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CLARKE SCHOOLS FOR HEARING AND SPEECH
WEBINAR SERIES: AUDITORY PERCEPTION IN INFANTS AND TODDLERS
AND THE DEVELOPMENT OF THE LISTENING BRAIN
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>> JAN: Welcome to our noontime seminar here from Massachusetts, the name of our talk today is from ears to the brain auditory perception in infants and toddlers and in the development of listening brain.
For those of you that attended our last seminar, thanks for coming back. And for new attendees, thanks for coming today.
I'm Jan Gatty, I will be your moderator today and I work at the Clarke School.
I will introduce the other speakers, to my left is Barbara Hecht, in the campus in Boston and also in the Option Schools International, a private school, and she is the co director of a program we have in Soundbridge in Connecticut and we're looking at telepractice with families with young children who have hearing loss.
And on my right, Barbara, would you just like to say hi so they hear your voice?
>> BARBARA: Hello, everybody. Welcome back.
>> JAN: And on my right, Elizabeth Cole is sitting and she is the director of CREC Soundbridge in Connecticut. This is a public school program which has a very similar mission to Clarke working with children who are hearing impaired and listening and spoken language and Elizabeth is the author of a book *Children With Hearing Loss Developing and Listening and Talking* and it's a book we use in our training programs around the country for teachers of the deaf. Elizabeth?
>> ELIZABETH: Hi, everybody. Welcome.

>> JAN: I'm not going to read these mission statements but I'll give you a minute to do it. The Clarke School has six campuses located in Massachusetts, New York, Pennsylvania, and Florida.
And it's a private school using listening and spoken language and the CREC program is a public school that serves the state of Connecticut. And what you should notice is the similarities of our mission. Both schools were really developed to help families who decided to use hearing and spoken language with their children, with their deaf and hard of hearing children.
This is the second of a series of four webinars. It was designed for early intervention professionals who probably are working with children who are deaf and hard of hearing but may not have specialized information in that area and it's using technology and practice.
Our speakers   well, we know that first of all, that children who are deaf and hard of hearing, most of them have hearing parents and they're at risk, the greatest risk is that of developing language. Children have lots of options, families have lots of choices, some parents will choose a listening and spoken language approach, some parents will choose a sign language approach and some will use a combination of the two.
But our speakers here today really have expertise in the area of listening and spoken language and we're focusing on that for parents who make that choice for their children.
We're all teachers and as good teachers. We have learning objectives for this hour's session. By the end of an hour, you should be able to describe the function of the ear and the function of the brain and the human auditory system.
You should also be able to cite the result of congenital hearing loss on the auditory development of the brain.
You should be able to understand and report on the importance of early and consistent auditory access, particularly for developing spoken language skills
And you should be able to identify specific strategies that make the most of a baby's auditory brain development.
The focus of our talk today is on the development of the auditory brain system and I'm going to read to you this quote by Lise Eliott, because it really speaks to our goal today.
The act of hearing itself influences the quality of auditory development and shapes the way brains become wired to process and understand sound.
If you're interested in this area, if it continues after today's talk, we recommend her book *What's Going On In There*? It's very clearly written, readable, accessible, funny, interesting account of neurological development in children.
If you look at the bottom of your screen, you'll see a nice list of new technology and imaging procedures that permit study and neurological development in a young child and specifically activity in the brain.
But I want to give you a little background about what we learn from development before we had these techniques by studying animal behavior and the important lessons we've learned from that that kind of provides a foundation for this later work.
You may recognize this picture from your first year of psychology class of Konrad Lorenz who studied imprinting, and he looked at innate behavior of baby

goslings, I guess that's redundant, they followed or imprinted on the first moving object they saw after they hatched. Later in his work, he investigated the role of learning and experience by looking at the goslings' response to auditory stimuli and he found that babies preferred to follow the moving objects of the sound of the mother goose they had heard before they hatched.

About the same time, Stanford University there was a guy named Eric Knudsen, a neuropsychologist, and he was studying the plasticity of barn owls and it turns out there is a well sonar system and they rely on that to find their prey so it's important to localize the sound source of where it's produced in millimeters and they can do that after they were born and what Knudsen was he altered their state of hearing and disturbed the sonar system and what he found out was as long as he corrected their hearing within three months, it was in three months of age, the babies could relearn the skill. After that, they were unable to relearn localization skills permanently, so it gives us information about plasticity and also critical periods in neurological development.

We talked about the relationship of biology and experience and critical periods in animal research. The behavior in brains in human beings is more complicated, we will refer to this during the hour, I want to talk about it, the concept of developmental synchrony and this refers to increased development across domain and we assume this will happen in typical development and we assume that children will be able to have adequate auditory skills so they can differentiate the sounds of their native language when they get ready to produce them.

We also assume that children will have nicely developing cognitive and conceptual skills, be able to engage in symbolic thought, and this provides the foundation for using the symbols of language and words when they get ready to use them.

And what should be on the slide and what you should make note of is when there's a sensory loss of any kind, it really puts developmental synchrony at risk.

Okay. I'm going to turn the microphone over to Barbara, she's going to talk a little more about this.

>> BARBARA: Again, hi, everybody, and welcome. We couldn't leave this topic without showing you a wonderful little cartoon that illustrates the danger of the lack of synchrony, and in case you can't read the words on the cartoon, it says "Cirque De So Late." It is a wonderful theme to say that without appropriate experience during sensitive periods for brain development, a child is at risk, and this is the kind of situation we want to avoid.

So, what is the problem for a child with hearing loss? As we discussed in our first webinar, most of the time sensorineural hearing loss is the result of a problem in the development of the cochlea or less commonly it could be a problem in the neural pathways along the auditory nerve to the auditory centers in the brain

And it's this lack of access that poses a risk to developmental synchrony and auditory brain development The problem then is one of getting acoustic information to the brain because we're actually processing sound or listening with our brains.

So, just a reminder about how the ear works This is really a remarkable set of structures, remarkable sensed organ. Sound waves are collected by the outer ear and they're conductive through the ear canal to the eardrum or the tympanic membrane which vibrates in response to those sound waves and it moves the three tiny bones in the middle ear which eventually pushes up against the oval window of the cochlea and the cochlea is really the sense organ, it is the inner ear, and it is in the cochlea where these mechanical movements are transferred by the fluid, the sound waves are now going through fluid, and those mechanical waves are passing through the cochlea and moving tiny, microscopic hair cell nerve endings, basically transforming those sound waves into frequency or pitch specific electrical impulses Those impulses then are passed along the auditory nerve to the brain.

The human cochlea is really quite a remarkable sense organ, it does a lot of work. It's detecting the sound information and effectively filtering that into various frequencies, translating that acoustic information into an electrical signal. It's key to development of the auditory system. But when does this remarkable organ develop?

This leads us to our first opportunity for you out there in the audience to participate by trying to answer this question. By what age do you think the cochlea, the human cochlea, is fully formed and full sized?

Do you think it's at 20 weeks of gestation? Is it fully formed by birth? By 12 months of age? Or by 5 years of age?

You'll see the polling questions appearing right now and you can just use your mouse or your finger, click away and see where you think this occurs.

Okay. I think we're going to close the poll; do your last clicks. This is a very well informed audience 76% of you thought that the cochlea was fully formed and ready to go by 20 weeks in gestation and you are correct

The cochlea is really virtually its full size and even though actually the outer ear continues to grow a little bit, that cochlea is really at its adult size and it is ready to do its work halfway through gestation.

The ear, we often talk about, as being really the peripheral part of the auditory system. The ear is really the root into the brain and it's in the brain that listening occurs.

So, if we're going to say that we listen with our brain, what we mean is that the ear is receiving the sound, but it's really in the brain that auditory information is processed, received, and interpreted.

This is a fun kind of conceptual model, you have the deliverers, conductive mechanisms, and these going to the central mechanism of the brain and particularly the auditory cortex.

Someone once said that the ear is an ear without a brain is kind of like an unplugged microphone, so you can talk into that microphone, but if it's not connected to anything, you can't really hear that sound.

So, now a little bit about what happens once sound reaches the brain, and here we get into some neuroanatomy. What you're looking at is a cut away version, we're facing you which is a horizontal cut away so we can see this is where one ear is and the other ear and we've got these auditory serve here entering the brainstem, and the brainstem is really the first weigh station in the brain. It's where some very primitive kinds of sound localization occur. The brainstem is actually also very good at detecting the duration,

the intensity or the loudness and the frequency of sound, the pitch.
The midbrain is the next weigh station, before we go to that, I want to point out that sound is coming in in an intact auditory system, sound is coming in from both ears and it actually crosses over the midline to this little structure called the superior olive and it's important to note, this illustration doesn't quite show you this, but information is coming both from to the superior olive on the side where sound is coming in and on the other side, so we're gathering information from both sides of the head, and it's really in the superior olive we can do that initial localization analysis because sound will be a little louder on the side where the closer to the sound source.
Then we are moving up to the midbrain and in the midbrain, we've got more opportunity for localization and timing. And here, what the midbrain is using is not just the loudness but the time duration, the difference in timing between when the signal reaches one side of the brain or another, and it's actually doing some computation to determine where the sound might be coming from
Then that signal is sent up to the thalamus where a lot of integration of information is continuing to occur, and possibly preparation for a motor response to sound.
And then to the auditory cortex This is really key. This auditory cortex is where the sound is recognized, memorized, and integrated, and also then coordinated with other aspects and other parts of the cortex having to do with language and motor responses.
I wanted to point out, though, that as we travel up through the different weigh stations in the brain to the auditory cortex, we're also following the sequence of development. So, the first area to develop in the developing fetus are those areas, those auditory areas in the brainstem, followed by the midbrain, and then followed by the cortex.
So, as we learn, the cochlea is fully formed by 20 weeks gestation. Auditory brain development is occurring at the same time And interestingly, the very first auditory neurons can actually be imaged by three weeks gestation. By six weeks, we can see the beginning of auditory nerves and parts of the brainstem, and by about 17 weeks of gestation, we see some very obvious development of the midbrain
The auditory cortex is the last to mature. It's maturation begins early but continues all the way, actually, through childhood.
The interesting thing about the auditory cortex as opposed to other components of the cortex is that it is one of the earlier developing areas. And we think that that's because the developing fetus has access to sound, and so the auditory cortex is stimulated, whereas the visual cortex is really not stimulated.
Another area of the cortex that develops early is the area that has to do with the sense of touch and that's because that fetus does have access to touch sensation.
So, already we're beginning to see that experience has an impact on the rate of development and the type of development that occurs in the brain.
And so that brings us to an interesting question: What can the fetus hear? We know then that the cochlea is ready to go. But what kinds of sound does a fetus actually process as hearing?
We know from fairly recent research that by the beginning of the third trimester, in the sixth month of gestation, a fetus is really pretty good at recognizing low pitched sounds

that are high volume, and that the range of frequencies, the range of pitches that a fetus can detect continue to expand and develop during that last trimester of pregnancy. There's some speech sound discrimination by 30 weeks and discrimination, there are some studies where they looked at whether a 35 week old fetus could tell the difference between high C and middle C in preparation for singing, maybe, the Star Spangled Banner and that's really in place before birth.

So, by the third trimester, the fetus can hear those low frequency sounds. And it's not an accident that low frequency sounds are the ones that readily penetrate the abdominal wall. Again, we're learning that experience and the access to those low frequency sounds makes it possible for those areas of the brain that are ready to detect local frequency sounds to develop. The baby pre term can also discriminate certain speech syllables, for example, the difference between bat and B and developing memory for certain sounds and auditory memory patterns.

If sound is really if the baby starts to listen or that fetus starts to listen in the last trimester, then an infant who is born prematurely is at some risk, because the baby may be born with little or no prenatal listening experience. Even if there's a completely intact ear and the cochlea is fine and no indication of sensory hearing loss, we do know that premature infants' auditory systems are immature and they're also highly susceptible to noise damage.

The greatest sensitivity to noise damage, particularly damage that would affect the hair cells in the cochlea, seems to be between six months of gestation to about three months of age. And this is the reason that many, many people in neonatal intensive care units now are carefully examining the auditory environment in those NICUs to really reduce the sort of overstimulation from the noise of all of the machines and the talking and the kind of crashing and all of those sounds that really overstimulate and possibly could actually produce damage to the ear.

So, if a newborn baby has had experience listening, what do we see in their behavior right after birth? Well, we know that newborns prefer the sound of their own mother's voice, that they've heard not only through the abdominal wall, but also that they've really heard through the skeleton, through the sound that's conducted through the bones.

And we know that infants/newborns prefer the sounds of the language they were exposed to prenatally. Interestingly, there's some wonderful studies done where mothers were told to read stories aloud to their tummies and one group of mothers read *The Cat in the Hat* and other mothers read different groups and it turns out as newborns these babies responded by quieting and listening to the story that they heard prenatally.

And we even know that babies will respond to music that was played prenatally, and even TV show theme songs there's actually research on this (laughs), but after I was talking about this with one of our staff members, she said that this was really true, that her friend a friend of her daughter's was a big fan of the TV show "2½ Men" and right after birth the only thing that would stop the baby from crying to be to play the theme song from that TV show. So we know that prenatally that baby had actually been listening and remembering sound.

The baby is also able to do some sound localization particularly on the horizontal plane.

If you think about what this baby that is able to do at birth and then we look at the characteristics of the language that people intuitively use, both parents and other caregivers intuitively use, it seems to be perfectly adaptive to the baby's developing auditory system.

There's a real mutual interaction then or synergy, really, between what the baby's maturing auditory system is receiving and the kind of input that responsive caregivers use. So, I think probably you're very familiar with these characteristics of caregiver language, particularly high pitch, a lot of variation in intonation and melody, getting closer to the child's slowing pace and so forth.

And this input then is both finally tuned to what the child is capable of responding to and then that, in turn, stimulates the auditory centers of the brain to develop new abilities. This synergy or mutual interaction between the experience, this auditory access, and the developing brain continues throughout infancy and childhood. As the brain gets more and more experience, the synaptic connections, chemical connections between nerves that pass information along to the auditory cortex, those synaptic connections strengthen and develop with the right kind of exposure.

Myelination is where the nerve fibers develop a fatty sheath that really provides insulation and allows the impulses to be passed along very efficiently to each of the weigh stations.

In the early months, then, that baby is expanding their ability to respond to various frequencies, to localize not only based on the loudness of the sound, the difference between the loudness that comes in from one ear to another, but based on timing and they become more sensitive to soft sounds and temporal cues and be able to hear in a noisy environment.

One thing we know is babies do not really do very well at picking out sounds when there is a lot of background noise

Hearing loss has sometimes been referred to as a neurodevelopmental emergency and that sounds quite urgent, but really, when you think about it, the lack of access to sound and lack of access to language, whether signed or spoken, can have a cascading developmental set of impacts, so if the baby, because of hearing loss, doesn't have access to the sounds of spoken language and doesn't then have access to language, we know that that has an impact of socioemotional development, of cognitive development, later academic development and so on.

The same would be true for a parent who chooses to use sign language with their child. It's still a neurodevelopmental emergency and the emergency, really, is to begin to develop skills using American Sign Language or some other visual language system to stimulate the language centers of the brain.

Why is it so urgent to do this so early? Well, it's because of these sensitive periods, these periods we sometimes call critical periods We know from animal research that any alteration in either the amount of sound or the type of sound actually has an impact on the structure of the auditory system. And we know that from some research where either the cochlea was removed or the ears were plugged and then we can go in and look at the development of auditory neurons and we see that the number in size of

those neurons is quite depleted.
What's interesting here is that it's not just total deafness that changes the structure of the auditory system. Any degree of hearing loss changes the availability of the input and the amount of input and potentially puts neurodevelopment at risk.
Sensitive periods in development for human babies really follow the course of development of the auditory system in the brain. So, those earlier sensitive periods have to do with developments in the brainstem and particularly frequency discrimination that occurs and localization that occurs in the brainstem and midbrain.
The later auditory abilities are going to remain flexible or what we sometimes call plastic a lot longer, and particularly the ability to hear or pick out particular sounds in noise and to use binaural information and those skills begin to development in early childhood.
We also know that without auditory stimulation early on, without really complete lack of access, the auditory cortex begins to take on some other tasks and it can actually be used for visual perception. We think that's because some visual neurons, neurons specialized for vision, actually start to make their way into the auditory cortex and if they're not crowded out by neurons that are specific for listening, then they begin to sort of grow and develop in the auditory cortex, and there's some research showing that deaf adults who really have not had access to sound have actually the auditory cortex will show a lot of energy and activity when they're given visual tasks, particularly tasks having to do with peripheral vision.
This is a slide that we actually showed in our first webinar and I want to come back to it, because it illustrates then the important role that experience plays in auditory brain development.
This is some work by John Niparko at Johns Hopkins and as you can see here, this first slide shows an auditory nerve fiber in a normally hearing cat. These little stars and humps here are synaptic connections that really provide the synaptic chemicals and this is what an auditory nerve fiber would look like in a typically hearing cat.
A cat that is deaf, the auditory nerve fiber kind of peters out and where you see these little arrows, we would expect to see synaptic connections and there really are none that have developed.
So, you can see that the structure is really quite different, dependent on the experience that the brain has.
And then deaf cats were given cochlear implants early on and what's fascinating here is to see that a deaf cat who, through a cochlear implant, gets auditory stimulation, but those auditory nerve fibers actually grow and develop and look virtually identical to the auditory nerve fibers in a hearing cat.
So, congenital hearing loss or, really, hearing loss in early childhood or hearing loss at any time reduces access to auditory experience, not just in the quantity of that auditory information, but also the quality of the auditory information. Whether it's distorted or reduced or eliminated. That, in turn, affects the way the brain's auditory system wires itself.

>> ELIZABETH: So, this is Elizabeth Cole now. The question arises, why, then, if the system, the auditory system is compromised or is at risk, why would you teach this child with hearing loss spoken language through listening?
Well, the answer is that speech is an acoustic event. Speech being, of course, part of spoken language
Obviously spoken language has other cues, visual ones and tactile ones, but they're just supplementary ones, they're not sufficient for truly understanding spoken language.
It's really easy to illustrate that with thinking about what happens when you're watching television. If you close your eyes, you can still hear the spoken language and understand what's going on, assuming that you're a fluent user of spoken language.
But if you turn off the sound and just watch what's happening on television, you'll have a tremendously difficult time trying to understand. That's just sort of a crude illustration of how it is that speech is acoustic, but I think it does make the point.
The other reason that we teach children with hearing loss through audition when talking about spoken language, now we have the technology to provide early auditory access to the sounds of speech and begin that process of optimizing auditory brain development
So, what are the abilities then that are being acquired through listening? Ira Hirsch in 1970 came up with a model four dot points, detecting, discriminating, identifying and understanding and this is a widely used model, you'll see it in lots of literature how to work with children who have hearing loss.
Detecting is fundamental to everything else in terms of this auditory process because obviously you need to be able to detect the sound to begin to do anything else with it.
Discriminating then is trying to or having the ability to tell whether or not a sound   two sounds are different from each other.
Identifying has to do with associating that sound with some other thing. So, what made the sound and learning that kind of auditory connection.
And then, of course, understanding is what does the sound mean.
And when I say sound, it can be   I mean, a single sound is what does that word mean or what does that sentence mean?
So   here's some more detailed list of auditory abilities and skills, which was compiled from several different sources. Again, detecting is at the base of it all, since you need that for everything else that comes after it The other skills that are listed on here are things that you might see on an IFSP or an IEP for a child who was in the process of learning to listen and who needed particular focus on one of those aspects in order to further develop their skills in that area
So, one of the things that's important or incredibly important is that the auditory signal that the child's brain is receiving should be as clear as it possibly can be. And the three items that are on the list here are aspects of an auditory environment that can truly cause great problems in providing that clear auditory signal.
I want to demonstrate to you right now what that's all about And I guess one of the things that's really crucial here is that you, right now, are listening through electronics and that's what the child's doing, too, the child with a hearing loss who is wearing

hearing aids or a cochlear implant, they're listening through a microphone just as you are right now.
So, when I speak really close to the microphone here, I'm now about, I think about four inches away from it, you get to experience what that's like.
I'm going to keep the intensity of my voice at the same level and now I've moved back about double that distance on to about maybe eight to ten inches.
And now I'm going to move back even farther in this room to a distance from
(Room chatter).
>> ELIZABETH: I am now about six feet away and you can see that with the help of my colleagues here, making noise and talking at the same time, that there's a huge risk that that signal to the child is not going to be clear, it's going to be extremely difficult to understand.
Part of the reason is the distance that I as the speaker was from the microphone, the child's microphone, your microphone, but also background noise which can mask or cover up whatever the message is.
Reverberation is also part of it but you may not experience that as a real problem.
Many homes with very high ceilings and certainly many classrooms are very reverberant and that's a real problem unless the room is treated with carpeting or bulletin boards or something on the walls to absorb sound, as well as curtains and drapes on the windows and so on. So reverberation is a problem to overcome.
Another important point is that with regard to development of the auditory centers of the brain, children are not just small adults the way that people in the Middle Ages actually thought they were; that children are very different from adults with regard to the way that their auditory brain is working.
Which brings us to the second of the poll questions and adults, may tell you, adults need the speech signal to be about twice as loud as the background noise in order to be able to have about 95 100% comprehension of whatever the message is.
For young children, however, I would like you to indicate what you believe the speech signal needs to be. There are four choices in this poll. The first one is at least as loud as the noise; B will be two times louder than the noise; C is ten times louder than the noise; D is twenty times louder than the noise.
The poll is open right now, so feel free to click on what you believe is the amount. And we'll wait just a second to see all the answers.
Okay. I think it's whoops, it keeps moving slightly (laughs). Anyway, I think we'll close the poll now.
And you all can see on your screen what the answers were. Again, this is an educated audience (laughs). It is ten times as louder than the noise that the signal needs to be in order for children to be able to comprehend.
So, we'll move on whoops, sorry the next slide. As I said, with adults, it needs to be two times as loud and for those of you in this educated audience, you might very well know that that means it's approximately six decibels louder than the surrounding noise, that is the signal is six decibels louder. For children, the signal needs to be 15 20 decibels louder. And remember that the decibel system is logarithmic means, it's

expediential, so 15 decibels is not just 2½ times louder but 10 times louder than the background noise. So it's a significantly large increase.
So, why is that? Why do children need a louder signal? Well, one reason is because of neurological immaturity and that is what Barbara was talking about, that babies begin to have some ability to pick out the signal from noise, but it's a very slow developing thing. And in fact, I think it's actually not at adult levels until the child is about 15. At which point they are using earphones on their ears (laughs), and iPods and ruining their hearing from that.
(Laughter).
>> ELIZABETH: Anyway...
The fact is that it is truly a problem.
But the other issue about this is that young children are developing language; they're not just recognizing it. So, an adult might be able to recognize and understand a degraded signal with a lot better ability than a child who's just developing language. And you can certainly relate to that, I'm sure, any time somebody's used a word that you didn't quite understand, that you would ask them to repeat it because you need a really clear signal to get it
So, let's talk about noise levels in homes and classrooms, the auditory environments where children find themselves most of the time. There's a lot of variability in those levels in all the situations where children are, depending on the time of day, depending on how many dogs you have, how often the phone rings, or how many other children you have, and so on. And especially in daycare centers and pre schools, how many other children and adults are there in the classroom. And, of course, what's the room like in terms of acoustics. So, that's what creates all of the variability.
What will counteract that, of course, is the vigilance of the adults in those environments to try to monitor the noise and keep it as quiet as possible.
Research shows really that in all of those environments the speaker's voice is right often at the level of noise, the 0 dB ratio and in that case the speaker's message is being masked by all of the noise Remember, that 0 dB ratio is what I'm talking about right here, when the child in fact needed to be 15 20 decibels louder than the noise, ten times.
So what can we do? I already started to talk about this, but what can we do to help the child have really the necessary access to speech that they need both at home and at school? Reduce and eliminate unnecessary sources of noise So, turn off that television.
This is only important when you want the child to hear you. So if you don't care if they hear you or not, it probably doesn't matter. But actually (laughs) in my view, the child you want the child to hear you all the time, everything is learning. All of your talk is so important. So if you want the child to hear, and since you want the child to hear, you will want to do things like turn off the TV or the radio, don't have it on all the time when you're talking or playing with the child or just in other times, too, because the child needs to hear all of the conversation that's going on in the environment.

And other things on the list, there, too, closing the door, noise in classrooms, that's a big point, but also if somebody is making a lot of noise in the hall at home, you can close the door and it will be quiet where the child is and they will be able to understand you and hear you better

Another thing is to provide appropriate amplification noises and talk close to the microphone, because now you know what it's like in terms of distance what it needs to be.

The wonderful thing about very young babies and parents is often you are extremely close to the child as you're changing their diapers or using motherese and talking to them and using caregiver talk. That often happens very close to the child and so that's a great thing about that age.

But then as soon as the child starts to move away from you, like when they can crawl and walk around or whatever you want to however far you want to take that, you might want to consider using FM equipment.

So, you ask, what is FM? Here is a picture of what the child would wear, the part of the FM system that's part of what the child wears. It's just a tiny little additional piece that's attached to the hearing aid or it's attached to the cochlear implant, and I put several different varieties up here so you can see what the variety is like, and it's both hearing aids and cochlear implants.

In addition to that, that's what the child wears. It's called the receiver What the adult wears is a microphone and a transmitter The important thing about the microphone is that it needs to be close to the speaker's mouth and that is a really important point. Anyone wearing a microphone, you don't want to wear it on your belt, you want to wear it as close as you can get it to your mouth within about four to maximum eight inches of the mouth.

Those microphones come in a number of different styles. One is one you can just wear on your lapel, another one is one that kind of hooks over your ear and it looks like a singer or an actor. Another one is one that you can wear on a lavaliere like a string around your neck. Those are all different kinds.

With a microphone, six inches from your mouth, for example, it's as if you're six inches from the child's ear, which is wonderful, the ear and the microphone, that is, and what you're doing is reducing those detrimental effects of distance and noise and reverberation which we said can garble the auditory signal.

So, which children need a personal FM system? Well, personal FM systems are essential to any child who wears a hearing aid or cochlear implant and who is learning spoken language or is using spoken language to learn Any child

However, there are some caveats to this, in that FM systems, the equipment and technology and the need for them is clear. What makes is more complicated is that one needs an educational audiologist, I mean, you need the expertise of an educational audiologist in order to select the appropriate FM equipment, to fit it, to verify that it's the appropriate that it's set appropriately and also to monitor and maintain it.

It looks like a simple little thing just hooked on the bottom end of the hearing aid or the cochlear implant and just it's a microphone and it looks so simple, but in fact, it's electronics and it really needs to be carefully monitored and carefully selected and monitored and fit, as I said. If you wear the microphone under clothing or too far from your mouth, it doesn't work, if there's static and the child either can't tell you or doesn't tell you about it, it's masking the signal. So all of those things can be detrimental and consequently it's incredibly important to have educational audiologists working with any child who is using the equipment.

I wanted to show you some pictures of parents and young babies using FM equipment. In each of these pictures, the parent is wearing a mic of different kinds. I don't know if you can see, but the little blue arrow shows how far the mic is from the mother's mouth, that's how far the mother's signal is from the child's ear, and then it's carried over on the red lines that we drew on to the photos

Okay. We're going to move right along here. What can we do to optimize auditory access for brain development? Technology. Hearing aids, cochlear implants, and/or FM equipment The learning environment needs to be quiet, and you need to be as close as you possibly can be to the microphone.

And then what can we do to optimize those experiences, not just the auditory access, but how to optimize the experiences? One of them is catch the baby listening and talk about the sounds you're both hearing. Again, reduce the noise. Respond to the baby's vocalizations, make it fun to babble and talk back and forth. And expect the child to hear and listen. Behave as if they are listening and you will make it come true (laughs), assuming you've done all the other things.

So, how will you know if the baby is really responding? If it's a very young baby, these are things, I want to give you a few ideas, because this is the tip of the iceberg. Our next webinar we're going to talk a lot more about what to do and how the babies you would expect the baby to respond.

But young babies, when they're listening, they startle to loud noises. They have to be new loud noises, you can't keep repeating the same one or they'll just not pay attention to it after a while because they've learned it's not something to be afraid of.

They'll also either get quiet or get very excited when a novel sound occurs. They smile or they coo responsively and look for the sound. And that search initially is just side to side and don't expect it to be quick because the baby can't move their head so fast but their eyes may go in that direction and their head may follow it, and it's slow initially and then it gets faster.

And of course they may show fixate to the sound too and all of those are signs that the baby is actually starting to listen and they're great events too when it happens.

Okay. Now I'm going to turn it back over to Jan to wrap it up

>> JAN: I want to thank my colleagues and get in the role of summing it up for you. We were trying to think of a way to give you the message and that noise. Yeah, there are providers in homes where the television is on, and you can be the no no noise nanny.

>> BARBARA: I would also add, this is true of any child you work with, whether this is a child with a hearing loss or a child who is receiving early intervention services for other developmental risk factors. The importance of getting that auditory access and appropriate auditory access is critical for any child and particularly urgent for any child

at developmental risk.
>> JAN: So in summary and in conclusion, we've talked a lot about the relationship of biology and experience to the development of the auditory brain.
Children need auditory capacity to hear. This speaks to the integrity of the auditory system. For children who are deaf and hard of hearing, we have nice sensory aids and technology that really help compensate for that integrity, and if you can really create an environment for those devices to be used, you'll capitalize on their effects on helping children to hear.
And there's auditory experience. This is any event that takes place   whoops, excuse me   in the child's life to activate the auditory system.
And we want the experience, this is true for all children, but particularly for hearing impaired children when you're supplying this extra auditory information and enriched experience is the experiences should be very consistent and an auditory event, you can isolate it to talk about it but it usually takes place in the context of a multi sensory event so it's important for children to have opportunities to associate the auditory experience with the other sensations that take place during that event.
Auditory performance refers to how we use hearing to adapt to our environment.
And for children who are deaf and hard of hearing the risk is that they really need to have experience and capacity to use it for speech perception and production.
And the last closing model looks at the ability to hear, which is auditory capacity, the use of the ability to listen, which is auditory experience, and then the way we perform based on that.
And these factors feed   it's a cyclical model, one interacts with the other and capitalizes and enhances the other.
So, I would say that the ability to hear, listen, and use sound to adapt to our environment is interdependent and it contributes to the fullest development of the auditory brain.
Thank you very much I hope that   oh, I forgot   this is a slide that our assistant put in. I want you to   we had lots of questions about this last time, but we will e mail you a link tomorrow for this webinar and all responses to the questionnaire that's on that link will be evaluated by third party evaluators and they will be anonymous.
We want to know how we're doing. We have two more presentations in this series and we really take the feedback very seriously and we will modify what we do in the future based on your feedback. So, be honest, do not be cruel, you know, if you can avoid it, anger management (laughs), but we're taking your responses seriously; we're good teachers that way.
There will be certificates of participation available after you finish and submit the survey.
Our next meeting will be on Wednesday, lunchtime, March 13th eastern standard time at noon, and the topic will be how do infants and toddlers with hearing loss learn to listen and talk. Hearing aids and cochlear implants are only the beginning And it will be a more detailed and expanded view of strategies providing auditory access to foster an early language environment and promote early language development
Thank you. Have a good afternoon

(End of presentation).