Interviewed by Lydia Gregoret, Ph.D.

A Look at Bilateral Cochlear Implant Research

Ruth Litovsky, Ph.D., director of the Binaural Hearing and Speech Lab at the Waisman Center, University of Wisconsin, Madison, studies binaural hearing – how people hear with two ears.

She has a scientific background in developmental psychology and neurophysiology and is particularly interested in learning how people hear with bilateral cochlear implants. Litovsky is currently guiding a team of doctoral and post-doctoral students, audiologists and undergraduates who are investigating different aspects of binaural hearing in adults and children. Her work is funded primarily by the National Institutes of Health, and the results of her group's studies on children with bilateral cochlear implants are eagerly anticipated. I recently had a chance to speak with Dr. Litovsky about her research and the studies on children with bilateral implants.

Lydia Gregoret: What is the essence of binaural hearing?

Ruth Litovsky: Binaural hearing is the use of two ears to listen to sound. Our brain has specialized circuits with neurons that are sensitive to how information arrives at the ears and the direction or location of the source. The neurons are therefore responding to differences in timing and loudness that result from the different directions from which sounds reach the ears. Having two ears offers a number of advantages, including the ability to localize sound in the environment and isolate sound sources so that we can listen to speech in a noisy environment.

LG: How did your project on studying children with bilateral cochlear implants evolve?

RL: I was invited several years ago by Cochlear Americas to help design clinical trials, initially for their studies with adults and more recently for their studies with children.

LG: What are the main experiments or tasks you study in children with cochlear implants?

RL: We study three things:

1. We observe how well children hear speech in quiet and in the presence of competing speech. In our experiments, the competing speech is noise that sounds like a conversation. We vary the location of the competing speech to see what happens when it is coming from the same location as the target speech that the individual is trying to listen to as compared to when it is coming from a spatially separate location. We do this test with every combination of devices (cochlear implants and hearing aids) that the child uses, testing each one separately and then both together to determine the extent to which there is a "bilateral advantage."
2. The Minimum Audible Angle (MAA) test measures whether a child can discriminate a sound coming from the left or right and determines the smallest angle of separation they can detect. A five-year-old with normal hearing can discriminate between sounds coming from locations separated by as little as one degree! For children who use implants and hearing aids, we first try to see if they can even perform the test. Children with one implant typically are not able to perform the task well, if at all. Children who only recently

received a second implant are still learning the concept of "where" the sound is, and it's quite remarkable to observe the learning process.

3. If a child is able to perform the MAA test, we see if they can actually localize sounds using a semicircular arrangement of 15 different loudspeakers. In other words, how well can they identify which speaker the sound is coming from in a real-world testing environment? This is significantly more challenging than simply discriminating whether the sound is coming from the left or right.

LG: What are the benefits to binaural hearing in children who are bilateral cochlear implant users?

RL: The majority of children can hear speech in the presence of other competing speech better with both implants than with only a single implant. Since situations with competing speech mimic a classroom environment in which the teacher is the source of the target speech and the classmates are the competing speech, the experiment may be very relevant to a child's day-to-day experience.

On the same 'speech plus competing speech' test, when the target speech and the competing speech noise come from different spatial locations — let's say, separated by 90 degrees — children with bilateral cochlear implants achieve something we call 'spatial release from masking.' This means they are able to use directional cues to segregate the target and competing speech into separate auditory "channels" in their brains, allowing them to ignore the competing speech more effectively.

LG: Have any of the results of your work taken you by surprise?

RL: When we first began to conduct these studies, adults with three months of bilateral experience were able to localize sounds significantly better with two implants than with one. We originally expected the same thing with children with bilateral implants. We've since learned that it usually takes children longer than three months to acquire this ability.

LG: How do you explain the difference between adults and children?

RL: Many of the adults we studied became deaf after having had hearing in both ears, so their binaural brain circuits may have previously been established and were reactivated after

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receiving the second implant. In contrast, most children receive bilateral implants in sequential surgeries separated by several years. Their auditory system has become used to functioning with a single ear, and activation of binaural brain circuits may take time. In fact, it's still too early to know how well the binaural circuits will ultimately operate in children who were deaf from birth and received sequential implants.

LG: Do children who use a single implant together with a hearing aid do as well as those with two implants?

RL: Some children with a hearing aid in the non-implanted ear perform as well as children with two implants, but others perform significantly worse on the MAA task than children with two cochlear implants. More importantly, most children with a hearing aid in the non-implanted ear perform worse on speech in noise tests when using both the cochlear implant and hearing aid together than with the implant alone. This may be because the ear with the hearing aid still has a severe-profound loss and is adding some "noise" to the audible hearing provided by the implant.

LG: Do you have any idea how many children in the United States have bilateral cochlear implants?

RL: I would venture to guess between 50 and 100.

LG: Is there a "best" age to get a second implant?

RL: That remains to be seen. Studies show that children who receive their first implant before age three have a high likelihood of developing language abilities comparable to their hearing peers. If the same mechanisms are involved in binaural hearing, then this might predict that it is better to get a second cochlear implant before the third year of life.

On the other hand, we are studying several children who got their second implant in their early teenage years, and they are still showing benefits. It remains to be seen how much benefit can be gained by decreasing the age at which a child gets a second cochlear implant. There are very few children in the USA with bilateral implants who are younger than three years of age. We are developing age-appropriate tools to follow these very young children and hope to better understand how the age of bilateral implantation influences the development of binaural hearing as that population matures.

LG: How long after activation of the second implant does it typically take for a change to be measurable?

RL: The benefit of speech in noise is seen as early as two months after activation of the second implant. Even though a child's speech discrimination scores are still much lower in that ear alone, combining the input of two ears enables children to take advantage of the binaural input and hear better in noise. The time it takes for children to learn to localize sounds varies. In some children you see an advantage in the first few months, and in others it can take a year or longer.

LG: Should a child who has received a sequential bilateral implant practice each day using the new implant alone?

RL: I think that it makes a lot of sense to have a child spend some time every day getting used to using the second cochlear implant alone. Parents may want to pick a time that is not stressful or demanding, such as while the child is watching TV or while reading a story the child already knows. The idea is for the child to not have to work too hard. You might not want to start this right away after the second implant is activated, but perhaps once the child starts to develop usable hearing in that ear.

LG: Do children with bilateral implants favor their first implant over their second?

RL: At first they do, but parents shouldn't assume that this will continue to be the case. Some adult bilateral implant users actually prefer their second implant after a while. It is hard to predict which ear will be better. It could be that nerve survival is better in the more recently implanted ear, especially for children whose worse ear was implanted first and who used a hearing aid in the other ear prior to

receiving a second implant. It is also possible that children may eventually like both implants equally.

LG: Other than the risks of surgery, are there major risks or options eliminated when one chooses a second implant for their child?

RL: This is a hotly debated topic, and it's important for parents to educate themselves on the issue prior to pursuing a second cochlear implant for their child. Some researchers believe it is important to save the second ear for future treatments that may be even more successful. Others insist that children need the best hearing possible while they are young, developing and engaged in learning at school.

It's important to engage in this debate, because the answers are not clear. If treatments such as hair cell regeneration, stem cell therapy or gene therapy are only three to five years away, holding off on a second implant may be more compelling. No one knows for sure how far off these other treatments are, but leading researchers think new treatments are at least 10 years away and probably closer to 20 years.

LG: I read an insurance policy that estimated a "1 percent to 4 percent improvement" in hearing in people receiving a second implant. Is it even possible to express improvement in terms of a percentage, and if it is, what is that percentage?

RL: It is hard to quantify the benefit and its value in dollars. For instance, if someone is 50 percent better at localizing sounds with two implants than one what does that "buy"? It is difficult to put a dollar amount on the fact that many bilateral individuals negotiate many aspects of their life more easily and that their quality of life may be significantly improved. For example, there are reasons to believe that bilateral implants may improve a person's safety crossing a street, because they'll hear sounds indicating which way to look to avoid oncoming traffic. There are reasons to think that bilateral implants may provide better means for acquiring knowledge in complex, noisy environments. Those benefits might actually be worth a tremendous amount, but they are difficult to quantify.

LG: Are insurance companies justified in denying coverage of bilateral cochlear implants?

RL: I don't know much about how decisions are made by health care

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providers and how their businesses operate. From their point of view, they need to spend as little as possible while providing excellent care, in part, to avoid future problems that might turn out to be more costly. The cost/benefit formula for what is gained by providing even a single implant is not well understood. But insurance companies probably understand that hearing is extremely important to functioning in a very auditory-based world. Now comes the question of how good your hearing has to be and how much worse will you function with one ear vs. two?

LG: Why aren't there more articles in the medical literature about bilateral cochlear implants in children?

RL: Good science takes a long time! I would say a good solid paper in this field takes a minimum of one to two years for data collection and at least another year to analyze the data and prepare a manuscript. Once the paper is submitted to a journal, the editor sends it out for anonymous review by other scientists in the field. Reviewers often make suggestions about different ways to look at the data, and we perform additional analysis and edit the material. It typically takes a year from the time a manuscript is submitted to a journal to publication. Sometimes it is also important to hold your data and think about it for a while, so the research that goes into a good paper may take as long as four years to see the light of day. I don't know many scientists that would disagree. We've only had children with bilateral implants in the United States for two and a half years, so that gives you some sense that we're still in the early stages of scientific investigations.

LG: What future projects do you have planned?

RL: In the next six months, we're planning to recruit very young children with bilateral implants for our studies. I feel we have to move in that direction because it will allow us to make cross-age comparisons. We plan to study adult bilateral implant users to understand how the age of onset of deafness affects binaural sensitivity. We're also studying whether adults can take advantage of new research processors that synchronize the two implants, and we will probably study children using those processors as well.

LG: How many children have participated (or participate) in your studies?

RL: To date, we've studied 18 children with bilateral implants and numerous others with one cochlear implant, or an implant and a hearing aid, or with two hearing aids.

LG: Do you study children with all three brands of cochlear implants?

RL: Yes, we've studied children with all brands of implants. Whoever is willing to come, I am happy to study! While the studies were initiated with children who have Nucleus devices, we've had a small trickle of children with the Clarion and MedEl devices. Several surgeons around the country are referring patients here, so the subject population will depend on who gets referred to us.

LG: What can parents learn about their own children if they participate in your study?

RL: Parents can learn how their child negotiates complex tasks; how the child learns to respond on tests that s/he may not have been exposed to but which mimic real-life situations. We also spend time talking with the parents about many issues related to deafness and implants, and they always seem to enjoy those interactions. The children who participate in the research seem to love being here. We work hard to engage them in interactive games, and the hearing tests become somewhat incidental from the child's perspective.

For more information about the Binaural Speech and Hearing Lab at the University of Wisconsin, Madison, please visit: www.waisman.wisc.edu/bhl/index.html

For additional research by Dr. Ruth Litovsky on bilateral cochlear implants in children, please see the following references:

Johnstone, P., Litovsky, R.Y., Agrawal, S., Godar, S., Parkinson, A., Peters, R., and Lake, J. (2005). Experience improves minimum audible angle in children with bilateral cochlear implants 15 months post-activation of the second CI. Poster presentation at the Association for Research in Otolaryngology Conference. www.waisman.wisc.edu/BHL/Posters/ARO2005_BiCI_MAA_Patti_Ruth.pdf

Litovsky, R.Y., Parkinson, A., Arcaroli, J., Peters, R., Lake, J., Johnstone, P., and Yu, G.. (2004). Bilateral cochlear implants in adults and children. Otolaryngology, Head & Neck Surgery, Vol. 130, pages 648-655.

Litovsky, R.Y., Johnstone, P., Parkinson, A., Peters, R., and Lake, J. (2004). Bilateral cochlear implants in children: Effects of experience. In International Congress Series, Volume 1273, R. Miyamoto ed. (New York: Elsevier), pages 451-454.