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Mild TBI - The Not So Mild Effects

Presenter: Liz Fuemmeler, AuD, FAAA, CCC-A; Julie Shoemake, MS,
CCC-SLP, CBIS

- And again, welcome to our course, Mild TBI- The Not So Mild Effects. Presented by Liz Fuemmeler and Julie Shoemake. Liz is a vestibular, audiologist, and clinical product manager within her acoustics. She hosts co-hosts a monthly podcast called "A Dose of Dizzy". She's the president of the Missouri Academy of Audiology, and is an advisor for the National Student Academy of Audiology. Julie works clinically as a private practice SLP, specializing in auditory processing disorders and cognition, and has received the certified Brain Injury Specialist Credential from the Brain Injury Association of America. And I invite you to read much more about both of them on our website. So with that, I'd like to thank both of you for joining us today.

Liz, I'll go ahead and turn it over to you.

- Perfect, thank you so much for the introductions, and I think before we get started, we're going to review the learning outcomes that hopefully by the end of this session, you'll feel like you learned something. So Julie, if you wanna go to that slide. But after this course, we hope that you'll be able to describe a mild traumatic brain injury concussion and the most common effects and impacts of a concussion on hearing, cognition, vision, and the vestibular system. We've got a lot to cover today. Second, we hope you'll identify appropriate hearing and vestibular tests to perform post-concussion. And lastly, describe common assessments and treatment methods for cognition, including auditory processing disorders in patients post-concussion. I know we just had an intro, but just as a reminder, my name's Liz, I'm an audiologist.

Besides being on research and development with a diagnostic medical equipment company called Interacoustics, I also work as the vestibular director at a local clinic, where I am in Kansas City. So continuing to see concussion patients regularly, which really helps as I am designing equipment to better diagnose patients. So we'll talk a little bit more about our roles, but I first met Julie, we worked together at a private practice, and through our collaboration of seeing some of the same patients, we

started to see a lot of interactions between the role of an audiologist and the role of a speech language pathologist post-head injury. And so hopefully, by the end of today, you'll be able to see the unique role that each can play post-head injury and also how we can collaborate together in the future with these patients.

- All right, and then Amy did an excellent job covering my bio. So a lot of this is very similar to what you guys had already heard. So I work locally for a private practice here in Kansas City, so Liz and I are local to each other. So yeah, we've gotten a lot of great opportunities to collaborate and really work in an excellent interdisciplinary way with a lot of the same patients. And so at the very end, we've got some case studies on patients that we both saw together, so you guys will get some insight into that.

- Perfect, so we're gonna start, obviously, most of you have probably heard the word "concussion". That's not something that's new. If you've turned on the news in the last 10 years, I feel like there's been an increase in post-head injury coverage, but just from a definition coming from the CDC, a concussion is a type of traumatic brain injury or A TBI that's caused by either a bumper blow to the head or a bumper blow to the body that causes that brain to rapidly move in the skull. So there's, of course, a high prevalence of TBIs. We see this quite commonly around the world and especially in the US, it's been a focus, because of how much money it costs our health system.

But about 42 million people are diagnosed with a concussion worldwide each year. And something that I thought was interesting, especially as an audiologist, we tend to see quite a few patients in the geriatric realm, especially if you're focused on dizziness and imbalance. And I think this 75 years and older doesn't get as much attention in the media about being a top head injury age group, because, usually, we're hearing about the professional athletes and the young, you know, sports individuals, but it's really

these older adults that have some of the highest impacts, both with high hospitalizations and deaths. So something, of course, to keep in mind. There's a lot of different reasons people can get a head injury. Many of us, even as kids, probably remember times that you've gotten a head injury.

But most of the time, what we see clinically is people will come in due to motor vehicle accidents, sports-related injuries, falls are very common, especially in the winter. I don't know if anybody else has snow, but we got a ton of snow in Kansas City. So falls are a big concern, especially with ice. Of course, military or combat experience. And then assault is something that if you're in the concussion realm, you have to get comfortable talking to patients about even domestic violence cases. There's a lot of different really hard reasons that people get head injuries, and, of course, more than that are listed here. When people hit their head, there's two main types of ways that the brain is impacted, and this is talking more from how the force impacts the brain.

The first is known as a deceleration injury, and this is probably the most common type of injury that we see on an everyday basis, but this is when the brain actually goes forward and backwards within the skull, and you can have impacts on that first impact site. You can have damage to the second impact site or to both, and it's really just this rebound effect. And it's most common, especially when you think about the types of injuries like a motor vehicle accident or a fall, they tend to be one directional with the way that the force impacts the brain. The second one is maybe less common, but more detrimental to the patient as far as symptoms and clinical manifestation.

But it's known as a rotational injury. And exactly as it sounds, it's when the brain is rotating within the skull. It has some really interesting effects on the brain, and can cause a longer term recovery, and, you know, takes a lot more effort to get some resolution of their symptoms. And what you see in these rotational examples is that you have a stretching and tearing of the axons that are within the brain, and you also may

even have stretching and/or tearing of blood vessels within the brain. And so that can result into hematomas, maybe something that's a little bit more significant for that patient. Although, we're not gonna cover the pathophysiology of what's actually happening in the brain in detail, I think the most important things to realize is one, it's not a structural abnormality.

And what I mean by that is usually, head imaging or things that takes pictures of the brain are not gonna give us a ton of information specifically on concussion, maybe on more significant head injuries, but in a concussion, we don't really see structural abnormalities or changes to the brain. Scans, we'll talk about in a second are typically used to rule out brain bleeds or those structural changes that we see like a skull fracture. But most of the time in concussion, you don't have any anatomical differences to the brain. What we actually are noticing are functional differences. So it's how the brain is operating, and researchers believe that this is happening, because when the impact or the force is put on that brain within the skull, it leads to a wave of energy that goes through the brain tissue.

And this causes basically a mass miscommunication among how the neurons usually fire, so it causes this big dysfunction. And so many people talk about this being a bio-mechanically induced brain lesion, and you're not gonna see anything on the imaging. So that's really where I think audiologists and speech language pathologists can be very helpful. We're used to looking at how the brain functions in a variety of different manners. And so this is why I think post-concussion, we have a very unique role to play. There are a lot of different challenges with concussion diagnosis right now. So if you've known somebody that's gotten a concussion or you've had a head injury and you go to see your physician, it's actually quite interesting how the diagnosis happens.

And I think the main two challenges are, one, we don't just have one test that exists that's objective to say, "Yes, you've had a concussion," or, "No you haven't." I know there's been a lot of advances in the last five to eight years on blood tests, or, you know, functional MRIs to try to figure out what's going on. But really, right now, what's being used in clinical practice is many disciplines and many types of tools and evaluations to try to figure out what from here from my assessment matches an assessment from somebody else and putting those together would make us think a concussion had occurred. So that's a challenge, obviously, because usually, these patients have to see multiple individuals to get a true diagnosis.

The second thing that I think is really challenging, and we know this from seeing patients with all types of disorders, so it's not concussion, is not only the type of disorder that can have this issue, but no two concussions are the same. And actually, the variability that you see post-head injury is really wild. It's very large spread of what you can see. And this is due not only to what we talked about before, like how the force directly impacts the brain, so the injury mechanism, but it also is due to their preexisting medical factors, how their symptoms are presenting. And, of course, any prolonged recovery risk factors, there's actually six that are identified by the CDC that if you have those in your history, you're more likely to have a longer recovery from a head injury.

So concussions quite unique that it can be difficult to create diagnostic patterns due to all these different variables. Most of the time different hospitals or clinical practices are using this main framework for how to evaluate a concussion. And, of course, there's variability everywhere, but the first is some type of neurocognitive evaluation and that can be everything from a computerized evaluation like the ImPACT test. The King Devick tests are very popular, computerized evaluations to something that's more paper standardized assessment. The second aspect is some sort of neurologic evaluation, specifically looking at your general reflexes, both ocular motor and balance.

The third we've already touched on is imaging. And this is becoming less and less common, because a CT scan, which is probably the primary type of scan used post-concussion, doesn't really give information for what's going on with this individual.

It's more a ruling out factor. We're ruling out brain bleed, it's we're ruling out skull fractures, so it can be very important, but it's becoming less and less common in the emergency department post-head injury. And then lastly, some type of symptom evaluation. And this can be everything from something that's more computerized. I know like, for example, the impact test includes a lot of their symptoms in their assessment every single time you take the test, or it can be something very informal like an oral case history, which many of us are used to taking with our patients. But those four elements tend to help people diagnose whether a concussion has occurred or not. We're gonna talk about concussion from first the audiology perspective, and then we'll move to the SLP perspective, looking at what you can do if a concussion patient shows up in your clinic from diagnosis to treatment, and there's a lot of things we could cover.

Obviously, we have limited time today, so hopefully, we'll give you a framework, so that you can take something back to the clinic tomorrow. So audiologists are not new post-head injury. We've been studying the effects of head injury on the ear for a long time. I'm gonna focus on an area that's growing within audiology, and that's post-head injury vestibular evaluation. And there's quite a bit of research coming out about how our equipment and diagnostic power can be really useful for these patients. After a head injury, there's a lot of different symptoms you can experience. Something that's always interesting when you're looking at common symptoms post-head injury is the top three, tend to be headache, dizziness, and tinnitus, so ringing in the ears.

And so both from a dizziness and tinnitus perspective, those my audiology ears perk up, because I am also trained with my degree to look at dizziness and tinnitus. So it's very common to look at the symptoms and to evaluate where can I fit into this picture. Most of the time with my patients, I'm concerned with asking about these four realms. Of course, dizziness, which people describe in a lot of different ways, eye-related changes. So that's everything from visual acuity, so like blurred vision to even sensitivity to light, balance problems, balance walking, gait issues. And then lastly, of course, auditory complaints are very common post-head injury. When we look at what the standard is right now in vestibular, we do have a lot of different tests in our disposal to evaluate patients for their dizziness and balance issues.

And many of these tests can be associated with head injury. So we know for example, that one of the most common types of dizziness is a positional vertigo. It's spinning when you lay down in bed roll over in bed, that BPPV, benign paroxysmal positional vertigo is one of the top inner ear issues that we see post-head injury, but there's also many tests that are emerging that we haven't used in our typical assessment that are showing better diagnostic power for these concussion patients. So I'm gonna go through what my initial assessment typically looks like, because we have so many tests, we do post-head injury for dizziness and eye-related issues, we are not gonna go through them all.

I just wanna show you some of the new ones, so that you're kind of up to date on what's coming out in the literature. When I see a patient for the first time, I do have a few goals from my audiology realm. First of all, as always, our goal is to assess the peripheral auditory system. So we wanna see if there's been any changes to hearing post-head injury. So I've had a number of patients, one that I remember in particular, who was a 21-year-old baseball player, collegiate baseball player, and a pitch hit him in the temporal bone. He actually experienced a one-sided hearing loss. If I wouldn't have

done a hearing test, which should be a part of everybody audiology wise, typical assessment, we wouldn't have established that.

So step one is always establishing if there's changes to that peripheral system. From the auditory side, same thing from the vestibular side. We wanna see if anything's changed more in that anatomical origin region. And then the third one is a little bit more sketchy, because it's harder to do. It's evaluating a lot of reflex pathways. So there's three main reflex pathways that are related to the vestibular system, and specifically, we know that the vestibular and ocular reflex pathways tend to be most impacted post-head injury. So I not only wanna identify the abnormalities that I found, but also, establish a baseline for treatment. And a lot of this is evaluating whether the symptoms that they're reporting match something objective that we can measure throughout the recovery.

So we're gonna start with ocular motors. Ocular motor evaluation means simply looking at how the eye muscles move. So it's less focused on how well you see, how clearly you see that tends to be more in an optometrist realm. But now looking at how the eye movements track, and what one big benefit for audiologists is that we actually have video goggles that we use typically. We have a standardized stimulus, and we have our age-based norms. So in comparison to what's being done, a lot of times on the bedside manner, in the emergency room, on the sideline, we have a lot of equipment for us to say, "Is this a true difference that we're seeing post-head injury or is it just related to your age?"

" That's a super important question for our patients. So my typical ocular motor evaluation involves the following tests. I'm gonna focus on the three that are in bold, because these are a little bit newer. You may not be using these as frequently in the clinic. The other ones that are not bolded are part of a typical VNG assessment. So these are much more well known. So the first one is called near point convergence,

and whether you're an audiologist or a speech language pathologist, I don't know our split of who's attending, but whether you're a discipline, you're able to do this test, because it's a quick screener that gives you an idea of whether you need to refer on for further evaluation.

So the ability for our eyes to converge, what that means is to come together, and focus on something really close to the face without us seeing double. And this is super helpful in today's world, because we usually have cell phones really close to our face when we're laying on the couch. You know, we use this very, very often, and it tends to be the number one ocular motor abnormality post-concussion. So if we go to the next slide, there's been quite a bit of research that's supported the fact that your convergence, your ability to focus on the object close to the face can be disrupted post-head injury. And they've studied this from children to sports populations, military, and adults, and they found that anywhere from about 20 to 50% of patients that you see after acute head injury has this inability.

So one easy way to assess for this is using a popsicle stick or a pin. I use a popsicle stick and put a little letter A on it. You bring it towards the patient's face, and you ask them to tell you when they see a doubling of that target. The other thing that you're doing while you're pulling that popsicle stick close to their face is you're watching their eyes, because their eyes will start to come together, and if you see a convergence insufficiency, you'll actually see one eye fade away from that focus. So it's very obvious from you, an objective standpoint, and from the patient, they're subjectively saying, "Ooh, I've got blurred vision or double vision.

" That is how you can identify whether a convergence insufficiency exists. So again, it's a very simple use a popsicle stick, bring it towards their face, ask 'em for when you see a doubling of the target, and you're watching their eyes. And what's normal in this population is between five and seven centimeters of the tip of the nose. So they should

be pretty close to their face, and be able to still read and see that target. If they are way out here and they're seeing a doubling of the target, and you're seeing their eyes drift off, then that could be a sign of a convergence abnormality, and I would refer to an optometrist for further evaluation. The next test that you may not be as familiar with is something called the smooth pursuit neck torsion test.

So smooth pursuit is something that we perform quite regularly in the audiology clinic. It's when we have a patient follow an item going back and forth. And a lot of times, I say this ability to track, we use every single day. We watch it when we see cars go by. If you're watching a kid swing on the playground. We're using our pursuit system to follow that target as it moves, so it's really important that we're able to do that. And most people post-concussion can follow a target just fine. Where they have difficulties are if the target starts moving really, really quickly, or if their head or neck are in different positions, while they're following the target.

So the purpose of this test, the smooth pursuit and torsion test is you have them perform facing the screen, and they're following the target. You see how they do. Then for the next test, you have them turn their body, so they're at a 45-degree angle, and their head is turned back to the screen. And again, you have them do the pursuit test. So you do it in each direction. And what you can see, patients who have neck-related issues as a result of their head injury, they perform worse when their neck is turned in that direction and they're following the target. So it's a really nice way to see where and how the neck is also impacting how our eyes move, which it impacts it a lot on a daily basis, especially more for these post-head injury cases.

Now, this has been studied quite a bit. I think the next slide has some more studies post-head injury, but what they saw is that typically, post-head injury patients who are turning their neck and following a stimulus, they have what's called psychotic intrusions. So their eyes get really jumpy as they're following the target, which you can

imagine if your eyes are jumping while you're trying to follow something smoothly can make it quite difficult to follow, make you feel dizzy. So there are some tests or some studies that are showing that you see not only the increase of the jumpiness, but they may not even be able to follow the target, as well. So reduced gain is what we call that.

There's also been some clinical studies with this smooth pursuit neck torsion test that looks in just neck pain patients. I think it's interesting when you start to see concussion patients, as a vestibular audiologist, you're trying to figure out where is their dizziness or their ocular motor complaints coming from? Is it coming from the vestibular system? Is it coming from a migraine headache variant? Is it coming from the neck or neck-related issues? So there's been more studies that look in neck pain patients and have shown some differences here. So still an emerging test and something definitely to be aware of. The next test is called saccadometry, and this is an advanced ocular motor test, and it's super interesting.

Julie will be covering some aspects that relate really, really well to this test, so perk up and hear what this one's about. But like I said, it's an eye-related test, so they're following a target in some capacity, but it's been shown to have really great sensitivity post-concussion. So the next slide describes different measurement parameters. What we're looking at, the patient is typically looking at this red dot on the screen, and we're not only measuring how fast the eyes are moving, how quickly they're moving, which direction, but we're also measuring something that we call directional errors. And so the point of the test is you're staring at this red dot in the center. When the dot moves, you actually instruct the patient to move the opposite direction.

So instead of following the dot, they're going to move the opposite direction, which is quite difficult, because you have to not only identify that something in your peripheral vision has moved, but you have to inhibit the ability to look towards that, and you have

to mirror by going the opposite direction. So it's quite complex, it's not just following the dot like we do in many of our tests. It takes it a step up for these concussion patients, and really tries to figure out what areas of the brain may be impacted by their head injury. Now, post-concussion, there's been quite a bit of research on what you may see in these patients. So the next slide talks about some of the studies that have shown not only do people make more errors, so instead of going the opposite direction of the dot, they tend to follow it, because that's the easiest, and we're all used to that.

But I also, we've shown that there's an increased latency, and basically, what that means is the time for them to make the decision is quite delayed post-concussion. And none of this is surprising. If you've ever seen a concussion patients, the processing time in general can be quite delayed or slowed down, especially compared to their baseline. But it's nice to have an objective measurement of this with using their eyes only. This is the language free test that makes it really easy for us to evaluate some of these brain processing functions. So we're gonna move out of the ocular motor realm for a second, and talk about vestibular ocular reflex testing. So the VOR is probably one of the best reflexes known to man.

It's our ability to keep vision clear, while our head is in motion. And the VOR is something that vestibular audiologists evaluate all the time. Physical therapists love the VOR, and it's super important for us. It starts to develop and mature really early in our lives, and we're able to see that maturity continue up until about age 12. Again, what's being used standard baseline on the sidelines in the emergency room is the VOR is being evaluated, but many times, it's not with anything that's standardized, there's no use of video goggles, and we don't have age-based norms to compare to. And that can make it quite difficult when you're trying to track progress for a patient. If you don't have standard objective data, it's hard to measure how much progress has really occurred.

Now, the vestibular ocular reflex, like I said, it's the ability to keep your vision clear, while your head is in motion. We use this all the time. When you're walking on the street, I keep going back to the cell phone example, but if you're walking on the street and texting someone on your cell phone, the ability for you to move and to focus on what you're writing and be able to read it clearly is due to your vestibular ocular reflex. The ability when you're driving to turn your head and see a sign and say, "Yep, that's my exit, I just missed," that is the ability of your VOR. So it's super important that we're able to do these basic general functions.

We look at the VOR across different frequencies, and what that means is different head speeds. So in the clinic, I just put an example, and again, if you're in vestibular, this is very familiar to you, but the very, very low frequencies, we do a caloric test, which is putting air or water in the ears to evaluate how the ear is functioning. And then the highest speed that we can do is called the video head impulse test. And those are very quick head movements to see how stable our vision stays. There's been a lot of research looking at the VOR and post-head injury cases, because not all of these tests are helpful to do post-head injury.

So the next slide talks about some of these examples, rotational chair studies, it's pretty split on whether we should be doing them post-head injury. So there's been some studies that have shown that there is no difference in concussion versus control patients when you do these rotational chair studies. And it's something for us to consider, because rotary chair can make people feel quite dizzy. Post-head injury, people usually aren't feeling their best, and probably don't wanna be spinning around. So it's good to look at these studies, and make some clinical decisions for your patient what's best. On the flip side, both in the military population and pediatric population, there's been conflicting studies that, sometimes, we see impacts on rotary chair, and then, sometimes, we don't see any impacts.

So this is one of those, you know, in my clinic, I like to do rotary chair if the patient can tolerate it, because if you can get information on the mid frequency VOR, it can be really helpful for the patient's care. But that being said, this may be a test that's really difficult to get in this population just due to tolerance. The other test that's been evaluated is VOR suppression. So this is when they're turning in the chair, we're measuring their eye movements, except this time, they have a light on inside their goggles, and we're looking at their ability to overcome the VOR and keep their vision nice and stable. And that has shown to be a significant difference in concussed athletes.

So again, the purpose of just reviewing some of this literature is that right now, we're pretty split on some of these vestibular tests that we tend to do in all of our patients. They may not be the most useful post-head injury, and we have to keep an eye on that. The next slide shows some tests that are known to be very helpful post-head injury, and those are the bottom two tests, dynamic visual acuity, and gaze stabilization. vHIT, the video head impulse test, like I was just talking about, the highest frequency evaluation that we tend to do actually hasn't shown to have any difference between concussed and control individuals and populations. So this might not be the test you wanna do post-head injury, which is super surprising, because most of head injury patients who come in, they say, "I'm dizzy when I move my head.

" Well, anytime I see a patient like that, I wanna do a test where I'm moving their head and measuring their eye movements. But vHIT may not be the ideal test to help diagnostically with that patient. What's shown to be much more helpful are the bottom two tests, dynamic visual acuity, and gaze stabilization testing. And these are more frequently done by our physical therapy colleagues, but the purpose of these tests you're shaking the patient's head, and they are reading a certain opto type or a little letter on the screen, and they have to tell you how clearly or what letter they're seeing on the screen while you're shaking their head at various different speeds. So in

dynamic visual acuity, the size of the letter is changing, and that has shown to be very sensitive to identifying post-concussion VOR abnormalities.

For gaze stabilization, you're actually changing the head speed, so the size of the letter change stays the same, but you're altering how fast their head goes. And that has also shown to be abnormal post-head injury patients. So again, I wanted to look at, of course, our typical evaluation, many vestibular audiologists are very familiar with, but also taking a look at maybe some emerging tests that are not part of our standard protocol that may be way more helpful in these patients. So we'll be reviewing some examples in our case studies of how we integrate this information and we'll also talk about what to do with this information for the patient.

- All right, so now, we are gonna start the section for diagnosis and treatment of concussion patients on the speech side. So what is our role in evaluation? So most of the time when people come in and I see them for concussion, most of the time, they're going to report at least one or more of these symptoms. The vast majority of the time, people are going to say that they have difficulty multitasking, difficulty with short-term memory, and difficulty word finding. Now, when a patient comes to you, they may not use that exact verbiage. I find that it's about 50/50 with who uses what kind of language, but, of course, that's kind of on you as the clinician to further investigate what exact complaints that they are coming in with, and then provide that education to them on what different domains they're experiencing those difficulties in.

There can also be some executive dysfunction in there, but I find that most of the time, in this more mild TBI population, they don't have as many issues with this, and often, that executive functioning system is working really pretty well, and we'll get into that in a future slide. But often, their executive functioning system is looking pretty good and that can definitely impact how they're perceiving their difficulties and what you're gonna do with them in treatment. So the evaluation really should focus on a lot of these

areas in terms of just your cognitive battery. Obviously, if your patient comes in with difficulties in swallowing, motor speech fluency, et cetera, you're obviously going to want to pull assessments that are going to measure those areas, as well.

But just talking about the cognitive battery, these are a lot of the areas that I assess. So immediate and delayed memory, maybe through list learning or story recall, expressive language, so anything they're speaking to you. So confrontation naming, convergent-divergent naming, attention skills. Sometimes, visual-spatial and constructional skills through things like clock drawing or line orientation tasks. And then processing speed through things like stroop tasks and trail making. Here are some examples of assessments that can be used. For the most part, if you are going to be billing their insurance. Insurance is really going to want to see at least one comprehensive standardized battery being used. So if you are gonna bill that concussion assessment, 96125 code, you really need to be using at least one of those.

I often will do one of these, and then I will include bits and pieces of other standardized assessments depending on what deficits the patient is showing once I get them in there, and do that comprehensive battery, and then dig in to other areas as needed. So here on your screen, I've got the RBANS, the CLQT, the SCANN, and the SCATBI listed. These are just ones that I see commonly used. These are certainly not the be all end all of comprehensive assessments that you could be using, and certainly different tests are more or less appropriate for different severity levels and different specific deficits. So then some informal and qualitative measures that I like to do, as well, because while insurance is definitely going to want to see your comprehensive standardized test battery, and I do think that does give you some really helpful information, but it's also important to get the patient's subjective opinions and their own perceptions on how it is that they're feeling.

And so one of the main things that I do on this is give them a patient reported outcome measure. So most of the time, this will look like a questionnaire that I'm giving to them, and I say, this is really gonna help me get a gauge on all the things that I can't test for in the therapy room. So it will ask them questions such as, you know, how often in the last week or so, how often were you able to complete all of your work fully? Or how often did you have to take breaks from work or do less work than you wanted to complete? Or how often were you able to go and engage socially with your family?

Did you have to leave early from those social engagements? Things like that. Other things that I like to look at are their sense of metacognition and self-awareness, and then any strategy use that they use independently during the testing. So metacognition, of course, is thinking about how you're thinking or what you're thinking about. So for example, if I end a subtest and the patient says, "That was really difficult," I felt like I had to repeat the numbers back to myself in my head to be able to do that. So, of course, that's them indicating that they've used the rehearsal strategy, which I find that most of the time, if people are going to engage in a strategy independently on testing, it's probably going to be rehearsal.

That's the one I find that people use, tend to use with the most automaticity and the one that most people use more often. Sometimes, I will also see people counting on their fingers. Oftentimes, post-concussion, people will completely close their eyes, or they'll find a fixed point on the wall or the floor to stare at, and really hyper-focus on that area, and whether they know that's why they're doing it or not, it's so they're taking in less visual stimuli, so they're not having to process as much in, excuse me, incoming information, so that they can really focus on whatever task it is that I've given to them. So some treatment tools that I've got listed here on the page, I've got a good variety here.

So first there is the WALC textbooks. These are really well known I think in the community. They are essentially a series of textbooks that focus on stroke, aphasia, brain injury, et cetera, rehab. And they cover such a wide variety of topics. So they're essentially a series of work books. Now, of course, the whole workbook thing is kind of split in the community with who feels that these are appropriate tools for therapy or not. Some people feel that they're not quite functional enough to use in therapy with patients, and they don't lead to great gains. Some people really like to use them in their clinical practice. I fall sort of in the middle there. So I really like the WALC books for quick, easy to grab, no prep kind of tools.

And I find that they're really excellent to demonstrate a strategy. So for example, if I'm trying to demonstrate what, maybe the rehearsal or the visualization strategy may look like for that person, I may pull like a list of words, and say, "Okay, you're gonna memorize these words. I want you to practice using that visualization strategy that we've been talking about, and I'm gonna set a timer and I want you to tell me those words, those same words in 20 minutes from now when that timer goes off," and see if they were able to actually engage with and use that visualization strategy there with you in the therapy room, so that that way, you know that they're going to be able to understand how to apply that with whatever they need to remember at work or at home, etc.

The next tool I've got on here is the Constant Therapy app. So this is an app that is free for clinician use. There's a clinician version of the app, and then a patient version of the app. And so the clinician app is free to use. The patient app does cost money. You can, on your clinician app, build a whole patient profile for that person, and then just very quickly and seamlessly send different tasks that you can assign to them for home exercise program, and then they can receive it on their patient app and do it, you know, as many times as you said, or, you know, how often you want them to do those things, etc.

So this one I really, really enjoy. This one is probably the one that I grab for first when I'm looking for a quick no prep tool. Next is Tactus apps. Tactus have a really great reputation in the community, as well. I find that most of the time if I try to pull one of these tasks for my more mild TBI population, they tend to be a little bit too easy for them. So I have found that they're definitely, I think a bit more appropriate, level wise for the more moderate to severe, and then aphasia populations. So just keep that in mind as you're pulling different tools. Next is native smartphone apps. So things that come pre-installed on your smartphone just out of the box.

So things like timers, alarms, calendar, to-do lists, all of those things that just come pre-installed that are great for external memory tools. So maybe you're trying to help someone access a grocery list on their phone or set different alarms or a calendar set up for their medication management. Another one is the Honeycomb Speech Activity Studio. This is a monthly paid for subscription service, but this one has some really excellent functional tools that are customizable and personalizable to each patient. So, you know, if they're taking some specific medications that need to be at different times of day or different dosages, et cetera, you can kind of really lay that out for them, and add in whatever images and whatever other texts that you want on there, so you can really customize those.

So that's a really great tool. I'll have some demonstrations of some of these a little bit later in this slide, so you can actually see what they look like. Then I've got the MedBridge HEP up here. So I think a lot of clinicians are familiar with MedBridge in the term or in the way of physical therapy exercises, and they've had a lot of great PT tools for a while now I believe, but not the case for the speech and language side. But recently, maybe within the past year or so, they've really expanded this on their platform. So they've got a lot of really great stuff for areas like motor speech,

swallowing, they've got some good language things on there for adult language like semantic feature analysis, cart, etc.

The cognition section I think, again, may be a little bit too easy for the mild populations, but I'm hopeful that they'll continue to add to their HEP since they've completely added all of these new great speech and language tools. Then we've got just some general brain training apps, and I've got Lumosity written on here just because that's the one I see discussed the most and recommended the most by various rehab professionals. These are ones you're definitely going to want to consult the research for periodically. Right now, the gold standard is if you're going to recommend a brain training app to a patient, you're definitely going to want to be coupling it with formal therapy, and that's when you're gonna see the most improvement.

So as of right now in the research, I'm not familiar with any studies that have shown significant improvement with just a brain training app alone. And then, of course, you're always going to be wanting to make your treatment patient-centered and patient-focused. So definitely ask each patient what they want to achieve, what specific areas and goals that they want to work on. Then you're gonna want to incorporate some strategy training, as well. So these are the main four that I see used the most often. So they are rehearsal, chunking and grouping, visualization, and then use of mnemonics or a sentence strategy. Again, ask your patient. Make sure you offer a variety of strategies, and then recommend the ones that work best for various tasks.

So for example, the chunking and grouping strategy, it's kind of just segmenting different pieces of the information that you need to recall to make it a little bit easier to remember. So for example, most people automatically use the chunking and grouping strategy for a phone number. So you have your area code, your first three, and your last four, just makes it a little bit, kind of more bite-sized, a little bit easier to remember. So for example, if they have to remember for their job, maybe they have to write down

phone numbers, or addresses, zip codes, things like that, that would be a strategy that I'd probably recommend to that person that would be great for that specific task.

Sometimes, too, I'll introduce a strategy to a patient, and I'll say, "This I think would work great for this task." Sometimes, they'll come right back to me, and they'll say, "Ah, I don't really like that one that much, I don't think I'm gonna use it." And I say, "That's just fine, we'll find a different one." Everyone's a little bit different in what they prefer to use and what they find most helpful. So definitely work with your patient on an individual level like that, so you can find the best fit, because whatever they're most comfortable with, that's the one they're actually gonna use the most. All right, so then we've got some treatment samples. So first here, I've got an image of a stroop task.

So on a stroop task, you are going to tell the patient, you're gonna show them something like this, maybe on a piece of paper or a screen, and you're gonna say, "Instead of reading these words to me, I want you to tell me the ink color that they're printed in." So again, with what Liz mentioned earlier on that inhibitory control that comes into play in saccadometry, that is that same inhibition that we're analyzing here. So on this, for example, they should say green, red, orange, instead of reading those words. Now, at some point, I come to a point in the therapeutic process where this is now too easy, so then I make it harder, and now I add another rule in.

So then I say, "You're gonna do the same thing that we have been doing with naming the ink colors, but now, every time you come to one in a box, then you're gonna alternate to another rule, and you're gonna actually read the words by the text on there." So this one, for example, you would say green, blue, yellow. So now, not only are they having to initiate that inhibitory control and quick processing speed, but now they're also having to remember both of those rules. And I'm not at this level, I'm not writing those down for them. So they're having to remember that information. So

there's always really good ways you can differentiate a task up or down depending on the difficulty that they need.

And Liz, you can jump in.

- I was gonna say inserted a slide in here, because when Julie and I were putting this together a long time ago, we were like, "Ah, this fits perfectly." So that same stroop task is exactly the idea that saccadometry is based off of. So as we talked about before, saccadometry is when the dot moves, you look the opposite direction. So there's two subtest. The first test, you follow the dot, so you get that voluntary movement. And then the second task, you have the inhibition aspect, but this is just an example of the data that you get from that type of test. And overall, you're looking, if you look at the bottom right, you'll see that error rate.

So the directional errors is how many times they were unable to inhibit that reflexive response. And it's super important, because there's two main areas of the brain that this test looks at. But depending on where their errors occur, you can get a better idea functionally where in the brain it's impacted. And one thing I love about saccadometry is you're able to see the hemispheric differences. So based on if the eye or if the stimulus is moving to the right, that looks at left brain and if the stimulus is moving to the left, that looks at right brain. So if there's a difference between the green and the red lines, you're actually able to see not only the site of origin that the issue is occurring based on the type of abnormalities, but also the site of the brain that's more impacted.

So now, we're getting really, really detailed with how to form their treatment plan.

- All right, second treatment sample here. I've got an example of comes from the Honeycomb Speech Activity Studio that I mentioned earlier. So this is just one I just

happened to pull from the reading comprehension section. So you've got a pool schedule on the screen here that they can reference to, and then they have to answer those questions. And I just find something like this, for example, to be such a functional tool, because often in our lives, you know, we're checking restaurant schedules, time slots, booking things, especially for someone with kids that might be wanting to take them to the pool in the summer, this would be such a functional task. And then this one comes from the Constant Therapy clinician app.

This is level three of clock math. So this could measure or improve things like processing speed, mental math, working memory, and again, how often during our day are we having to check the time, or we're having to do things like backwards chain, you know, I've got a meeting at 11, so I need to make sure I've got my slides finished by 10:30 or whatever the case, right? So then you're having to kind of backtrack like that, and think through that process, and this kind of emulates that. And again, this one is one you could easily differentiate up and down depending on the difficulty they need. So if I'm pulling this for a patient and they're just absolutely acing this, then I'm gonna take it to the next level, and I'm either gonna cover either the multiple choice answers there on the right, or I'm gonna cover the visual stimulus of the clock, and just tell them what time it is, and then show them the options and the question.

Or I'm gonna hold the iPad and they can't see any of it, and I'm just gonna verbally dictate, you know, it's X time, how many minutes have passed since whatever other time. And then kind of make it a little bit more challenging in that way. All right, so then we are gonna jump into some specific cognition in terms of auditory processing disorder. So the ASHA definition is there on your screen, and it's a bit lengthy. So essentially, what it boils down to is that when a patient comes into your office with some complaints, if the diagnosis is truly auditory processing disorder, the issue that they are talking about isn't the hearing piece, it is the overall cognitive processing piece.

So some common complaints that people discuss in this situation is difficulty understanding speech and background noise, maybe some misunderstandings during conversations in this head injury population. Oftentimes, they will also have some tinnitus and sound sensitivity. Maybe they need to ask for repetitions often, 'cause they're just not able to keep up with the speed of conversation, maybe they take longer to respond, so they've got some decreased processing speed, any of those things, and there's some a few more examples on the screen, as well. So the evaluation of APD really should be done by an audiologist, because as I mentioned before, they are really the professional whose scope of practice really includes the ability to differentiate between is the issue that this patient is describing, is this due to a hearing problem or a processing problem?

So this is just an example test battery that I've seen some audiologists use. So the first test here is called the staggered spondaic word. This is a dichotic listening test, and I will get into that in a few slides. The next one is phonemic synthesis. This is for sound blending. This scan has a few different subtest on it. So one of them tests for background noise, one of them does another dichotic listening assessment, and another one is rapid speech. Then you have the auditory skills assessment. This one I believe tends to be more appropriate for pediatric populations. So if you've got some younger pediatric concussions, that can be an option to use in that case. And then sometimes, I will see audiologists report if there's an ear advantage, as well, and we'll get into that in a minute, as well.

So results can look like this. There are four main areas that can be diagnosed in terms of APD. So they are decoding, organization, integration, intolerance fading memory. So decoding as SLPs you may be familiar with in terms of something like reading difficulties or dyslexia, where, you know, if you're reading a word, you're using that decoding skill to figure out what that says. That is that same issue that we're talking

about here just in the auditory pathway. So being able to quickly and accurately process speech that's coming in. Organization is sequencing and organizing auditory information. So given a perhaps multi-step, auditory direction, can you, A, understand what was said, and also B, then be able to do those steps in the correct order.

Integration is combining auditory and visual information together. And then tolerance fading memory, for example, one of the skills within this may be the ability to process out background noise. Ear advantage is just the mathematical difference between the accuracy of the right ear and the accuracy of the left ear. So then some treatment targets. We're definitely gonna be working on background noise. I find that that is the number one complaint that people say when they come in post-concussion. Number two, and oftentimes, they don't know that that's what that is. But number two often tends to be dichotic listening. So when something is dichotic, I'm presenting auditory stimulus to both ears at the same time, but what they hear in the right ear is different than what they hear in the left ear.

So it's often difficult and pretty complex. Then we're also going to do some auditory memory, some strategy learning or reinforcement based on what level they're needing. Perhaps some phoneme instruction and discrimination. Again, based on what level they're needing, but typically, also some phonological and phonemic awareness, especially focusing on blending and segmenting skills. Targets for older children through adult age. Just oftentimes, just the group of people that I end up having referred to me tend to be adults for concussion, but sometimes, I get, you know, early to late teens, as well. So you are gonna want to consult the developmental norms to see what skill levels your patient is gonna need based on just whatever's developmentally appropriate for their age.

Typically though, I'm gonna be working on background noise, dichotic listening, auditory memory. At this age and level, typically more so of the strategy reinforcement

side, more so than the learning piece, probably not as much phoning instruction and discrimination and more so of the blending and segmenting skills. Some common treatment programs that I see used often, most of the time, I see the buffalo model, and this is the one that I use for the bulk of my therapy process, as well. And I've got some sound samples that we can listen to here in a minute, so you can get an idea of what that sounds like. The next thing that I use a lot of is listening and communication enhancement, which is LACE.

So this is a program that you can access, I believe, on an app, but also through a web browser. So this is something that patients can easily work on at home if they want to, as well, or you can recommend it as HEP, as their home exercise program. But this is a very, very challenging level program. So for example, I will use this with people who have already pretty mild deficits right out the gate, or if I'm working with an adult and we are kind of nearing the end of the therapy process, and they're starting to get really good at things and I need some harder, more difficult stimuli for them, I'm gonna pull LACE, because it's very challenging.

CAPDOTS is one that focuses more on the dichotic piece. CAPDOTS fast forward, and then the acoustic pioneer apps on there are definitely more geared to the pediatric side. And then interactive metronome. I've seen a variety of rehab professionals use this in a variety of settings. So that one would be great for kind of coupling with overall cognition, as well. All right, so let's get into our treatment samples. This first one is background noise. So this comes from words and noise therapy from the Buffalo Model. So the patient is to listen to the stimulus, and then tell me each word that they hear the speaker saying in increasingly loud levels of background noise. So I've pulled a couple different levels of noise here.

This jump doesn't happen quite to this extent in the track, it's very subtle as it shifts from level to level, but I've kind of cut pieces in or out just for demonstration purposes.

So you can see a quiet level of noise paired with a very loud level of noise. So here is that.

- [Man] Chase. Not.

- Okay, so bit easier. Now, let's go to a louder level.

- [Man] Fudge. Red. Each.

- So hopefully, you were able to tell the difference in those levels of background noise, and how just how much more difficult that louder background noise is to tell what the words are, even for probably many of you who aren't post-concussion. So that is a really great task that I like to use again with most of my concussion patients. And you can even see within that louder level of noise, the difference between that first word fudge, and then red after it. Theoretically, red is much easier to understand just because of the specific phonemes that are in it. That F phoneme that's beginning that word "fudge" is just so much more difficult to understand, because it's just so much quieter.

- Oops, all right, then we've got some dichotic listening. So this comes from dichotic offset training, again, from the Buffalo Model. So hopefully, this translates through all of your headphones and your setups correctly. But theoretically, what you should be hearing is two letters in your right ear, and then two letters in your left ear. And then in the middle, they overlap, and you should hear it at almost the same time. I pulled, not quite the highest level, but definitely up there in terms of difficulty for demonstration purposes here. So let's give that a shot.

- [Man] G-A-R.

- And we'll do another one.

- [Man] U-N-C.

- So this often is very, very difficult for people. Hopefully, like I said, that translated through your headphones correctly. Sometimes, if it's not working correctly, you can hear all four in both ears, and then it's not truly dichotic, but of course, in the office setup, we have them wear headphones, so we can control what letters are going to what side. And then one more sound sample, we've got phonemic synthesis. So sound blending, again, from the Buffalo Model. So if given a list of sounds that you dictate to them, can they blend those together, and tell you what word they make.

- [Woman] G, a, r, a, j, sh, or, t.

- Okay, I'm gonna cut it there for time. All right, and then Liz, you can jump in.

- Perfect, so Julie just covered obviously from her perspective both assessment and treatment options. And I better circle back to treatment options after someone comes from the audiology clinic, 'cause it can get quite complex. So I created this little chart, my mind thinks in charts, sometimes, but dependent on how, what the patient is experiencing from cognition, hearing issues, dizziness, imbalance issues, and ocular motor issues, there's a variety of different places that they can go. So obviously, if I had concerns with cognition, most of the time, I'm referring to a speech language pathologist for those. There's times that you may refer to a neurologist, as well or in addition to, but that mainly is the treatment option. From a hearing issue side, most of the time, you are referring to an audiologist.

Someone asked a question which was really, really good about whether audiologists always perform auditory processing tests when the patients are referred for a hearing test, or if they need to be explicitly stated in the referral in order to ask for an APD assessment. So it is not typical that if you were to refer a patient to an audiologist for a hearing test, it is not likely they will do an APD evaluation. So that may be something to be aware of. They're also, not every audiologist does APD evaluations. It's kind of like vestibular. So find a partner in your area that does the APD testing. Many times, and this is a growing message in audiology, if their hearing is normal, but they're complaining still of hearing difficulties, there's something going on.

So most of the time, we hope that audiologists, even if they get a normal hearing threshold assessment, that just says how soft of sounds you can hear not what your brain is doing with the sound. So again, I would, if I were you, I'd be pretty explicit and refer for an APD evaluation. As a precursor to that, they will always do a hearing test, because if you have hearing loss, sometimes, it's a different route. They may not send you through a typical APD evaluation. From dizziness and balance side, this is where, hopefully, you can partner with a vestibular audiologist in your area. But this dizziness can come from a lot of different sources. So sometimes, we're sending to physical therapy, sometimes, into neurology, ENT.

Cardiology is, there's a lot of cardiologic issues that can occur post-concussion, which are super interesting, but very complex and super out of my scope. So I would definitely be referring for those. And then as we talked about ocular motor issues and/or dizziness may lead to referral to a neuro optometrist would be the ideal, someone who has specialty training with vision issues post-head injury. So there's a lot of different options of where people can go and probably even more so, but if there's one thing you've hopefully learned so far about treatment options is partnering with other disciplines can be very beneficial, and knowing the when to make that referral is

very important. I think before we continue to the case studies, there's a couple questions.

So Julie, there's a couple questions for you. The first one is, have you seen or do you recommend neurofeedback therapy for your patients? I've read on several forums, that's been incredibly helpful for TBI for memory and concentration. So they were just curious of your experience.

- I'm really glad you asked that, because yes. So I haven't had a massive amount of patients come in who've also had neurofeedback, and so I can't say, you know, with a huge population of people to work off of here, but the few patients I've had post-TBI that have received neurofeedback just have so many excellent things to say about it. So I've got a guy right now who's now had two head injuries, and he went to do some neurofeedback, and they essentially, based on his brainwaves, we're telling him that he's basically in fight or flight, 100% of the time. So think about what that level of anxiety and those feelings do to your higher order cognitive functions.

They're probably not working very well. So if you're in that state just constantly or even most of the time or a lot of the time, that's really gonna inhibit those cognitive functions. So I think yeah, if there are some good neurofeedback providers in your area, I think that might be a great recommendation to make. And I've actually started adding that to my list of recommendations just because I've had so many patients come in, and report such great things from that. And also, as a practice, some of our other providers, so sometimes, more on the sound sensitivity and tinnitus side, some of my coworkers have met with some of the local neurofeedback providers, and we're really impressed by, you know, their knowledge and what they're able to do.

So yeah, I think that could be a really, really helpful piece.

- Awesome. A couple more for you, Julie. So what or do you know the research on brain training activities and what does therapy look like for coupling with brain training tasks or apps?

- Yeah, so if I am recommending a brain training app, I am using it as a home exercise program kind of task. If nothing else, just to help them stay focused on looking at some of those areas that we're working on in treatment. So oftentimes, I won't do like a Lumosity kind of brain training app during the session, unless they need help getting it set up, installing it, all those kinds of things. But typically, I'm having them do that at home. So for example, Lumosity is like 5 to 10 minutes a day, you open up the app, it gives you three exercises to practice with, and then it shows you kind of your scores and your progress. But typically, yeah, in therapy, I'm doing, yeah, some constant therapy apps.

A lot of times, also with concussion, we'll be doing some of the auditory training piece, as well. We'll be doing some, yeah, immediate delayed memory, word finding typically, all of those kinds of things just again depending on the patient profile and what it is that they're needing, so really kind of patient-specific there.

- Perfect. One for me, is there a way to test for various vertigos and a two-year-old who has a history of a large fall and delayed speech and language? So from the dizziness side, and maybe Julie will have some interesting things to say from your side, but with a two-year-old, there's definitely a lot of tests you can do to evaluate for vestibular damage. I will say as a caveat, most of the time, below age eight in the vestibular world, if they're having dizziness issues and like nausea and vomiting, a lot of that is related to a migraine variant that exists in pediatrics, so that's one realm. If you're noticing delayed motor milestones or physical issues like with gait or, you know, slow to reach those motor milestone expectations that you would have, there may be things that play with the vestibular system.

So in the audiology world, the most reliable for young, young ages would be rotational chair, vHIT, and VEMP testing. So those look for permanent damage, and also a little bit of the status of compensation. There's also some very easy like standing balance screeners that you can do with patients that are even as young as two, if they have the ability to stand independently. So the answer is yes, there's a lot of ways to test for it, and I know it can be challenging, especially without having the language to tell you how they're feeling, but that's when these objective tests from the audiology side come in very handy, because we are able to look at eye movements, and also evaluate some of those vestibular reflexes.

I don't know, Julie, if you had anything to say from your side with young, young ages?

- Yeah, not too much, unfortunately. I don't typically work clinically with that age population, so I don't know. I'm sure there are some cognitive tests that are able to be done. There may be some more, as well on the, I wonder like educational psych side perhaps if there's kinda an early intervention provider perhaps that may know some more about that, especially in terms of, you know, at two, theoretically, they should have a bit of language, but some tests that may be able to be done that are, you know, maybe a bit more nonverbal-related, so that you can kind of test without the language piece interfering. But yeah, I'm just not too familiar with many of those.

- Yeah, last question then we'll get into case studies, and then we can take a few more at the end if we have time. This is for you Julie, but where can we get the entire program for the demonstrated audio treatment samples for the Buffalo Model?

- So the Buffalo Model is created by an audiologist named Dr. Jack Katz, who we are very lucky to have right here with us in Kansas City. So I believe the CDs that we have, the sound files from here in my practice, the owners already had them ready to go for me, but I believe if you search his name, you should find his website, and I believe you're able to order them from there. But yeah, there's a whole recommended treatment book with protocols and recommendations and things like that. So I recommend reading that book, as well.

- Great, okay, let's look at some case studies, hopefully, to tie it all together. So I think we have two or three. The first patient, here's kind of an overview. I know there's a lot of words on the screen, but just of like history and complaints. So I saw this 14-year-old female. First, she came to me with three concussions that she had had in the last few years, and they were due to motor vehicle accident, a fall, and then due to soccer injuries. Her main complaints included sound sensitivity, difficulty with background noise. I ask a lot of questions about all of this just 'cause of the high prevalence that we've seen of APD, but reduced ability to multitask and also very easily distracted by noise.

She reported daily headaches, wasn't sleeping as well, very common post-head injury. She does have a previous history of dyslexia, and also vision issues, and she's completed a round of vision therapy through a neuro optometrist. From the dizziness side, she has weekly episodes of vertigo imbalance, pretty vague description. They tend to be less than a minute. And then she also said her balance was worse than what she experienced before, and she's in balance therapy to help with that. And then anytime she moves her head or her eyes quickly, that seems to provoke some dizziness for her. So the next slide talks about my evaluation, and again, I just put a little summary here, but from the balance aspect, again, she's 14, we wouldn't expect that she would have any deficits, but when we put her on a piece of foam just as a

quick screener and had her close her eyes, she was swaying quite a bit, and as soon as I threw in a head shake condition.

So I like to challenge my concussion patients. They tend to pass all of my typical assessments, but as soon as I had her shake her head on the piece of foam, she fell. So again, it's a higher level balance activity, but for a 14-year-old, especially an athlete, 14-year-old athlete, it would be something that I would expect them to do. From the vestibular ocular reflex side, she did not do very well in that dynamic visual acuity test. And then also, one of our rotational chair tests, the VOR suppression test, she failed that. From the ocular motor aspect, her eyes were super jumpy as she was following that smooth target. And we saw in saccadometry testing, I put her a screenshot of her error rate.

So normal at her age would be probably about 7% errors, and you'll see she was at 86% errors. So it was extremely high and definitely outside of our normal range. And then I tend to do quite a few questionnaires. So the easiest, shortest scale to incorporate into your daily routines would be the post-concussion symptom scale. It's 22 points, but she had a 65 on that. So normal would be 0, so 65 is quite a few. And then I do an anxiety and depression screener just because those are very highly comorbid post-head injury and she had a mild and a moderate self-reported scores on both of those. So at the end of my appointment, I recommended continue with vestibular therapy.

Of course, I recommended referral for an APD test, and then I would see her for a follow-up assessment. And you'll see this is just, I tend to type up a lot of my recommendations for concussion patients. So this is the handout that I gave her at the end of her appointment, just because, of course, as part of that auditory memory tends to be really difficult for patients to remember. So then I saw her back, and actually, I saw her on the same day that she did the APD test, which maybe was in retrospective

very bad idea. We try to pair up appointments for our patients, but she was completely drained. So a lot of her assessments and her symptoms increased and her assessments got worse.

And again, I think this was probably just due to we had tapped out on her cognitive abilities for the day, how much she had already put effort in. But she then, the APD test, like I said, was performed on that same day. And so here's her results and what was the recommendations there.

- Yeah, so she tested with all of the areas of APD, decoding, integration, organization, and tolerance fading memory. She did not have any ear advantages though, which is great. We want those ears to be as equal as possible, so that was a positive thing. So here's her pre-test score in the chart there. So on the staggered spondaic word, that SSW, she had 76 errors, and for her age norm, she should be scoring six or less. So you can see from that data point alone, she was pretty severe. Phonemic synthesis, she scored 17, that's out of 25 questions. She scored 17 correctly. And for the age norm, they should be scoring at least 23 correctly. So that was, again, below normal limits, but not quite as much as SSW.

And then for auditory figure ground, which is for background noise, she had a standard score of five, which put her in the first 10th of a percentile rank. So just across these specific measures, you can see how severe her symptoms really were in this initial point. So we did 13 sessions catered to those deficit areas. This person in particular, they didn't make a retest appointment, so we just don't have that data to show. But I talked extensively with her and with her mom, and they both had a subjective report of really improved background noise processing, so much easier for them to go out in public and into crowds, where before they had to specifically orient their schedule, so they would avoid those things.

And just affect-wise, at the beginning of therapy, she was very easily frustrated and so irritated by sound work, and we really just would have her come in, and then really get right down to business, and then she would leave. We wouldn't really converse, or chat, or anything like that. But at the end of therapy, she had so much higher tolerance and a much calmer affect. We were laughing and smiling together, telling jokes. It was really cool to get to see like her actual personality come back, because she just had the bandwidth for that again, where, you know, before we did this, she really didn't, and then she also reported significantly fewer migraines, as well, which is also great.

- Perfect, okay, second case study. This was a 27-year-old female who experienced a head injury at work. I'm pretty sure she was in patient care, I believe a nurse, and she was punched by a patient between the eyes. She did not have any loss of consciousness with this head injury, but noticed other symptoms. She does have a previous history before this head injury of migraines, anxiety, and depression. Since she works at a hospital, they did a negative or they did a CT and an MRI which both came back nice and clear. The only time negative is a positive thing, right? And then she reported constant headaches, light and sound sensitivity, and difficulty concentrating in noise. She had quite a bit of like nondescript dizziness and nausea, which has improved since she's been in weekly physical therapy.

But she noted increased neck pain, and currently, when I saw her for the first appointment, she was on light duty at work, so she wasn't seeing patients. She was doing more of like paperwork and about four hours of the day. So when I saw her for the vestibular assessment, which, again, the way that our clinic function, most of the time, I would see the patient first before Julie would or any other audiologist. But so I saw her first, she did have normal balance. Again, from the VOR perspective, we did dynamic visual acuity, and she had abnormal findings there, but normal on our

rotational chair testing. From the ocular motor perspective, she did have that psychotic pursuit, so jumpy eyes when following a target.

She also had a spontaneous nystagmus. So nystagmus is when the eyes involuntarily move, usually in the dark. Most of the time, when we put ourselves in the dark, eyes are not moving. So anytime they're moving, it's a little bit curious, and usually represents some sort of asymmetry in the brain that the brain is still trying to adjust to. So she had a spontaneous right-beating nystagmus, which increased when she looked to the right. Most of the time, vestibular audiologists know that that means maybe something peripheral is going on. She also, after a head shake test and in different body positional movements, had an updating nystagmus which for us represents something central going on, something brain-related, not something related to the ears.

And then lastly, just for her questionnaires, she had very high reports on all of them. Everything from the symptoms she had experienced post-head injury, her dizziness was having a severe impact on her daily living per her report. And then although, she had a previous history of diagnosed anxiety and depression, she had severe on both of our GAD-7 and PHQ-9 assessments. So after I had seen her for this evaluation, here's what I recommended. First of all, for an APD evaluation, due to her noise-related complaints, I also referred her for a, we have a specialist, a misophonia and sound sensitivity specialist. So where there's distinctions, noise can affect people in different ways. Noise can affect people by making them dizzy, so that may be a concern for superior canal dehiscence.

Noise can affect people by making them unable to process the noise, so it's more of a cognitive complaint. That's really when I start leaning towards APD, or noise can affect people emotionally. And when really, we see the emotional impact of noise or certain repetitive sounds on an individual, that is considered misophonia. So you may be familiar with this term, I feel like it comes up in like trivia nights, but when people have

issues with other people chewing, or tapping their pencils, or keys clacking, you know, keyboard clacking, those are all, if that's providing anger or causing that emotional response to the individual, your suspicion for misophonia should increase. And so I also referred her for this, because knowing that she has an emotional response, if I send her through APD therapy, if she qualifies, you're probably gonna be dealing more with that emotional aspect than anything.

So I referred both to the at the same time, and then she had not seen a neurologist, and just based on some of those central findings, that we saw in the vestibular assessment, I sent her there. And then, of course, to see her for follow-up. So I saw her for a follow-up, and she did still have some abnormal findings mainly with her ocular motor evaluation, but a lot of things had improved, which is good. We like to see, the brain likes to heal. So over time, as we retest some of these abnormal things, we hopefully should see that they naturally improve. But at this point I, of course, still recommended she see neurology, her headaches were still pretty consistent.

I did talk to the patient quite a bit about better management of her anxiety, depression. You should get super comfortable with talking about anxiety, depression if you're gonna see head injury patients, because it comes up in every conversation, it's important that you address it. Physical therapy, I recommended maybe after her migraine was managed, it's not gonna be super helpful. And then, of course, sound sensitivity, she had a consultation on the books, and then she did complete the APD assessment, and was qualified based on her test results. So Julie will go through that.

- So again, she had the same four deficits as before. She had decoding, organization, integration, tolerance fading memory, but this person also had a right ear advantage on the competing sentences subtest, and that is a dichotic listening test. And then in terms of her cognitive evaluation, she demonstrated deficits in short and long-term memory for auditory recall, alternating attention, and recalling information that she had

read. So here are her pre and post-test scores below. So on the left there her pre-test. So on the SSW, she scored 22 errors. Again, that age norm is six or fewer. For a phonemic synthesis, she got so close. She got 22 right and she needed at least 23 to pass. And then for background noise, she scored a 26 standard score, which put her in the 16th percentile rank.

So based on those findings, we completed 11 sessions of APD therapy and 10 sessions of cognitive therapy. At the time, I was really kind of splitting the sessions by one APD a week and one cog, well, it would be two sessions per week total. So one would be focused on sound-related stuff and one is focused on more overall cognitive kind of stuff. If the patient is mild enough in both of those areas, I can now fit both of those into one session, which I think is probably a little bit, just more helpful, just easier for the patient. So instead of having to come twice, unless that's warranted, unless they are a person that should be coming twice per week based on their profile and severity, I think that that just makes a little bit more sense.

But anyway, she ended up passing her APD retest after that, and then met all of her cognitive goals. So here's her APD post-test scores. So for SSW, she then was scoring three errors, well within that six threshold. She had a perfect score actually on the phonemic synthesis test. And then her background noise score did remain a 26 with that 16th percentile rank. So that's one step below that 25th percentile rank to be in that average range, so she was pretty close. We were able to improve her other areas, as well. She just was still a little bit impacted by noise at that point.

- I always love seeing the pre and post scores, 'cause you can see the big impact of APD therapy, and it's really helpful for the patient to feel that encouragement, as well, 'cause the day-to-day can be really frustrating. Okay, last case here, and then we'll have a few more questions. So this is a 22-year-old female. We got some young gals coming in lately. She had a head injury when she was hit in the head with a ball at

soccer practice. Again, no loss of consciousness. She, prior to this, has a pretty significant history of concussions and also a history of diagnosed anxiety. Noise for her caused nausea, lightheadedness. Also, just sound sensitivity and difficulty concentrating.

She reported headaches that were pretty short in duration. She described just being slower overall from everything from just like reading to processing speech, and then poor sleep. She noted imbalance with her eyes closed in the shower, which, again, from the vestibular perspective, we start to think, "Hey, is something going on in the ears when you close the eyes and also mess with the feet?" We're really relying on the inner ear for balance. So that's interesting she mentioned that. She also reported her anxiety has increased post-head injury, that's not a surprise. I feel like everybody's would. And then she noted she was completing vestibular therapy exercises with her athletic trainer at school. So I saw her first, she did, again, this is a young athlete, a collegiate athlete, so we would expect her balance to be nice and normal, but it was not.

When we put her on that foam surface, she was abnormal in swing and/or falling with her eyes closed, and also with a head shake. She had normal test results when we did her VOR test, but she reported dizziness, which for me is still something to note, because people shouldn't feel dizzy when they shake their head. From the eye movement perspective, she had abnormal convergence. So we had talked about that focusing close to the face, that was abnormal for her, and she was also kind of borderline normal for that anti-saccad task due to her number of errors. And then lastly, just reported her questionnaires. She, of course, reported symptoms, otherwise, I probably wouldn't be seeing her.

And mild self-reported anxiety and moderate self-reported depression. So after the evaluation, I had recommended an APD evaluation due to her noise-related complaints.

And because I had ruled out inner ear concerns for the noise sensitivity, that makes it really easier to refer for APD evaluation. I actually called her athletic trainer, and gave him some better direct exercises based on where her deficits were. I talked to her about her anxiety, depression, and then recommended a follow-up retest with me. And when I saw her the second time, her balance was better. She didn't report dizziness with her head moving, the ocular motor concerns had resolved, and her self-reported symptoms had gone down. So this is a very great example of people getting better over time and with the appropriate interventions.

- All right, and then in terms of APD, again, the four main deficit areas, and also right ear advantage for competing sentences, again, that dichotic area. So this person was really pretty mild in terms of testing. I really like this specific case example for being able to explain how it can really look for a patient in terms of, sometimes, you'll have a patient come in, and they'll have all these crazy complaints, and then you'll test them and you'll be like, "Huh. You look like you're doing pretty good, 'cause really, based on her pre-test scores, I mean especially in comparison to the first two case studies, just looking at the numbers, just looking at your qualitative data, you're thinking, 'Ah, you're fine.

" But really, what I find to be the case, often with APD, and I counsel this with my patients a lot, is that often I find they are able to score pretty well. I find that most of the time, by the time people find me for APD, whether that's through referral or whatever the case, they've been living with their concussion for at least a little while, at least a couple to a few months if not longer. So a lot of times, they get really good at compensating and at guessing. And so because they're having to tax their overall cognitive and language systems in order to get to the right answers of whatever it is they're listening to, they get really good at it, one.

But two, that's really taxing for your system, and that's really fatiguing. So I find that a lot of times on testing people can tend to look a lot better than they're actually feeling. So I talk at length with patients about that a lot. And so not only when I'm doing therapy, I'm not only taking qualitative or quantitative data, excuse me, on literally their accuracy, but I'm also asking them like was the right side or the left side easier? At this level of noise, are you having to put an increased effort yet? On all of those kinds of questions, how effortful are things? So for her pre-test score, she's scoring nine errors there. Of course, the age norm is six are allowed.

She did pass phonemic synthesis with a score of 24, and she did also pass background noise with a percentile rank of 50. So really well within that average range. So we did nine sessions of therapy for her. She passed, and then I'm gonna jump down to the table, and then jump back up to that last bullet point there. So on her post-test score, she's having two errors in SSW, which is great. She maintained her phonemic synthesis score, which is also great. That, for us in therapy, that wasn't a super high priority since she did pass with only one error on her pre-test anyway, so I wasn't expecting too much movement on that. But then for background noise, even though she started in the normal area since really her chief complaint was that background noise, I was still really prioritizing this for her.

And she did improve to the 75th percentile rank. She did also tell me though, that she would feel better, and I think this for her was kind of tied to her anxiety, where she said she would feel better if she could continue to work on some things even though she did pass the retest. So we got her set up with LACE, that browser or app-based program that I said from earlier patients can easily work on at home. So that way, she could work on that, you know, whenever she felt like she kind of needed that maintenance or needed that little bit of boost, if for nothing else just in order to help her confidence a little bit.

- So we have a couple questions, and then we've got one conclusion slide, and we're right on time. Two questions about who to refer to for that misophonia sound sensitivity. So typically, that would be an audiologist. Again, probably same thing in the speech realm. There's some audiologists that specialize a little bit more in this. So I would talk to somebody in your area, see if they're comfortable managing that. And many times in misophonia, you're also utilizing maybe a mental health professional of some capacity like a psychologist or even a psychiatrist to help with that. One question we can both answer, Julie, is about what is the time lapse between pre and post-tests for both audiology and speech?

So from the audiology side, I will say vestibular wise, I tend to see them as soon as they're referred to me either from the emergency room or primary care, but I will see them about weekly or every other week until their results get back to normal or that they plateau, and mainly just to evaluate that the interventions that they're receiving are appropriate.

- And then from the therapy side of that, in terms of APD, so they have to do the initial test, of course, obviously. And then if they are someone who is demonstrating deficits, then, of course, we do the therapy. Typically, I will see someone either once per week or two times per week, and I counsel everyone that it is perfectly fine to do either, but especially in this post-concussion population with a lot of my patients being adults, they're working on either they're back to work or they're trying to go back to work, and often, they're in at least one other form of therapy at the time, as well. And so I try to be really flexible with my patients on what's appropriate for them, both scheduling-wise, rest time-wise, and also how much are we taxing their system to lead to that improvement.

And it's kind of that fine balance of we have to tax them enough, that we're challenging their system enough to lead to that improvement, but we're also not completely wiping them out every single day because that's not super beneficial either. So when we see patients for therapy, we ballpark everyone at 14 sessions just because that's the average of how often, you know, of how many sessions people need. Some people need more than that, some people need less than that, just depending on the severity of, you know, what their symptoms are when they're first starting, how old they are, sometimes, two, you know, are they a five-year-old, where I'm having to spend 20 minutes of my 50-minute session, you know, trying to wrangle their attention and all the things like that versus like a 33-year-old who will sit very nicely in my chair, and do whatever I ask them to do, and then just how quickly they end up making progress.

Some people just zip right through, and we do eight or nine sessions like you saw in case study three. Some people take a little bit longer, sometimes, we do two rounds of therapy, so maybe we'll do 14 sessions, and then pause or, you know, if they hit a plateau, and then send them to retest, and then see what areas they're still struggling with on some of those comparisons to developmental norms, and then maybe initiate a second round of therapy. Sometimes, we do a break between, it really just depends on the person, and what their progress has been. If they've hit a plateau, I'm probably recommending a break.

- Good, thank you. And I think we have time, just enough time to look at our conclusion slide. So if you can move to that, Julie, hopefully, from today you're able to see that concussion patients can present with a lot of different symptoms, which involve a lot of different professionals. And you, as an audiologist, or SLP, play a really large role in helping not only the diagnostic characteristics of this patient, but also establish rehab and treatment plans. And there's a lot of well-documented research studies within both of our fields to show our benefits of helping with this population. And lastly, APD is

really common post-concussion, and can manifest as a variety of different symptoms. So make sure you're making this referral as an audiologist, doing the testing if you can, or evaluating as the treatment professional.

And I think we are officially out of time. Sorry, we didn't get to everybody's questions.

- That is okay. There is one last question that we do actually have time for, if you don't mind.

- Oh, perfect. Yes, not a problem.

- Can you see it or do you want me to read it?

- Let me pull it back open.

- Okay.

- Okay. Do you find that some of the symptoms and treatment strategies used for concussion patients would also be helpful for patients with history of seizures or seizure disorders? I would say from my perspective with seizure disorder or history of seizures, I'd be referring to a neurologist for appropriate treatments. That wouldn't be something that I would feel comfortable, providing treatments specifically for that type of disorder.

- Okay.

- And then from the speech side, I'm not sure if your question was more geared toward the audiology or speech side or both, but in terms of that, I have seen people with some case profiles where they do, where they have had just kind of a, you know, either

congenital or caused by something else where they have seizures. Just kind of coupled also with the sound complaints. And so, of course, you know, we do do APD therapy for those people, too, because they have those same kind of difficulties with sound, whatever their profile shows in terms of that testing.

- All right, perfect, thank you. Okay, so we can go ahead and wrap it up there. Thanks to both of you for joining us. It's been so informative. We appreciate you sharing your expertise with all of us today. And thanks to all of our participants for joining us. We appreciate your time, and look forward to seeing everyone again soon. Take care, everybody.