Cortical Auditory Evoked Potentials in a Pediatric Practice

Presenter: Shanda Brashears, AuD

It's my pleasure to welcome our guest speaker today, Doctor Shanda Brashears. Today she has going to present to us the cortical auditory evoked potentials in our pediatric practice. If you'd like to learn more about our guest speaker, you can read their course bio on the course registration page, but at this time, I'll hand the mic over to you. Great. Thank you.

All right, we'll start with some disclosures. Here are my disclosures, nothing to disclose here, and our learning outcome outcomes for today. Reminder again that you'll be prompted at the top right of a few slides that have some quiz contents on them. We're going to talk about why it's preferable in many ways to use speech stimuli as opposed to pure tones in obtaining the cortical how we can verify hearing aids and cochlear implants using this technology, how we can further our understanding in the severity of children with auditory neuropathy. Going to present some normative values both from the literature and from our clinic and discuss correction factors and how to apply them to your results.

How we use auditory processing the cortical in further evaluating patients with auditory processing disorders, we're going to consider the auditory efferent system. Look at some practical considerations such as electric and myogenic noise, which are a big part whenever you're doing electronics, electrophysiology, and consider some further directions, future directions. So, first off, the cortical has been around a long time, since the world war two era, and was first used to estimate hearing thresholds in patients, that is, before the ABR was even around.

The cortical is a late, near field obligatory response, and in comparing it to early evoked potentials, it is larger in voltage. And we're also measuring it closer to where it's occurring, so it can tolerate a good bit more myogenic noise and electrical as well than our early evoked responses.

The cortical gives us information about Heschel's gyrus and surrounding areas and their ability to detect auditory information, and we can infer the pathway between the cochlea and the auditory cortex as well. This response, however, does not provide us any information regarding the processing of sounds. It is merely a detection, can give temporal information, but not what we think of as processing, and we'll talk more about the temporal domain response. Morphology is dependent on several factors, a big one and a big consideration in pediatrics is the patient state. So you need an alert awake state that is preferably consistent throughout the study and placing your child in front of a silent movie is a very good way to achieve this state.

Age impacts the morphology and latencies of the cortical very significantly, and we know that p one is a biomarker for auditory maturity, that is generally at birth. Most patients, a lot of babies, have a p one and a p two, two separate responses that then become a p one, p two complex, one more rounded response, and then the two different distinct peaks resume around puberty, or they come back around puberty for most people.

There are some limitations here, one of which is the number of things that this test is called. And I have found in working with students and in the early days myself getting confused about the different ways that the name of this test appears in the literature. Of course, we love acronyms in audiology, so there's no shortage of them here. But I will be referring to this test as the cortical or the cape during this presentation. The test itself is not quite as sensitive in children as it is in adults, primarily because of their high level of myogenic noise.

And a practical limitation is that, at least currently, the same billing code is used for ABR and late evoked potential. So if you're doing them in the same day, you're only going to be able to bill this code once. A lot of you likely are here because you would like to obtain more training in this area. It's not difficult to run a cortical, but it does take a lot of practice in order to interpret the tracings in a meaningful way. So I hope I'll be able to bring you guys closer to that in today's discussion.

So why use speech over pure tone stimuli? For many years, pure tones are exactly what was used to elicit this response. However, scientists in recent years have been able to develop speech phonemes that are preferable for the most part, because, of course, what we want to know more than anything is how our patients are doing out in the real world, because both hearing aids and cochlear implants are processing speech information more optimally than any other types of sounds. This is another reason that speech phonemes lend themselves very well to verifying technology. And in some of the literature that we'll review shortly, we'll see that cortical responses correlate very well with outcomes such as speech testing and validation.

And you can also see changes that you make in programming be evident in your cortical recordings.

So, for clinicians, this test gives us a lot of good additional information to a standard test battery, especially for those who are not able to give us speech perception testing in the sound booth. And it can lend basically confidence to some of our recommendations, such as therapeutic interventions and changing the programming of our technology. For the families, showing cortical tracings can show literally in black and white to a family, how their child's auditory cortex is receiving sound in a better way with their technology versus without. And conversely, if you have a poor cortical in and aided condition, it can help you to counsel the family as to the need for more consistent use of their devices or may inform a clinical and family decision to move beyond hearing aids to something like a cochlear implant evaluation. So let's talk more about verification of technology.

It is possible to get a cortical threshold in the sound field. Generally, you won't need to get your unaided thresholds using the cape. Typically, they're done with ABR, and that probably is a better way of getting more like an estimated audiogram. However, there are kids who can't be sedated or don't sleep for a sleep deprived study, or maybe they have auditory neuropathy. And there are no neural thresholds.

So you can use the test to obtain thresholds that you would use to program your hearing aids. And when using speech phonemes, you want to minimally have a low frequency and a high frequency sound. You can add a mid frequency, such as a g sound to this battery as well in these consonant speech phoneme files, which we'll take a closer look at soon, there is no carrier valve, so it's not a ma or a s. It's a m or a s. And that helps to preserve the frequency specificity of these stimuli.

When you are looking at patients responses in the sound field, it is for a cortical test. It can be a very good data point to supplement your speech performance testing if you're able to get it and your SII and validation measures. Sometimes those things just don't seem to add up. And obtaining an aided cortical can be a really good tool in your toolbox. Now, applying the pediatric principle of they could spontaneously combust at any given time, meaning you don't know.

You might want to be testing this child for 45 minutes, but they might only give you three minutes. You don't, you don't know with a small child. So start with their real world condition of how they wear their technology, whatever that is. You're going to be placing the child in front of a speaker and obtaining a cortical threshold. Now, true threshold is not possible to obtain in all children.

What I mean by that is that if your no response run is not essentially flat, if it's wild with noise, you're not really obtaining a true neural threshold. In these cases, you can still get a look at aided benefit by doing the same conditions in the sound field with and without technology. Then you compare the latency and amplitude of each to try to derive some aided, or a lack of aided benefit in general with the cortical, it does not have a pretty latency intensity function like ABR, and you're going to see a decrease in amplitude more so than an elongating of latency.

So, diving into a little bit of the literature, and I've included some literature on adults as well as pediatrics, because they typically can give you more and more in depth information in testing. So it's always good not to discount the adult stuff. And in this study by Durant and colleagues, they found a very solid correlation between cortical detection in electrophysics testing and psychoacoustic perception of speech. Now, this automatic detection here is going to be mentioned in a lot of these studies. That is a way to use statistical analysis built into the software to automatically detect peaks, which takes out some variability when doing research.

In a study of older listeners, the cortical was compared with omnidirectional, directional, microphone enabled, and remote microphone technology. Directionality, when the cortical was presented in noise was better than omni, and remote microphones showed the biggest effect. And these authors also saw a higher correlation, a very high correlation in speech scores as compared with cortical results.

We know that validation is very important in pediatrics because we need to know how our patients are performing in the outside world. In this Gardner Berry study, they looked at the peach validation scale and compared that to cortical results in an ear specific, not in a sound filled paradigm. Again, a very high correlation. And this was true across three children with sensorineural hearing loss, auditory neuropathy, and those with multiple disabilities.

This is continuing with the same study. Detection rates increased with sensation level, so the higher above the threshold the cortical is obtained, the more responses were detected. This is pretty obvious. And they also were able to show that cortical thresholds correlated very well with VRA aided thresholds in the sound booth. These authors recommended using a correction factor of five decibels for kids with sensorineural hearing loss and ten for ANSD.

So that means that if your neural threshold is 40, then for a sensorineural kid, you would have apply an estimated threshold, estimated hearing level of 45.

I hope I said that right. So we, I mentioned earlier that it's not always possible to get a true neural threshold, and you need to be able to recognize if you have too much noise in your recordings in order to get a true threshold and no response run if you can't. These authors out of Australia proposed using this flow chart here where if your, your best cortical threshold is 75, let's say you're looking at likely a moderate hearing loss. And if you can get a response down to 55, you're looking at no greater than a mild hearing loss. And this would be with either using technology or if you're obtaining your cortical unaided.

So, moving on to some cochlear implant research, these authors found that the cortical response became shorter and shorter as time proceeds after activation. In this paper, they respond to the, they refer to the response as a p one. This would be in our clinic, what we call a p one, p two complex. So there's not two peaks here in these young children. The single peak this paper refers to as a p one.

So another thing to be aware of when you're looking at this literature, in children that receive sequential bilateral implants, the first implanted ear cortical improves over time after the second ear is implanted. So this is an impressive way of seeing that once binaural hearing is provided, the brain starts to reorganize around that. And not only the ear that's just implanted, but the one that has had an implant for several months is improving now that binaural sound is provided to the brain. These authors suggest that the maturation of the cortical on the first side may be a better indicator of the likelihood of success on the second side than the amount of time between the two surgeries. And they also concluded that increased auditory experience improves central auditory pathway maturation.

And while this seems very obvious, the point here is that with cortical testing, you can actually see this improvement over time in black and white or in blue and red. In a different study of three young cochlear implant recipients, they were followed for two and a half years with the cortical and validation surveys. All showed gradual improvement in both, and all had a normal cortical and normal scores on validation by two years post implant.

This is a large study of children and adults that were broken up into five different groups. They too found that cortical thresholds decreased from pre to post implant. So as the behavioral thresholds are decreasing, you see a concurrent decrease in cortical thresholds. But what's really very powerful about the cortical is that from that three to twelve month period, authors also saw that the latency of the response is getting earlier and earlier and ending up normal after enough time has passed. So bringing down the threshold is one thing, but we also want for the auditory cortex to become organized and fast in the way that it's time locking to the stimulus.

This is one of my favorites. It's a case study on a ten year old with single sided deafness. This child was followed with cortical testing in both the originally normal ear and the implanted ear. The implanted ear had signs of all the markers of a cortical by six months and fully mature by 14 months post implant. But what's truly amazing is that the normal hearing ear, while at ten years old, showed a p one, p two complex, which is normal at that age.

Over a year's time, the normal ear improved into a cortical response that has two distinct peaks and normal latencies and amplitudes. So again, the binaural hearing implant improved even the ear that started out normal. These authors also were able to show an improvement in both MRI and EEG data as the cortical is improving were these other medical tests. And like the other papers that we saw, scores on speech and validation were also improving. All the while, this patient was old enough to also report a good decrease in listening effort.

And, you know, sometimes we talk about, not with a single sided kid, but we talk about, oh, this child's too late to implant. So ten is not too late to see some really powerful improvements in auditory maturation in a relatively short amount of time. Here at nemours, we are implanting kids with single sided deafness at this time, most predominantly in those who have a risk factor for losing hearing in the good ear.

So let's start taking a look at some normal corticals. So, from inner acoustics, this is the type of system that we use and how I learned a lot about corticals. Some of these here are the statistical analysis that you can employ to, can still pick your peaks with, with your own eye, but have some stats to help you in your confidence in determining what is and is not a response. This one is a little bit unusual in that you see a latency intensity function here in your p two. That's.

You don't normally see that, but sometimes you do. We've got our p one here around 30 seconds, our p two around 150, n two around 300. And so this, this is a threshold study. We're following the response down. I would suggest that you generally do just like with our ABR training, two responses at your threshold run and two responses at your no response.

Even with the statistical support, I prefer to do it that way, if the child will give you enough time to do that. Of course, this is what I meant about the no response run being generally flat. You don't see any kind of wild noise in here.

Here's another example. So this one was at 2000. This one is to a DA. We used the DA exclusively for many years. So it's a little bit of an upgrade from a pure tone in a way, because it's speech but it's not frequency specific, that the ah carrier vowel makes it a pretty broad signal.

We do use this for our cochlear, our auditory processing and our auditory processing battery, which I'll talk more about soon. But here we see that we've got not too much of a latency shift here. We can see the, you can see the amplitude decreasing as we go. And again, I would get a second run here at no response, but we've got a nice normal threshold at 30. So if we're going to.

For a normal child, like with sensorineural, you would use a five threshold correction factor rather. So looking at down to 25 we would consider that pretty much normal.

One other thing on this one I wanted to show you is that it is very typical. We don't see it here because we only have a p one, p two complex. It's not labeled as such. We would label this p one, p two, but your p one starts to go away, a lot like your waves one and three in the ABR that you have the p one at high intensity and it's very normal for it to go away as you start getting close to threshold.

So here are some frequency specific speech stimuli. So unlike the DA, this is just angt and s, no vowel. That's how we maintain the frequency specificity. This is in the temporal domain here across the top and in the frequency domain on the bottom. So we see how we'd be able to use the m as a low frequency stimulus, the g as a mid frequency t and s as high frequency stimuli.

So if you're able to get all of these on a child, you can almost obtain an estimated audiogram.

Here's an example of aided versus unaided, and I'd like to point out some differences with the MH. The 500 hz cortical is similar to this in that you tend to get a more broad response, just like with all low frequency stimuli. And other types of electrophysics testing. And you're not going to get a p one as often with an m. You have a nice p one, small.

This is probably a young child for your t and your g and a p two that's much bigger. But for all of them, we see that the unaided tracings have a much smaller amplitude than the aided tracing. So this would be a good way to show some aided benefit.

Moving on to auditory neuropathy, we know that early evoked potentials really don't give us a lot of information as far as estimating behavioral thresholds. This is found in a lot of places within the literature. It's kind of widely accepted in audiology these days. So many of us have scratched our heads. What do we do with this infant with auditory neuropathy?

Do we try a hearing aid? How do we set the hearing aid? So this is a great opportunity to use the cortical for estimating hearing level. And because cortical stimuli are slow, we use a 1.1 /second it is possible to create speech phonemes that do sound a lot like speech, and also the neural synchrony. You're more likely to be able to get a response with these late potentials than with an early evoked because it's slower.

So the auditory system has a better chance of latching onto that in the temporal domain. And there's more redundancy in the auditory pathway from the ear to the cortex, as opposed to from the ear to the auditory brainstem. We very strongly recommend using speech, consonant phonemes, or even a da over pure tones with auditory neuropathy. And the reason for this is that this kind, this kind of stimulus you can see is much more broad than a pure tone. And like we'll talk about on this next slide.

When you have a very discreet pitch that you are presenting to an auditory system that does not have a full complement of nerve fibers, you're likely to hit a bald spot when you spread the signal out. You may catch some more nerve fibers, more likely to. Some other reasons that an ABR does not generate neural thresholds with these neural types of hearing losses is long neural refractory periods. Each neural impulse is not able to respond fast enough to time lock to each stimulus presented. In a person who has auditory neuropathy and is able to hear pretty well and quiet, of course, their brainstem is detecting something, but the problem is that the system is not organized or fast or synchronous enough to sync up to the stimulus that you're presenting.

So what we have up here is a condensation and rarefaction ABR tracing. You might want to call this a wave five, but it's really just noise. When you add these together, gather the cochlear microphonic goes away because it's a sensory, not a neural response, and it's therefore polarity dependent. And like to just ask a rhetorical question, what kind of an ABR do you think that we would get? I'm sorry, what kind of an audiogram do you think that we would get from this Abr?

Trick question. You can't know. This is the audiogram that goes with this AbR. Older kid that can do a full audio. But this was obtained using narrowband noise in the booth rather than pure tones.

When you test a patient with auditory neuropathy, two pure tones, sometimes you get these outlying thresholds that are way down here in the severe to profound range and may not make sense with your

SRT. Speech is a broad frequency signal. And when you're getting frequency specific thresholds, it's best to use something like narrowband noise so that you spread out that signal and you're not just stimulating discrete points that may not have any neural fibers there.

So some research by Sharma, one of my heroes, on using the cortical with auditory neuropathy patients, is that they found essentially three different types of corticals on people with this disorder. Children with this disorder, a normal p one, p two. That is entirely possible. Maybe the threshold is elevated, but we're talking about at 80 decibels, normal latency, normal amplitude, as opposed to a delayed cortical response, or then an abnormal or absent cortical. These authors suggested using the cortical response.

And let me back up and say that for each of these groups, the it may's, a validation scale, was much better in the normal, less good with the delayed, and not good at all in this third group. So Sharma and colleagues proposed using this as a way to triage patients with auditory neuropathy. So if you've got a normal cortical, you may want to consider not using hearing aids at all. Or if you do use hearing aids, you want to pair that with a remote microphone, provide the family with validation scales so that they can give you feedback as to whether or not the child's doing better or worse with the amplification. No technology route is an option with auditory neuropathy, but you have to monitor the child, their speech development, and everything else very closely.

If you're getting a delayed cortical, then they suggest that that is a hearing aid candidate. You should obtain a cortical threshold and use that to fit your amplification. We'll talk more about that in the next slide. No cortical or very delayed or abnormal, then you're probably looking at a cochlear implant candidate. And I think, like a lot of clinics, we would include a hearing aid trial with that.

But we're being very conservative with the amount of amplification provided and using those validation scales to inform us more than just booth testing and how the child is doing with the amplification. It is possible to make the situation worse instead of better by providing amplification with auditory neuropathy, because it is a disorder of timing as much, if not more so, than a disorder of not being able to hear soft sounds. So this kind of messy study right here is from our clinic. The idea of using cortical thresholds to obtain estimated speech awareness thresholds is from the literature. But here we have, and we probably also obtained this at higher intensity levels.

And you would want to see something a little bit better than this. Also get 80, but it's looking here like we're seeing a p one and a p two, not that typical of a morphology, but present definitely here in the raw data with no discernible response at 60. So this is to a DA before we had our speech consonant phoneme stimuli. And the way that we would apply this is to use a ten decibels correction factor, which is taking our 70 neural threshold down to a 60 estimated threshold threshold and then program into NOAA. So that's always a big question.

What do you put into your NOAA audiogram for a kid with ANSD? So we've got this one threshold, and we're going to build around it something that takes into account the upward spread of masking. Start at 500. Then, of course, after the child has a little bit of experience wearing the amplification, we want to repeat this in the sound field with the hearing aids on.

So this one, I remember, was not able to get any more tracings than this, but I wanted to show you some real world stuff here. This is an aided versus unaided child with auditory neuropathy from our clinic. And we see the unaided condition has a pretty lousy looking but present cortical response. And I'll point out here that it looks like this was the first one obtained, is a lot earlier than the second one obtained. You see this a lot with neural hearing loss because the refractory periods are very short and there's neural fatigue that happens very quickly into the test.

This is the aided response, and I think we might have a response here. It's, you know, way outside of the normative range, but, you know, regardless, it's looking better unaided than aided. And if you think about compression and all of the other processing that you have in modern hearing aids, and the fact that this is not a hearing loss, that's just the inability to hear soft sounds, but a full disorder of neural synchrony. That's why, yes, hearing aids are helpful in some kids with ANSD, but not all.

So, diving into some of the normative data, we used this for years. It's from a journal article by Wonderlic and colleagues that goes over all of the different ages and compiles some norms obtained from many, many, many different research papers, and leaves us with these suggested values here. So I just want to point out that we have a very wide range in what's normal for an into and an infant. Also, knowing that this is commonly seen in normal hearing infants, you want to make sure that you're using a window that's at least 600 milliseconds when you're testing very young babies. Babies.

So we've got all these different age groups here, and this is based on normal hearing children without processing concerns. This data was obtained in our research lab across the street here, and they looked at kids with and without auditory processing concerns. These are the norms for the normal hearing kids without auditory processing concerns. We have latencies expected for p two and n two. P one was not included because it is not present in all of the kids within this age group, and it's not stable.

It's. It tends to sometimes have a different latency depending on the day that you test it. So just looking at p two and n two in quiet and in noise, and if you choose to use this, you know, take this into your clinic and apply it, if you will. What this is here is the mean one standard deviation, and the two standard deviations range here. This, again, is on a DA.

I'll mention, too, that the noise presented is a speech weighted noise that's presented five decibels quieter than the DA.

So, recently, we obtained some cortical results on each other. After earlier this year, we obtained our consonant speech phonemes, and they felt different enough that we said, okay, we're going to do some site specific norms. And on ten adult audiologists, these were the results. The ranges are very similar to what you find in the literature. So we felt good about that.

And they're also very similar to what our research lab here obtained to adopt, we did this right, left and sound field. The amplitude range was roughly two to six microvolts.

All right, so diving into auditory processing disorders, this is probably the most corticals that we do in our clinic is on this population. And just explain the way a little bit about how our process works is that when we identify a child with, or the family comes to us with auditory processing concerns, we start with an intake. We ask that they get a speech evaluation and psychoeducational testing. Bring that with them to the appointment, which is two and a half hours to include a comprehensive audiogram, reflexes, noise, all that good stuff. And in addition to some basic auditory processing tests across each domain, we also do a cortical to a DA aids in quiet and in noise.

So we're looking first at the presence or absence of a cortical response. Is there a p one, p two complex, or are there two discrete peaks? And how does that jive with the patient's age? When comparing the absolute latency to the norms, we're using a 20 millisecond cutoff, and that is applied to the outside of the one standard deviation, so it would be 20 milliseconds more. Basically, this plus this plus 20 milliseconds.

More important than comparing the child to the published and site specific norms, is comparing the child to himself, him or herself. That is, how does the right cortical look compared to the left? And how does quiet compare to normal noise? Some of these other examples here, outside of our auditory processing realm here, we're using the same 20 millisecond cutoff to consider if the right is 20 milliseconds later than the left. We consider that to be a significant finding.

Oftentimes, n two is later, but p two is not. That's typically representative of a morphology difference and not considered as strong a finding as p two. Key to and into being late now, we worked a lot over years on this 20 millisecond cutoff. And one of the things that has always stood out to me and made me feel very comfortable with it is that 20 milliseconds is also the cutoff for random gap detection. That is, if you can't tell that two beeps are two beeps when they're 25 milliseconds apart, that's abnormal.

So this 20 millisecond fidelity of the expectation of how time locked our auditory systems should be to the stimulus very much seems like, like the right thing to do. As far as our benchmark for what is an abnormal cortical. So I'm diving into some of our auditory processing tracings here. This one is a morphological difference between the left and the right. On the left side we have a p one, p two complex, and on the right we have two distinct.

The morphology of the right is not beautiful, but there are two peaks. You see this a lot, where you get a marker that's not all the way down to the trough. I'm a trough marker personally, but you can see how in the raw data, you see where this is has been derived. So when looking at the latency of p two and n two, it's not nearly as meaningful in a case like this because you're not comparing morphological apples to apples, right. This is two peaks, and this is one large peak.

So using an exact 20 milliseconds second cut off to judge normal versus abnormal doesn't feel right here, but you can say that there is an asymmetry, and this is something worth pursuing or monitoring. So these next two slides go together. This is in quiet and this is in noise. And we see no difference in latency here, but a pretty significant difference in the amplitude, with the left being smaller than the right. And then when we add our plus five signal to noise ratio, speech weighted noise, we see with these stars indicated here that, that the noise tracings are later than the quiet tracings.

And this is happening in both ears. So some kids will fall apart completely in noise. The morphology will be just awful, or the response goes away completely. This, even though it's 20 milliseconds difference, based on how nice this still looks in noise, we would definitely consider it a finding, but not anything like, you know, terribly egregious in this child's auditory system. If there are other complaints, such as difficulty in the classroom, out in the world, understanding speech and noise, if the child does horribly on auditory figure ground testing, this 20 millisecond finding, we can combine with the other factors to consider something like a remote microphone system in both ears.

So I want to point out a few things you might have noticed that we are obtaining this at 105 NHL. I know it looks crazy. I promise you it's not. So when we first got our infant, just in listening to them and running each other, we knew it was way too soft. So we used our verifit to get some output measures, and we worked with our calibration company and inner acoustics to basically develop a 25 decibels correction factor.

Thought that this was a more solid approach to changing the calibration so that's what we're doing. 105 is 80. We are using a zero decibels run here just to add confidence in the presence of our responses. And I wanted to point out that we're using a very long recording window and that the zero milliseconds here has a hash mark. If you set your window in a certain way, you may end up with negative 30 to 30 here, and zero is in between the lines.

You want to know where zero is very quickly and easily just by looking at it. So we recommend that you create your window so that you can see zero. And the reason we're doing some pre time here, negative 60 milliseconds, is just because it's nice to see a little running eeg before you get into your cortical response.

All right, so these two go together in quiet. We have, and we've developed this system of letting each other, and mostly each other, know what the latencies are and how we're interpreting them. So we have here an interaural latency difference of two milliseconds, which is nothing. But then we come over here, and while the morphology is not as good and the amplitude has decreased, we have latency that are earlier by these amounts than what we saw in quiet. Seems strange, but it's actually very common, and we're going to talk about that in a few minutes.

Here's another morphological difference, an example. And then, very interestingly, this one actually improves in noise. Now, speaking of noise, this is a very noisy tracing. We have MRI directly above us where we do our electrophysiology. If you see this, don't panic.

If you obtain enough runs and add them together, then you can still see your response, even in this really obnoxious amount of noise. So while left ear looked much worse and quiet, it actually got earlier than the right in noise. So I'd like to talk a little bit about the right ear advantage. We know that the left hemisphere is more tuned into speech signals, and for all sensory systems in the body, the contralateral path is stronger. Farah and colleagues found with imaging that those with auditory processing issues have disruption in nerve fibers going from the right ear to the left cortex.

And we know that inner hemispheric transfer in young children is very slow. So their right ear advantage is more pronounced than in older children and adults. You're more likely to see a right ear advantage in degraded speech tests than in the cortical once you're above age seven. When we see a left ear better than right, we do consider this significant and we refer to it as an atypical ear advantage. Here's an example of an emerging peak, emerging p one, which at a lot of age groups, this is very normal.

You know, you can, you do not have to have this beautiful two peaks in order to identify. Okay, we're starting to see the p one e mercury here. And then just a reminder to be consistent with your marking. This is not wrong, but if you're going to do this on the left, like we see here, you want to also do it on the right. Okay, I'm going to come back to that one if we have time.

Basically, the idea is that we have a process of co signing each other's waveform. So before it hits the chart, another pair of eyes takes a look. The cortical.

So some of the power and limitations of this test. We know that the cortical is a biomarker for APD because multiple authors has have described it as being impaired as compared to normal hearing, normal listeners in the auditory processing population. It can help you to have more confidence in your diagnosis and recommendations. But amplitude is tricky. Some authors have published very solid research showing that those with auditory processing issues sometimes and in noise, but especially in noise, have a larger amplitude.

And the reason or theories behind this are that because of an impaired system, more. More resources are needed to do the task of listening in noise, and that good listeners in noise have greater inhibitory control. That is, their efferent system is stronger, so their cortical and noise might look more like they're cortical and quiet because it's no big deal to their auditory system.

So we really love having the cortical as part of our auditory processing battery. But of course, you cannot use it alone. You need it along with all of these other aspects here.

So what you're doing when you obtain a cortical and comparing it to a cortical in noise is in large part evaluating the medial olive cochlear system. That is, the system that goes from the superior olivary complex down to the cochlea. The most direct way of evaluating the olive cochlear system is with efferent suppression of otoacoustic emissions. I would not recommend this in kids. I've done this test a lot in my former life as a researcher, and if the person moves significantly or the probe falls out of their ear, you have to start over, because you're looking at a very small difference in oae amplitude between your quiet and noise condition.

The probe moves. You got to scrap your test and start over. So it's not a good thing for kids. But this quiet versus noise cortical is a great way to get a little bit of insight into the auditory system. So we know that those who have a lot of good efferent suppression, more higher amplitude of suppression than others, have excellent abilities to resolve frequency and discriminate speech in the noise.

Conversely, those with auditory processing disorders have a poor amount or no efferent suppression of oaes. And in 2003, I had the pleasure of testing the Louisiana Philharmonic Orchestra and comparing their efferent suppression to non musician controls and found a very statistically significant effect there. More recently, I happened upon some literature that did almost the same study on dancers. And also dancers have significant, significantly more efferent suppression than non dancers. So it's a very much top down way of thinking about this, to consider that training in music or in dance is by its nature, improving.

A person's physical, their body and their mind and their ear all have to temporally lock to the signal, which is music, in a very exact and precise way. And this training, which we think of training as happening in the cortex, can be measured down to the level of the outer hair cells. Good stuff.

So, my bottom line here, as far as applying the cortical to this population, is that it is not unusual, and, in fact, probably normal to see some responses in noise better than in quiet. If you do have noise responses that are 20 milliseconds or more later than in quiet, that is really. It's an abnormal finding. And. And, you know, if it's also supported by other complaints and test scores, then you might want to consider looking at remote microphone system and some other auditory training, or better yet, recommend lessons in music and or dance.

What a great way to supplement therapy and other kinds of clinical interventions.

So I would, if you're not already doing this, suggest the. I call it a the Berlin triage. Gonna keep talking here about how you really should be doing middle ear muscle reflexes on all your patients, you know, if you can, if they'll sit for it, if they don't have tubes, flat temps, etcetera. It's a really good clinical, in the sound booth way to get a peek into their auditory efferents. And we know that a lot of people with auditory processing issues have abnormal or absent middle ear muscle reflexes.

If reflexes are absent, if you're not already doing discrimination, it should be done not only in quiet, but in noise. And if a person has very abnormal reflexes and also very poor hearing and noise, you have to wonder if there's auditory neuropathy or some other neural component to their hearing. There's very mild cases of auditory neuropathy that do not present, like typical hearing loss. So our suggestion is to rule that out with a high intensity click ABR, which we do incorporate into our two and a half hour auditory processing intake evaluation. While we're doing our cortical, even though we can't bill additionally for it, we're also doing a high intensity click Abr just to rule out the possibility of ANSD.

The middle ear muscle reflexes might also help you to identify kids that need to be referred for an auditory processing evaluation. So why do I keep saying the mouthful of middle ear muscle reflexes? That is because there is another acoustic reflex. I don't like to call them acoustic reflex because there's two, and they. There might be more than two.

The two I'm thinking of both evaluate the medial olivacocochlear system. So there's the middle ear muscle reflex and the other one. Whoa, there it is. Efferent suppression of oaes. While we're talking about semantics, I'd like you to consider the sensory versus sensory neural terminology.

If a patient does not have any hearing thresholds worse than 65, no thresholds worse than 65, word rec is good and quiet. And in noise, OAE's are absent, but reflexes are present, maybe even reduced. You can expect great hearing aid outcomes because you have a sensory hearing loss and there's no real obvious neural component. So a neural or, you know, we have sensory neural. A lot of patients have sensory and neural.

So I'm not talking about neural hearing losses or auditory neuropathy here, but you would have possibly impaired middle ear muscle reflexes. Word rec may not be great and could be horrible in noise.

Essentially, when you're seeing these signs of neural involvement, you have to be a little bit more careful about good communication strategies using remote microphone technology consistently. Maybe we need to look very closely at. Is this a cochlear implant implant candidate? Because hearing aids don't do very well with the neural part of hearing loss, they are designed to just make soft sounds louder, addressing the sensory part of hearing loss. So what do a hearing aid and an outer hair cell have in common?

Wide dynamic range compression. They both do the same thing. They make very soft sounds, much louder, kind of soft sounds, a little bit less louder than. And that etcetera, it's wide dynamic range compression.

Okay, so a few practical considerations here. Noise was a huge problem for us at first. We had to really work through a lot of different things. We have an inline power conditioner that we got from our manufacturer, and then we, when we added physical grounding, that really did the trick. And let me show you what that looks like.

So there's a tool that you can get. It's like an alligator clip. We have a metal cart, which helps. It needs to clip to metal. The.

There's like a ring here that's gets screwed onto the back of the amplifier. And then you've got this, you know, shielded. Nice cable here that's got your alligator clip clamping onto the metal. And since we did that, we've really had a lot less problems. Still, sometimes they start to run an MRI and the noise goes crazy.

You can go into your parameters and open up this rejection filter. You don't want to open it up so far that you're having a ton of noise go into your recording, but, you know, like 80% to 99% of your sweeps accepted is kind of the sweet spot. So you can run quickly, but, you know, have as clamp down a noise filter as possible without it making it impossible to get results. For myogenic, we recommend having a recliner, not all the way flat, just slightly reclined, head resting comfortably on the recliner. Not the child's not holding the weight of their head up themselves.

It's rested legs uncrossed as opposed to crossed. Seems to make a difference. Watching a silent video. And I like to put the captions on for kids. They're old enough to read, so they get some reading practice in there, and they're less bored, which makes them less fidgety throughout the test.

I'll just let you guys take a look at some of my ideas for things that I'm interested in either doing or seeing happen. Moving forward, maybe just highlight this about the frequency following response. I've been careful to say auditory processing this whole time instead of cap, because Nina Krause and her brilliant body of research has helped us to understand that not all auditory processing is central. The frequency following response and someone who is a good listener, their response looks exactly like the temporal envelope of the stimulus, whereas somebody who's not a great listener, the temporal stimulus looks like this. And the way their auditory system follows it is just not a high fidelity representation of that.

So processing is happening lower than just the cortex. And I would like to thank my department, especially Tammy Rigner, who is the APD aficionado around here. She and I worked very closely together in getting the cortical protocol as a nice part of what we do for our auditory processing patients, and also Kat Trobolsky, who helped me a lot. We worked together on the output studies when we first got our consonant phonemes, and helped as well with just the whole project of getting our site specific norms run. So with that, I would like to open it up for a couple questions.

Thank you so much, Doctor Brashears. We do have a couple questions here. The first one was from earlier on in the webinar. Cassandra asks if we need to worry about neural fatigue in children with ANSD, and we are running aided versus unaided cortical assessments for verification. Will order of collection be important to consider, and is it possible to record better responses for the first few collections than the last, just due to neural fatigue?

Yeah, that's a great question. And I think that I do very routinely see better waveforms in the first few that I collect. So I give them a lot of breaks, like really frequent. They don't have to be long breaks, like two minute breaks between conditions, between aided and unaided. I've also, over time, tried to not do aided first on everybody, but switched it up kind of every other patient randomized.

I feel like I do whatever I do first, usually whatever they walk in with, which sort of randomizes itself, because a lot of these kids are not wearing their hearing aids because I'm trying to over time, see like, is this a primary recency effect or is it an aided versus unaided effect? So, yeah, I mean, the best answer I can give you is not long breaks, but frequent breaks.

Another question. Here we have a participant saying that they're in an office building where there's a lot of noise in the recording, and they narrowed it down to the booth itself is the source of the noise. So would your workaround, you know, work in this situation? It might. I would definitely try the physical grounding the alligator clip to, to a metal cart.

If you only have one power conditioner, get a second inline power conditioner from your manufacturer. Those two things together. And then like, I don't know if you have any red outlets. Those are tend to be grounded by themselves. They don't have any other lines on the grounding of a red outlet.

It's just plugging into the wrong place since can sometimes send you up noise creek. So, yeah, those are my best suggestions.

So if anybody would like to. I think that my email address is probably associated with this course in some way or some way. But I welcome questions by email, even if you want to send me like a scan of some tracings to take a look at with you. I'm happy to do that. So I'd like to be a resource for anybody who wants to start using this technology more in your clinic.

Doctor Brashears, if you wanted to spell out your email, we can certainly drop it in for the participant and we can share that if you're wanting to. Okay, so it's s as in Sam, b as in boy. Rashea mors.org n e m o u r s.

Thank you. Which is sad because I don't get the word ears in my last name in that email address.

And doctor Brashears, would you advance the following slide just to remind the participants of the exam should they wish to earn ce credit?

And if you have time, doctor Bershears, we have one more question from Kathryn asks, what is the youngest that you test, since the variability is wider, the younger the patient is. So when I was talking about the window, I meant to say again that for an infant, you do want to open your window up to at least 600 milliseconds. Probably 660 is what I would go with. But it could be days old. It doesn't really matter.

The problem is infants, and keeping a newborn awake is hard, right? It's kind of impossible. If they're ready to sleep, they just go to sleep. So, you know, it's, if you get a couple of good tracings when they're awake and then they disappear when they're asleep, you say, okay, well, we can just use the awake tracings. That's what we got.

We got a tiny bit. This is what it is. You know, they have to be able to tolerate the electrodes, which is kind of easier in very young infants than older infants. But there's no age limit. You can do it down to newborn long window.

That's the only caveat.

Wonderful. Thank you, Doctor Brashears, for answering all the participants questions. We'll go ahead and close the classroom at this time. We want to thank Doctor Brashears for her knowledge and her expertise. And we thank you all for joining today on this webinar.

Have a great day, everyone. Thank you, guys.