last number of years. One of the things I've really appreciated is that we are looking at CAPD also through the lens of aging.

Now that is a topic unto itself. Itself. We're not going to talk a whole lot about that. But as we go through and we're looking at sort of these different diagnostic criteria, you can see that oftentimes these, these deficits that we see in folks who have capd, we see similar deficits in, you know, the elderly and aging population. So how do we look at this elderly population who may have hearing loss?

So again, like I said, this is a sort of a separate topic that could have its own multiple hour long presentation and we won't spend a lot of time on that today. But I do think it's important just for us to

think about now when we are thinking about definitions of capd. I wanted to just provide sort of a breakdown here. We have asha's definition and then we also are going to have triple aa. So asha, of course, is the American Speech Language Hearing Association.

They define central auditory processing disorder as deficits in the neural processing of auditory information in the central auditory nervous system that are not due to higher order language or cognitive factors. Right. So this is separate from language and cognition. And these are demonstrated by poor performance in one of these following skills. We have sound localization and lateralization, auditory discrimination, auditory pattern recognition, temporal aspects of audition, auditory performance in competing acoustic signals, and auditory performance with degraded acoustic signals.

Now, AAA further outlined these features of central auditory processing disorder. So poor perception of speech and non speech sounds, origins in impaired neural function, impacts on everyday life via a reduced ability to listen and to respond appropriately. This does not result from failure to understand instructions. And here's where things get a bit tricky. Can often co occur with other neurodevelopmental disorders.

Now the important aspect of both of these definitions is that folks are struggling with these auditory processing tasks in the presence of normal or near normal hearing. So this is almost what we might think of as like a subclinical hearing loss. It doesn't show up on our audiogram, but we have this whole population of folks who are having great difficulty with auditory stimuli. Now we're going to come back to our central auditory nervous system anatomy here and I think it's really important to review this and you'll see why in a moment here. Now I do want to say because we are looking at central auditory nervous system, we're not looking at peripheral hearing.

So I'm not talking about, you know, the middle ear or the inner Ear. So really, where our central auditory nervous system begins is the cochlear nerve. So that's cranial nerve 8. From there you can see our

input goes to the cochlear nucleus and from there to the superior olivary complex. Now, why is the superior olivary complex really highlighted here?

You know, at the superior olive? This is where the majority of our nerve fibers projecting from cochlear nucleus are going to cross contralaterally. And it's a really important thing for us to note in CAPD because much of our testing looks at contralateral deficits. So we're following this whole central auditory nervous system pathway, and we're trying to find where in the cans where these deficits may occur. Next we have inferior colliculus.

Then we move through the medial geniculate body, and finally we're projecting to auditory cortex. Now, what I don't have on this slide, and which we will see in a minute or two here, is the corpus callosum. Now, I know that I talked about that already in the context of those split brain patients, but again, this is a very important structure for, for auditory processing because the corpus callosum forms the largest system of interhemispheric transfer. Okay, now when we're thinking about, you know, the prevalence of capd, we have to look at both the pediatric and adult population. Now, the National Institutes for Health estimates that CAPD affects between 3 to 5% of children in the United States.

Now, roughly about 5% of children who are referred for audiologic evaluation, they are diagnosed with capd. And if you want to think about, you know, we mentioned that there's some other neurodevelopmental disorders, but the prevalence of CAPD among children who are already diagnosed with learning disabilities, it's 43%. So there is a lot of overlap there. Now, I will say it is difficult to really calculate the incidence and prevalence of CAPD due to this lack of standardized diagnostic criteria and because we have guidance from different academic organizations. Okay, now if we're thinking about adults now, adults, the NIH is estimating about 1/2 to 1% of adults with normal hearing do have CAPD.

And in adults who are referred for concerns like referred for evaluation for concerns in the presence of normal hearing, a little less than 1% are identified with CAPD. So the largest group overall who presents with CAPD are children with normal hearing. Now, I know that I mentioned previously we have this issue of what about older adults who are presenting this way as well? Again, there is going to be some overlap there. And A little bit later, I have a table of testing that you can look at.

It'll be, I think, more useful in the handout. But some of the tests that we do, you can complete those tests with hearing loss. You just have to modify the, your instruction and the level of presentation.

Now then, when we're thinking about the etiology of capd, it's important to think about both, you know, congenital and acquired neurologic conditions. But then we also have some maturational or developmental disorders. So there are a number of acquired conditions that can occur that result in central auditory processing disorder. So, you know, if there lesions or tumors of the central auditory nervous system, that can certainly affect things, neurogenerative disorders, so multiple sclerosis and multiple sclerosis, the myelination, right, of neurons throughout the body becomes sclerotic, and then those nerves are not able to function in the same way as they would normally. We also have cerebrovascular disease.

So this includes strokes, aneurysms, et cetera. In our imaging here on the right, we can see we have imaging after a stroke that's occurred of the left middle cerebral artery. So this is the most common artery where folks do end up having a stroke. So it does often result in damage to that left temporal lobe, which is, of course, where auditory cortex, you know, language reside. So something like a stroke in an adult in the presence of normal hearing can result in capd.

We also have traumatic brain injury. Now, I know that this is often an issue that comes up with our service members. Again, normal hearing. There's been a traumatic brain injury, and now they're really struggling to understand, you know, speech and auditory cues. There are also different prenatal and

neonatal risk factors.

And then we do have that degeneration of the central auditory nervous system, which tends to be age related.

Now, with these delayed cns, you know, maturation or developmental disorders, this is an important one to consider. Now the human auditory system is fully developed at birth. However, myelination of these higher auditory pathways, particularly our friend the corpus callosum, those are still occurring, you know, through 12 years old, and in fact may have finish even later than that. So because this is such a huge pathway for inner hemispheric transfer, any, you know, condition that's restricting auditory input, even if it's just an ear infection, it can really affect this auditory development disproportionately. And you can see more, more effects essentially with regard to central auditory processing in these children who do have this delayed maturation.

I know that I touched on it before, but I think it's sort of important. Often in the literature, we'll read about the right ear advantage. Now, the right ear advantage really occurs because, remember, when we have the majority of our neuron fibers that are going to project contralaterally at the level of a superior olive, and following, most of the input from our right ear goes directly to the left hemisphere. Now, most of the input from our left ear goes to the right hemisphere and then has to cross over to the left via the corpus callosum. So that's really where that structure comes into play.

Now we also want to think about comorbidity. So as we're going through and kind of looking at, you know, these. These features that we may see of central Auditory Processing disorder, you're going to find that a lot of these have features in common with other, you know, other disorders like attention deficit hyperactivity disorder, autism, learning disabilities, you know, language delays and other disorders, and sensory processing disorders. So roughly 50% of children who have ADHD also have CAPD, and about 70% of children with dyslexia also have CAPD. So it does become a bit of a

challenge, you know, for the clinician to tease apart what is this auditory processing disorder and what is, you know, these other attentional or neurodevelopmental disorders.

Now we're going to move into, you know, evaluation of capd, and these are the four things we're going to, you know, look through. So we've got our comprehensive case history, observational tools, diagnostic criteria, and then diagnostic evaluation. Now, a comprehensive case history is really, really important. We need to conduct a very thoughtful and thorough case history, particularly, you know, for younger children. So things like the family and personal medical history, so any potential genetic or abnormalities, these become important.

Any prenatal, perinatal, postnatal history and development. So pregnancy, you know, childbirth, development following childbirth, general health status. So any significant medical conditions, any psychological factors. We really want to look at communication, listening and auditory skills and behaviors. Additionally, social development, the linguistic and cultural background.

These things matter. As, you know, culturally competent providers. We do need to think about whether there are cultural norms at play when we're looking at evaluation. We also want to know about any prior therapies, any current treatments, and then any other ideological basis for these auditory deficits. So if there has been trauma, if the child is sustained, or adult has sustained a tbi, if there's a degenerative disorder, lesions, all of these things are going to be really important for us.

Now, I will say it's very difficult to test children who are younger than 7 years old. And most tests in the battery only have norms for children 7 years old and older. I think prior to 7, not only is it difficult to test, but it's difficult to tease apart what may be, you know, that learning disability or, you know, another neurodevelopmental disorder. Now, these are some pretty common behavioral, you know, reports and symptoms. So difficulty understanding speech and noise, I think this is one that you're going to come across probably the most Sometimes problems localizing sound sources, inconsistent responses.

A particularly difficulty following rapid speech. So sometimes you've got those people who are just talking so quickly. If you've ever seen an episode of the Gilmore Girls, Lorelei, she's a very fast talker, right? So it's difficult to follow speech like that, particularly if you do have, you know, difficulty with this auditory processing. So sometimes we'll see frequent requests for repetition or rephrasing.

There's difficulty following directions. Sometimes it manifests as a difficulty detecting tone of voice, sometimes difficulty learning and understanding foreign languages, maintaining attention, oftentimes folks get very distracted. Another kind of hallmark is poor singing or musical ability. And then of course, academic difficulties. So reading, spelling and learning problems, those can all manifest as behaviors that you may see in capde.

Now, our observational tools, I will say, tend to be aimed more at the pediatric population. So you've likely seen some of these checklists or questionnaires before. So I would say the apdq, the Auditory Processing Domains questionnaire, that's quite a common one. There are four subscales. So I do like this one.

This is for use by parents for children 7 to 17 years old. I do like those subscales. So you have adjusted auditory processing, attention control, language and target auditory processing. And it's reported in such a way that it really tries to differentiate auditory processing from attention and language, which is tricky and important. Now, this checklist of auditory perceptual subskills, this is designed for teachers and parents to complete for infants and young toddlers.

AAA suggested that it can be used as a screening tool. We also have chaps, the Children's Auditory Performance Scale. This is used to rate children's listening behavior against classmates in conditions of noise, quiet, ideal and multiple inputs. So this does look at auditory memory sequencing and auditory attention span. And these are for.

Or this questionnaire rather is for parents and teachers to complete for children' years old and older. We also have the Children's Home Inventory of Listening Difficulties Child. This is family centered. There is one completed by the child with the parent or audiologist's help. And then there's also going to be one that's completed by a family member.

So this rates the child's ability to hear in a range of listening environments in and around the house. And you can use this both pre test and then post treatment as well. And then we have the Listening inventory for education Revised student appraisal of listening difficulty. So Lifer sald this is a self rating by the student of their perceived level of difficulty in different listening environments in the classroom. And this is also available for teachers to rate listening difficulties or listening abilities of students.

Now for our diagnostic criteria, AAA and Asha do outline a couple different things. So Asha says the deficit cannot be due to higher order language, cognitive or other factors. It requires a performance deficit of greater than two standard deviations below the mean on two or more tests or greater than three standard deviations below the mean on one test. You can also diagnose with two standard deviations below the mean on one test when the finding is accompanied by significant functional difficulty in auditory behaviors. Now, AAA their criteria is a score of greater than two standard deviations below the mean in one ear or greater on two different behavioral central auditory tests.

Now we also have screening tests that are available. I would say most folks are pretty familiar with the scan. And then oftentimes folks are also familiar with the hint, the hearing and noise test or the hint C which is hearing and noise test for children. Now, the HINT and the hint C, those assess sentence recognition and background noise. So they use an adaptive or bracketing technique.

And the goal is to determine the subject's reception threshold, Right? Almost like an srt, but for sentences and noise. Now, the scan has a number of different modalities that it tests. They test a tonal

gap detection auditory figure ground. There are competing words, task filtered words and then time compressed sentences.

Now, screening tools really differ from diagnostic tools, right? They are faster to administer, but they tend to be much less sensitive. Now, Jerger and Music recommended doing a direct screening procedure that would include a dichotic digits task and a gap detection test. So we're going to look at both of those tests in a minute or two here. Now, when we are choosing tests for our battery, before we get into specific tests or types of tests, we want to think about what specific auditory processes are being assessed by the test.

So you know, you've got your rating scales, you want to really look at that and be thoughtful about what deficits are being reported and what tests you have in your back pocket that could really get at assessing those deficits. What other non auditory influences might there be on performance? We want to make sure that test materials are appropriate for the age and cognition or cognitive abilities of that person being tested. We also want to know if normative data is available and whether those norms are valid. And finally, we need to think about these comorbidities conditions effect on our results.

Now, we have four test subtypes, and we're going to go through these in more detail. But we have binaural interaction tests, dichotic listening tests, monaural low redundancy tests, and then temporal patterning and processing tests. So binaural interaction tests evaluate how well the brain integrates auditory information that's received by both ears. These tests assess central auditory processing, particularly the ability to combine timing and intensity cues from each ear to localize sound and understand these complex auditory scenes. Now, these are sensitive to brainstem pathology.

Okay. And one of the most common tests that's in this binaural interaction bucket is the masking level difference test. Now, I have a graphic of the MLB test on the left here. I don't want to go through it too in depth, but essentially this measures the ability to detect a tone in noise when phase or intensity cues

differ between ears. So if the sign is different in the two ears and the noise is not, it's easier to hear.

Okay. There are also, like I said, these interaural, phase and interaural intensity differences. Those are things that provide binaural cues that help us perceive these types of tones in context where they would have otherwise been masks or masked. Pardon me. Now, this image is from plaque 2005.

And this just. Or this just outlines sort of the four different listening tests or listening conditions in this masking level. Different tests.

All right, so differences between binaural masking and monoral masking, those are going to be related to issues of signal detectability in these complex environments. So binaural cues can also override masking of complex signals by other sounds, like noise, if some additional cues are also present, like pitch, timbre, the difference between signals arriving in each ear. So in the absence of those cues, this, you know, attention focusing isn't sufficient to override cognitive strategies that would link together these signals with similar timbre, pitch, and contour. So again, we're really looking at efficient integration of this information from both ears to mediate synthesis or this understanding. The next type of test is dichotic listening.

I would say of these kind of four different types of tests, dicotic listening is probably the most familiar so in dichotic listening, we have different speech stimuli and they are presented to two ears simultaneously. So these could be any speech stimulus. CVCs, digits, monosyllabic words, sentences, it doesn't particularly matter. Like I said, they can be any of these. Now, they sometimes require your divided attention, and some require directed attention.

So for divided attention, let's say you're able to hear or you're asked to repeat all of the words or sounds that you heard. So for dichotic digits, typically in one ear you would hear 1, 3, and then the other here you might hear 5, 9. In that scenario, oftentimes folks are just asked to repeat any digits they heard.

Now you have competing attention as well, or that directed attention. So for competing sentences, you might hear a different sentence right in each ear, and you're asked to repeat only the sentence you heard in your left ear or only the sentence you heard in your right ear.

Now, these tests are really sensitive to lesions of auditory cortex and importantly, interhemispheric pathways. Our old friend, the corpus callosum. So for when we're looking at these disorders that are related to maturation of the central auditory nervous system, particularly the corpus callosum, oftentimes what we will see is a right ear advantage. So folks are able to repeat those numbers or stimuli that they heard in their right ear. Again, because the majority of that information is going straight to the left hemisphere.

But you see deficits in that left ear because the left ear information goes to the right hemisphere and then has to cross over to the left hemisphere via the corpus callosum. So that is typically what we're talking about when we say issues in those interhemispheric pathways. We also have monoral low redundancy tests. Now, these kind of stress test the central auditory nervous system. So if the system is functioning well, the brain is able to compensate for degraded input.

So these will be stimulated with changes to the frequency, timing and intensity of that original signal. So we've got time, compressed sentences. So again, this is that very rapid speech. We also have filtered speech. So sometimes it's low pass filtered speech.

So a lot of the high frequency cues have been removed from that speech. So again, this is just where speech stimuli have been degraded. This is also where you'll see speech and noise testing. So we're trying to force the brain to work harder at decoding this message. So these are sensitive to cortical lesions.

So oftentimes we'll see contralateral deficits unless we have a lesion in the left hemisphere that is Very extensive.

We also have temporal patterning or processing tests, and there are four subcomponents to these. We have temporal ordering, temporal discrimination, temporal integration, and temporal masking. So these, these tests assess the brain's ability to perceive and interpret timing aspects of sound, which is a really important part of central auditory processing. So these tests are going to evaluate how well a listener can detect the order, duration, and spacing of sounds. And this is really important for understanding prosody, speech rhythm, stress, and intonation in language.

So poor performance on these tests can into or that may indicate deficits in hemispheric processing, especially the right hemisphere for pattern recognition, corpus callosum functioning for transferring information between hemispheres, and temporal resolution, which can affect speech clarity and rhythm perception.

So this, I actually should have gone to my slide before now. This is a sample from the Gaps in noise test. And essentially you, the listener, will hear a white noise signal that is interspersed with these gaps. And their task is simply to press a button when they hear a gap. So again, we're looking at that temporal discrimination there.

We also have duration and pitch pattern testing. So temporal patterning. And this would be for duration patterns. This tends to be sensitive to lesions in the right hemisphere. So for this test, folks will hear a beeping sound, and they're asked to reply verbally with that sound, essentially.

So they would hear and they're asked to repeat long, long, short, or long, short, long or short, short, long, whatever permutation there. So that doesn't require a verbal response. Right. If you do require a verbal response, if you ask them to say long, long, short, instead of sort of repeating or humming along,

then that test is sensitive to lesions in the left hemisphere. So you can, as I said, you can accept a hummed response, and that helps you also assess the function of the left hemisphere as well.

Okay. Now, I included this graphic because I think it's such a great kind of representation of what, you know, all of these processes that are going on when we're thinking about central auditory processing. Now, this came from an article called the age Related Central Auditory Processing Disorder, Silent impairment of the cognitive ear. Like I said, I think this can be its own sort of separate lecture. Lecture.

But I just wanted to include this because we're looking at the ways that working memory and speech perception can impact things. We're looking at these attentive and executive functions. We're looking at dichotic processing, temporal processing, speech and noise. So all of these things that can occur at different points along the central auditory pathway that are all really important for our perception. But there are so many places that this can break down.

Now, as promised, this is a table of tests. It's broken up by the type of test. So dichotic temporal processing and patterning, monoral low redundancy and binaural interaction. You'll see too there's a column for whether, you know, it can be tested with adults. So there are.

Some of these tests can be done with adults, Some are only normed for children. On this children bucket, you'll see the ages. So some are only for, you know, age 7 through 12, some are just ages 7 and older. I also have a column that's hearing loss. Okay, so if you do have a mild hearing loss, you know, you can still complete some of these tests because they just need to be audible.

So you would choose your signal presentation level based on their srt. And then that last column is, you know, what these tests are sensitive to and the kinds of sort of deficits that you might expect to see on these tests.

So now that we've kind of looked at these different buckets of auditory or central auditory processing tests, I want to focus now more on intervention and treatment. So there are, you know, a number of different ways that we can approach capd. Auditory training is a big one. We also, you know, recommend amplification and there are additional strategies or supports that can be put in place as well for folks.

Now auditory training, these types of training can be very effective, especially when they're very personalized and paired with other supports. So auditory training on the whole, these tend to be structured and repetitive listening exercises and they are designed to improve your sound discrimination, auditory memory, temporal processing, sound localization and auditory closure.

Now auditory closure, many of you may be familiar, but essentially is just the ability to sort of fill in that missing piece of information. Okay then when you're thinking about auditory training, we have bottom up training versus top down training. So for bottom up training, this is really focusing on the sensory piece of things. So perceptual auditory skills, so phoneme discrimination tasks, temporal gap detection, as well as dichotic listening. Then when we're thinking about top down training, this is really going to provide less of an emphasis on sensory, more of an emphasis on these cognitive and linguistic skills.

So following multi step oral direction, doing auditory memory games and speech and noise practice. So this is more that big picture work on these larger skills, that type of a thing. Now speech and noise difficulties are very common with central auditory processing disorder. And I would say, in fact that tends to be one of the things that you'll see the most on these questionnaires that, you know, when a child or someone who has CAPD is in noise, things just kind of fall apart. So for speech and noise difficulties, our treatment goals really include strengthening auditory attention to speech while suppressing noise.

We want to improve the spatial separation of sound sources. We also want to enhance temporal resolution, so detecting speech cues and fluctuating noise. And we want to build listening endurance and try to reduce auditory fatigue.

So the Listen and Learn is a very common auditory training protocol. This is for ages 6 plus and can be used for children and adolescents. Now this software trains the listener in localization and attention to speech and it's in spatially separated noise. So this does improve the spatial processing and real world listening. And this is going to be clinician licensed.

So the software. So some of the auditory training is software based, some can be done in the office by the clinician, but oftentimes, you know, what I'm seeing is a software based type of interaction. Now the clip on the right here, the picture on the right is one of the interfaces for what's called the goal game in this listen software.

Now another one that a lot of folks are familiar with is lace and this stands for Listening and Communication Enhancement. Now lace, I think was really one of the standard auditory training protocols. When I was researching for this class though, I found that now it's not just lace, there's LACE AI Pro. I know artificial intelligence is kind of everywhere in the world right now, but also particularly in audiology. So I thought it was interesting that LACE is now Lace AI Pro.

So LACE AI Pro, it is more of a phone based interface and it is designed for teens and adults. This also trains the user to understand degraded and rapid speech noise. It exercises your working memory, it uses visual and interactive modules, and it is shown to improve speech and noise performance and listening confidence. I do like. Now these are pictures directly from this LACE AI Pro site.

So I like that you have the ability to choose the type of lesson. It kind of gives you some positive reinforcement. I really, I would say the jury is still out on this AI piece of things, but I do think AI has the

potential to really improve, you know, some of these therapies, some of these strategies. So I will be interested to see how this develops in the next few years.

Now I want to mention the Buffalo model and specifically I wanted to take a minute just to acknowledge the passing of Dr. Jack Cass cats, who was really a titan in our field. He developed the Buffalo model and like I said, just such A huge figure in our field. I don't know about you, but I still have my cats. You know, audiology handbook. That's where I learned from.

I still use it as a reference. Now, Dr. Katz was, you know, his research led to the Buffalo model here.

Now the Buffalo model doesn't actually have a real Buffalo in it. And speaking of AI, this image actually was generated via AI and I just thought it was adorable. So I have included it here for you. So the Buffalo model is also very rooted in the anatomy of the central auditory nervous system and looking at deficits associated with these specific, these specific structures in the auditory nervous system. And I have a slide here because again, there could be hours long presentations on the Buffalo model, but I just wanted to kind of acknowledge that here.

So the Buffalo model uses three tests to diagnose central auditory processing disorder. And then folks are sort of put into these auditory profiles. So we have a decoding profile, the tolerance fading memory integration and organization. So then on the training side of things, for folks in that sort of decoding bucket, this really improves the ability to quickly interpret sounds. This tolerance fading memory profile, the therapy enhances focus in noisy environments.

For integration, the therapy connects auditory information with other sensory input for improved comprehension. And then for the organization profile, the therapy helps with sequencing and structuring auditory information effectively.

Now there are, you know, other additional training ideas that you can certainly incorporate. There are our app based trainings. There's Soundstorm, the Hear builder Auditory train your ears EQ edition. I am a big fan of having folks listen to, you know, an audiobook and kind of low level background noise and really just to kind of help them focus in on that audiobook itself.

I also wanted to mention, you know, compensatory strategies and support. So while CAPD does have specific interventions in relation to this auditory training and amplification location, I think it's important to also think about the classroom and the workplace. So preferential seating is certainly something that could be in an IEP or a 504 or a 504 plan. My husband is an accountant and I almost said a 501C3, but I really did mean a 504 plan. So preferential seating, any kind of visual aids.

Right. So this really goes to toward looking at different modalities, not just auditory, because we want reduce auditory fatigue as well. So visual aids and outlines of materials, any written instructions that are available to support any of these verbal directions and then built in quiet time or listening breaks again so that folks don't get kind of overloaded okay, now, kind of for our last bit here, I want to look at amplification and accessories. And we will be looking at some of Starkey's options as well. But as sort of an overarching theme to kind of tie this together, the amplification recommendations, we typically recommend binaural amplification with mild gain.

Right. We want to use features that enhance speech cues. So really be thinking about programming particularly in that range of, you know, that frequency range where speech is most important or those speech cues are. And then we would also want to have, you know, folks use a remote microphone or, you know, an FM system. Okay.

So for children, again, we want to look at, you know, bilateral devices with mild gain. You can certainly fit, you know, more of an open fitting, but if they truly are struggling in background noise, you might think about a semi occluded fitting just to kind of control the amount of noise that or, you know,

extraneous information that's coming directly through the ear canal that's not being processed by the hearing aid itself.

So, Starkey, our current line of devices are the Edge AI devices. These come in three technology tiers. We have three custom form factors and three RIC form factors. One of the sort of tenets underlying our devices are our neurosound processor. So we have incorporated an always on deep neural network.

And the goal of this deep neural network and our sound processing in general is to try to mimic what the brain would do on its own already. So we do have, compared to our previous generation, our Edge AI devices are 30% more accurate at identifying speech and diffused background noise. So I always used to tell my patients that hearing aids are smart, but they don't always know what we want to hear. So particularly for folks with central auditory processing disorders, this becomes important because we know that the speech is really the most important information that they're trying to hear and that they're trying to understand. So having devices that are more accurate at identifying speech is really important as well.

Additionally, we have another 6dB in low level noise reduction. So the devices themselves themselves are very quiet. We have, you know, very quiet devices just to sort of reduce that kind of distraction that you might, that you might hear. Now, one of my favorite features in our devices is called Edge Mode Plus. Now we do have our always on deep neural network.

In our devices. We also have Edge Mode plus, which is our on demand deep neural network. Now this is going to be more aggressive in gain directionality and noise reduction than what we have access to in the software. Even at our premium Technology level. So this is a great tool for those folks who may be struggling in background noise.

It is tiered based on technology level. So at the 24 technology level, this is going to be automatic once it is activated. So we counsel, you know, you get into that environment that's challenging for you. Toggle on edge mode. Plus if someone is using an app, there are these additional controls so you have best sound, enhanced speech and reduce noise.

Now those controls are available in the 24 and 20 levels of technology. So I'm a personal fan of choosing that enhanced speech option. I can tell you for myself who has central auditory processing disorder, that Edgebone plus particularly this enhanced speech piece of things is really, really great for kind of zeroing in on that speech signal. Additionally, we would recommend the use of remote microphones when it is appropriate and depending on that person's need. Now, I am a big proponent of our table microphone.

So this has eight built in microphones. It can be automatic in function. It can also be manual. So you can select the microphones that you want to be active. Now it takes about two hours to charge this device and the streaming time is up to 10 hours.

So this would be really great, you know, for an adult, maybe you are in, you know, a boardroom, a staff meeting, and you're having some difficulty kind of zeroing in on those voices. So using this table microphone would be a great option for you. And particularly if you were in a situation where you were the one presenting some information, everyone else is sitting, you know, around a table asking questions, that type of a thing, this is going to be a device that's really helpful in that situation for them. In addition, we have just our remote microphone. So this would be more of a use case for listening to maybe one person, one or two people.

Now in a classroom situation, this is a great device for the teacher or professor to wear. And this will stream that speaker's voice directly to the wearer's hearing aids will be be definitely helpful in improving that signal to noise ratio, which is one of the things that we really want to hit on with respect to that

central auditory processing disorder. So this also has a charge time of three hours and a streaming time of up to 10 hours in that operating range of 50ft. Again, when we're thinking CAPD, we're really trying to improve our signal to noise ratio ratio. We want things to be preferential towards speech.

So this is just one of the ways that we're trying to address that.

So all of our patients in general can benefit from edge AI, but particularly when we're thinking about this. Always on Deep Neural network that is preferential for speech, our Edge Mode plus feature and our remote microphones that are available as well. Well, excuse me, I seem to be having a little cough here, so I wanted to leave you just with some references here.

And let me see. I don't think I've seen any questions, but let me just pop up the chat.

I don't see any questions, so I will stick around for a few minutes in case any questions do come up. But please, you know, do always reach out if there are questions or you need further clarification. If not, thank you so much for spending your morning with us, and I think we're good to go. I hope everyone has a great day. Thank you so much.