

A CONVERSATION WITH...

Dr. Emily Tobey

The Nelle C. Johnston Chair in Early Childhood Communication Disorders

at The University of Texas at Dallas

(hosted by Communications Manager Brandon Webb):

WEBB: What in particular about early childhood communication disorders piques your interests?

TOBEY: *Well I think the most exciting thing is to believe that we have a new infant who is born, an infant whose two sides of their brain aren't connected, who has an immature motoric system and an immature body and mouth system. And within a very rapid time period, within four years, that infant goes from basically knowing nothing to having a vocabulary of over 10,000 words. If you stop and think about it, it is an explosion of anatomy and physiology and language development in young children.*

That's almost miraculous because at no other time in your life do you learn as much as rapidly and make as many anatomical and physiological changes. And so it's a time period where if you wish to be a clinician or you wish to be a scientist, you can peer into workings that are ongoing developmentally and allow you to have an impact if you have a child who's delayed or disordered, have an impact that will make them better down the road.

INTERVIEWER : **So, unlike most any other phase of life, this is where, if you were to imagine this on a curve, this is where the ramp-up or explosion of learning happens, right during these first few years.**

TOBEY: *And that's exactly correct. If you think about it, even if we take a brand-new infant, and I just exposed that infant for a few days of listening to a foreign language, by just that mere exposure, I actually prime that child to be a better language learner when they're in elementary school or junior high school. Such that introducing a foreign language to them at a later date becomes easier for them to actually learn and become more facile at. So babies are like human sponges. They are prepared, and all of the pieces are there ready to receive and to learn and to develop language. So it's a good time to figure out how you present those opportunities. Whether you work with parents to train them how to stimulate their child, whether you work with the child themselves, whether you work with the community to figure out how best to give them resources, you know that by working with those children, you can make a huge impact down the road.*

WEBB: Is there such a thing as too early to influence learning and recognition?

TOBEY: *No, but there may be an issue of perhaps too late. That is, we know that there are differences between how children learn before the age of 5 and after the age of 5. When we look at many of our techniques to help rehabilitate children, some of those techniques require that the child be at least a year*

or older. But even those techniques – as we get more perfected at how we do them and technology becomes smaller and technology becomes safer – become techniques that we would want to put into infants during that first year.

If we take an area like hearing impairment, which is one of the areas I'm most interested in, we know that if we can identify children within the first 6 months of life, identify them as having a hearing loss and then provide them intervention either with hearing aids or assisted listening devices, that those children will outperform children identified as having those problems in the last six months of the first year, even by the age of 3. Such that it's important for us to try to intervene as quickly as possible, but also to know what we're intervening with and how well we can measure that.

You can imagine that if you're a young child, you're going to be unable to tell me that you understand something or that something's painful or something's comfortable. So one of the more interesting aspects from a scientific stand point is how do we tap information about learning how these young infants are perceiving information that's given to them. So we try to develop new techniques that allow a child to respond not necessarily behaviorally, by raising their hand or saying something, but to use measurements that come from their neural firings or their cortex, so that we can look at how well different structures are receiving information and use that to interpret how the baby may be processing sound or understanding sound.

WEBB: In addition to the titles I mentioned earlier, you are also the director of research at the Callier Advanced Hearing Research Center, is that right?

TOBEY: *That's correct.*

WEBB: An area of your expertise is the so called bionic ear. It's a fascinating topic. I wonder if you could tell us a bit about what the innovation has meant to you in your career. Starting with maybe where the technology was in its evolution or what was available for people with hearing loss when you first started in the field.

TOBEY: *Well, it's kind of interesting. It turns out that the first stimulation that was done within current history occurred in 1952, the year after I was born. There was a Frenchman by the name of Dairs, who actually placed a single electrode into the cochlea, that's the snail-like organ portion of the ear. And he delivered electricity to this electrode, and the person that had the electrode in their ear, noted that they could hear low pitches and high pitches. And that was miraculous that actually delivering electricity to this electrode actually allowed people to hear different pitches.*

Just as several groups in Australia, Austria, San Francisco for us, began refining the technology, I began refining my interest in hearing impairment by first getting an undergraduate degree in speech pathology, then graduating from New Mexico State University and taking a job in New Orleans, Louisiana first as a speech therapist and then, because I knew sign language, becoming a teacher of the deaf. And that was just the most incredible experience. I had 12 children who were in seventh and eighth grade. The children were unable to use their hearing aids because the school, in their wisdom, determined that the children

were deaf, and that being the case, they put my classroom in between the band and the choral room with no insulation between the rooms.

It was also the case that they assumed that because the children were chronologically the same age as seventh and eighth graders that they would be able to read at seventh- and eighth-grade levels. And these children did not have that language. So I also, not only having an environment that was acoustically inappropriate for my kids I had no materials to teach with them. There were not appropriate reading level materials, mathematical level materials. And it was extremely frustrating. And it took me about a week in that environment before I decided I needed to go back to school. And I then went back and did my master's degree, or as my father said, I started the long sojourn of never leaving the University, which was quite fun.

Now it was really interesting, because when I left and started on my master's degree, I was, much like many of our students hear at UT Dallas, I was a really poor graduate student and I needed to find a way to support the lifestyle to which I had become accustomed. And I started working at Kresge Hearing Research Laboratory, and this was a really interesting place because it had anatomists, physiologists, psychologists, statisticians all working on some aspect of the ear, trying to look at how hearing and the ear fit into the big picture. And as I worked as a graduate assistant there, I began noting that in my master's level speech pathology classes, we were not necessarily using the materials that I was learning in the laboratory. And so I began to ask "Can I take information that I'm learning here in science and apply it directly to populations that I'm interested in clinically?" So I was able to do a master's thesis at that time looking at how well children who had auditory processing disorders were able to perceive information through the auditory channel, and that was quite exciting and that led me to think, "OK, I'll go ahead and apply for my Ph.D."

I applied to go to graduate school at City University of New York, and we also began writing a large program project grant. And I guess I was cocky enough and naive, and I didn't know enough to not think that I couldn't write a section of this grant, so I wrote a section of the grant trying to look at these children in more detail to ask whether they had difficulty processing auditory information and visual information and tactile information? Or was it just an auditory only problem? And, oddly enough, I ended up getting funded, so I was trying to do all my course work in New York City and do all my research in New Orleans and traveling back and forth balancing those two aspects.

And while I was in New York, I began, again sort of I guess not staying on target, I got interested in speech production aspects. So I also got interested in how does the brain influence the way you speak, and so my dissertation focused on how well people could speak who were Vietnam veterans who had sustained low-velocity missile wounds in Vietnam. In that instance, we were looking at how very tiny cortical changes, that you wouldn't think would have long-term effects, do they have long-term effects and something that would require a high degree of motor activity, your tongue and jaw would have to move very quickly, and require you to modulate your linguistic content.

And so that was a very interesting study from my perspective. It also led me to where I am now with my interest in the bionic ear, so sort of a long roundabout way to get to the story, but I got involved with the

bionic ear by working at Kresge and essentially being the low man on the totem pole. Being the lowly doctoral graduate student working on these two projects, it turned out that enough progress had been made since 1952 in terms of these devices that they were ready to have FDA clinical trials to determine if they were safe and if they were efficacious.

So, people from Australia were the first group to set up these trials, and they started traveling through the United States trying to recruit different groups to participate, and the laboratory where I worked didn't think these devices would work, in fact they were quite confident these devices weren't going to work, but they didn't want to be rude to these individuals, and so they decided that someone from our laboratory should host them but they didn't want to really spend their time doing it, so I was assigned to do the initial hosting. And it was fabulous for me, I kept thinking that these devices sound so interesting, so clever, and my goodness if these devices are going to work, don't you think they should work for more than hearing, that is if they are working for hearing, then surely we should see this in terms of speech and language and that children should have better communications. And that sort of set my pathway to where I am today.

WEBB: In your judgment, what has the development of the technology meant to the people who've enjoyed the benefit that it brings?

TOBEY: *I think the technology's huge. Let me just start by first reflecting on how I believe it's affected our knowledge about hearing, and then I'd like to expand and talk a little bit about how I think it's going to affect how we view vision in the future and pain management. If we think about what was going on in the past and we think about children who were hearing-impaired, we would typically put on massive hearing aids, and we'd put on FM systems which would allow sound to be directed to these hearing aids, and they were big and bulky pieces of equipment.*

Because the ear is damaged and hearing cells are not there to receive and begin this initiation of processing sounds, what most hearing aids do is simply amplify a signal that's spectrally compromised. So, you get a mumble and then make it louder, not necessarily clearer. What the processing strategies for cochlear implants did was allow sounds to become clearer, and that is that I could begin to spectrally tune the information that's within and being presented to this compromised ear. That makes it hugely important because a cochlear implant allows us to try to focus in on how better to present information that's associated with consonants. And consonants are really important, because if you think about how I convey a message to you and the information in that message, I primarily do that via my choice of consonants.

You can sort of think about it like Wheel of Fortune. If you think about Wheel of Fortune, you get money from Vanna White, and if you're thinking about vowels, you have to pay out for them, because the consonants provide enough message where you can guess what the clue might be, whereas if you have only vowels you can't effectively guess. So cochlear implants and even now digital hearing aids allow us to spectrally tune in and provide information in frequency areas that were not available to us in the past through conventional hearing aids. So that's technique number one.

Technique number two is that the spectrally enhanced signals that are being presented by cochlear implants also are being driven by smaller and smaller batteries and allowing us to sample a signal more frequently than we were able to do in the past. So you can imagine that if you sample something once or twice you have a very mild representation of it versus if you sample something ten thousand times. And so we're able to sample and give more robust representations to signals than we were able to do in the past, and that allows people to get more information regarding, if you will, the nuance or the melody of speech, and that's quite important. It also is the case that many of the people who use these devices are also able to use the devices without additional lip-reading clues so they can listen on the telephone. They can do it without having contextual clues where they set up and say that this is what we're going to talk about so you can make intelligent guesses. Many individuals can understand speech without looking at the speaker and can understand what is being spoken about without knowing what the context is.

WEBB: What is the quality of a modern widely available cochlear implant? Would we be looking at phone call quality? How would you relate the quality of what a cochlear implant these days sounds like to someone who doesn't suffer from hearing loss?

TOBEY: Well, this would be the plug I give you to come hear my talk on Monday evening because I'll be playing some samples to give you an idea of what a simulation sounds like. The idea is that a cochlear implant works by having a microphone that picks up the sound that we're accustomed to, like you would with a hearing aid or like we're doing right now. That sound is then captured by the microphone and then taken down into a piece of hardware called a speech processor, and the speech processor has, internal to it, software called speech processing strategies.

In their simplest of forms, what a speech-processing strategy does is sample this acoustic signal, it takes the sample and puts it through a series of filters and then allows the output of those filters to come out as a signal frequency. That frequency is then transmitted up to a receiver on the outside of the skull, radio frequencies across the skull into an internal receiver and then is taken down into a multi electrode array that is placed within the snail-like organ. So you get a pattern of electrical pulses. As you select the electrode and the rate at which you stimulate that electrode, you can begin to vary the pitch and the intensity that people hear. And as you make the variations in the pitch and intensity more complicated what you find is that the cortex of those individuals puts that all together and integrates and hears that as a signal that you and I would perceive as speech.

WEBB: While we're on the subject specifically of the cochlear implant, you are involved in the Dallas Cochlear Implant Program. Tell me what that is and how you got involved.

TOBEY: The Dallas Cochlear Implant Program is a cooperative enterprise between three major entities here in the Dallas/Fort Worth area: The University of Texas at Dallas, particularly the Callier Center, The University of Texas Southwestern Medical Center, the Department of Otolaryngology, and we also do research with our counterpart in the department of radiology and the nuclear medicine center, and Children's Medical Center, the hospital where we do our MRIs.

In order to place a cochlear implant as a permanent device – because this is a surgical procedure and the electrode is placed inside the ear – requires a very sophisticated team. So we have teams of speech

pathologists and audiologists who determine how well someone hears and how well their communication skills are before the surgery. We have medical teams that consist of our surgeons and nurses and radiologists who determine what the integrity of the ear is through imaging techniques and then who are there to handle all the medical conditions: the surgery, post-operative care, that sort of thing. And then we have audiologists and speech pathologists who work with people after the surgery.

The audiologists are there to actually tune the device and turn it on, because as you can imagine, this is a device that is delivering very small levels of current, but it is delivering electricity directly to their ear, and you can imagine that with parents there is a great deal of concern as to how these devices work with children, because if we're going to be implanting these devices in children as young as 12 months of age, we'll be delivering electricity to their brain for very long time periods, given that many people are living well into their mid-80s. So it requires many intricate personnel people, and I'm proud to say that the Dallas Cochlear Implant team is an excellent one. We have many people that are involved at the Aston Center in our adult cochlear implant program, and we have many people involved both at Children's, UT Southwestern, and the Callier Center who are involved in the pediatric program.

WEBB: Stepping back a ways, back into your memory banks a while, now after years of experience in the field, helping people with hearing loss, do you remember a moment, a time, or an era in your life, or a day perhaps, that you decided this is what you're going to do, this is how you're going to contribute your verse?

TOBEY: *Well it's funny. Lots of people have asked me about how I got started in the field, and all I can say is that this is what I've wanted to do since I was in the sixth grade. I don't know what got me involved in the sixth grade. I don't know if I read a biography about Helen Keller, or a book about something. I just always knew I wanted to be involved in speech and hearing.*

Fortunately, when I did my undergraduate career, I was at New Mexico State University, and I was able, my very first year of school there as a freshman, to get involved in research in speech and hearing. The chairmen of my speech and hearing department had received a National Institute of Health grant to look at whether or not paraprofessionals could deliver articulation therapy as well as professionals in the school system, and I was selected to be one of those paraprofessionals.

So I've been engaged in speech and hearing research, essentially, my whole academic career, which has been fabulous for me because it allows me to...I guess in this day and term we call it translational research, where you go immediately from the bench into the clinic to bedside, and throughout my career I've been able to do that. It's one of the reasons why here at UT Dallas, if you come into my laboratory and visit you'll see I have undergraduates and master's and doctoral level students, we try to recruit as young as we can.

There's something very magical about watching how communication happens. Of course, we're sitting here talking on radio and iPodding and that's pretty magical in and of itself, but there's just so many aspects about thinking about the world, if you will, through the eyes of someone who's handicapped, or the eyes of someone who's deaf, thinking about issues that are culturally related, because many of the deaf community believe that sign language and their visual communication system is more important to

them than perhaps hearing is to you or I. Getting a sense for how you put those types of communication efforts into perspective is just fascinating.

*I still remember there was a wonderful book called *In This Sign*. I really remember it because it was a poignant piece that there was a deaf couple during the Depression, that had to go to court because they had bought a car, or they thought they had bought a car, but essentially what they had done was put down a down payment and didn't realize that they had to keep paying for the rest of the car. And as they walk into this courthouse and they're think about this and their daughter, who is hearing, is trying to explain to them what's going on, this deaf woman looks up and sees a beam of sunlight coming in through the window and hitting up against the floor, and she turns to her daughter and says, "What does the sun sound like?" Now you and I, of course, know that a sunbeam doesn't have enough matter to generate sound but someone who's visually based can look at something like that and think, "Hmmm, what does that sound like?" And I've always thought that was a very intriguing observation that she had made.*

And it's also intriguing for us, because if you think about communication, as we speak, there's at least two languages that are dying somewhere on the Earth, that the last person who spoke that language is now deceased. If you think about languages dying, there are also languages that are emerging. There are many colleagues now who are in Nicaragua and Central America who have gone down and discovered deaf populations there where in those cultures they separated deaf people and did not allow them to interact with one another, primarily as a protection and keeping them safe. But as people have gone down and tried to start new schools for the deaf and allowing the deaf to start interacting, one of the difficulties is how do they communicate with one another because there is no communication system.

Many linguists are now documenting the emerging of new sign languages because it turns out that as deaf people begin to get together and begin to develop their communication systems, the language that they are evolving has many of the same rules and structures, vocabulary and grammar, that other sign languages have, of which no one has been exposed to in this particular group. Communication is extremely fascinating, perhaps one of the most fascinating pieces in science.

WEBB: Now we come to something that I think about when I look into people, to sit down and visit with a little bit, and research their backgrounds. We come to the part of our conversation where maybe I'll ask you to pat yourself on the back a little bit. And my question is really how you think that the work you've been able to do to this point in your career and the steps that you're taking today are helping people?

TOBEY: *Well I certainly hope that the future brings that I will be helping people a lot more. I think that research that I'm currently engaged in is asking a lot of questions that are important for families who have children that have hearing impairments. One of the grants that I'm involved in is directly asking questions that are important to families, particularly parents, who ask, "What are the repercussions of my child having a hearing loss, and how does this technology involve it?" You can certainly imagine that if a family learns that they have a brand new infant, that the infant's healthy – just this adorable cute little thing – but the shock of learning that your child can't hear, and the shock of thinking, "If my child*

can't hear, what does that mean? Will they have to learn sign language? Will they have to go to a special school? What kind of employment opportunities will they have? How am I going to provide for my child? Do I allow them to cross the street by themselves? Will they know if traffic's coming? Will they know if the fire alarm is going off?"

It's a tremendous rush of worry that comes to all parents. If you then couple that with the fact that parents adjust to that initial shock, and then you say, "And now here are all the options you have for equipment", and you start putting on high-tech equipment that has cords and batteries, and you couple that with other assistive techniques, and then you add on therapy and then you add on different communication systems, it's hugely overwhelming and bewildering for a lot of families.

So, one of the studies we're doing now is to track nearly 280 families who receive cochlear implants, and look at what happens to speech and language over time, look at how speech perception is developing with these devices, and then to query how family dynamics change. How do parents interact with their children? Does that change as you get more adjusted to the technology and as children get older and begin to learn more? How does that, in turn, impact quality of life? What would you give up for your child's hearing? What would you keep? We feel that that will give us a lot of information to tell families about what's happening.

Another way that we're trying to impact and contribute in a positive way to the world is to ask, "Is younger better?" Should we really be implanting children within that first critical year, as I mentioned earlier? We know that later may not be as optimal as earlier, but there are some problems with doing an elective surgery during the first year where you have to engage a child in a general anesthetic. Certainly, if you had a major emergency, you wouldn't even think about the anesthesia issues, but for an elective surgery, if you could not demonstrate a difference between what would happen in the first year compared to the 13th or 14th month, when you get over that hump of 12 months where the danger might be, I think most parents would rather wait until the 13th month of age. But if there is a difference you probably want to capitalize on that. So another study we're working on is really engaged on what happens to speech and language in children who are implanted in the first year of life versus to children who are implanted in the second year of life. And again, there the whole idea is to track what's going on with speech and language and academic preparation, so that we can provide people with an intelligent way of making the decision of when to implant.

Now, just as it's important to think about what's going on at the beginning of implantation, it also is important for us to think about how children evolve over time. If I were a deaf child in the United States, typically when I graduated 12th grade, I would read on average at a second or third grade level, which is an appalling statistic when you think about it. It's appalling because newspapers, for example, require you to read at a sixth- grade level; some people are saying that to use the Internet effectively, you need to be able to read at at least a high-school level, if not higher.

So about five years ago, two colleagues, Ann Geers and Jean Moog and myself, began looking at what happened with children who had cochlear implants. So we examined children who were 8 and 9 years of age, and looked at what their reading skills were like after 4 or 6 years of cochlear implant use, what

their language was like, what their speech perception was like. We were pleased to see that over 90 percent of the children were able to read at a grade-appropriate level. That was pretty exciting, to know that even at 8 and 9 years of age we had children reading at the levels we had previously seen after graduation. But the question is: Do those kids continue to improve? And what is the impact of that early performance we saw on their later literacy ability? So we're just now in the midst of bring back these children at the ages of 16 and 17 just as they're getting ready to graduate from high school, looking again at what their reading and literacy abilities are, and looking at what their language is looked, and looking at how prepared they are in terms of making the next academic step: Will they go to college? Will they go to community colleges? Where will these children be? And I can tell you based just on the two summers that we've got, we still have a few years of bringing in the kids to look at, that there seems to be an interesting phenomenon occurring: That many of the children are indeed reading at the levels we would expect for 15 and 16 year olds, but there is a small proportion of the children who are reading at the same levels they were when they were 8 or 9 years old, that they've actually not made progress.

Now it turns out that it's not due to something simple like are these children who speak only or sign only? Are they from rural or metropolitan areas? Are they from big or small families? It doesn't seem to be any one single simple factor, rather we think it's going to be a constellation of factors, but we don't yet know what that constellation will be. But hopefully, by doing this study, it will let us know how to work with elementary school teachers, speech therapists and families to say, "Here are a constellation of factors that might put your child at risk. You should continue intervention through this time period, or change the type of intervention you have, or emphasize something additional, which will allow these children to maximize their potential and their ability to participate in society as much as possible."

WEBB: When you look back over your career, any other career you would've launched into or, as you said, from six years of age, when most of us are just trying to figure out how to get our shoes on, you were identifying your passion. Can you imagine having done anything else with your life and career?

TOBEY: *Well it's kind of funny, I actually could, because I loved chemistry and I loved geology when I was in graduate school. I just thought that those were absolutely the most fantastic...I just thought they were fantastic. I mean I still love stones of course, I've moved to diamonds and emeralds, which are my favorite now, they're a little bit easier to remember the names too. But I do like them.*

WEBB: That's fascinating. I've really enjoyed the visit today. It was very enlightening, and I'd like to visit with you again, especially as you begin to uncover more and more results and the connections you talked about, the difference in reading levels and family circumstances and that sort of thing. Thank you Dr. Tobey.

TOBEY: *Thank you.*