Conversation with a Colleague: Ruth Litovsky

Ruth Litovsky
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Meet Ruth Litovsky

Ruth Litovsky is the next acoustician of our "Sound Perspectives" essay series "Conversation with a Colleague." Ruth is Associate Dean, professor, and Oros Family Chair of Communication Sciences and Disorders at the University of Wisconsin-Madison, with a joint appointment in surgery/otolaryngology (see bhsl.waisman.wisc.edu). Ruth received bachelor's and master's degrees from Washington University, St. Louis, Missouri, and her PhD from the University of Massachusetts-Amherst. She completed her postdoctoral training at the University of Wisconsin. Ruth received the Silver Medal in Psychological and Physiological Acoustics from the Acoustical Society of America (ASA), the first woman to receive this award. She is a Fellow of the ASA and served as an associate editor of *The Journal of the Acoustical Society of America* for seven years. We asked Ruth to give us her elevator pitch and then to elaborate on her inspirations, contributions, and hopes for the future.

Give your "elevator speech" about the thrust(s) of your scholarly work over your career.

We spend much of our lives in environments where our brains receive a barrage of sounds and echoes. Yet, somehow, individuals with typical ("normal") hearing are very good at locating the sources of sounds around us. Moreover, in a noisy restaurant, we can focus on what one person is saying despite a cacophony of clatter in the background. Throughout my research career, I have been passionate about understanding how our brain uses binaural information to compute sound locations, suppress echoes, and enhance speech understanding in noisy environments. Moreover, I study how we can use this science to guide clinical practices in listeners with hearing loss. My laboratory has shown that for children and adults who are deaf, bilateral cochlear implants can provide significant advantages over single implants, especially in noisy environments. However, patients face daily challenges because current cochlear implant technology strips out of the sound much of the information that the brain uses to build a three-dimensional picture of the auditory world. For example, perception of space is limited to some left-right localization, with little sense of distance or elevation, and pitch perception can be fairly "flat." To get at this problem, we use reverse engineering approaches to conduct studies on how to best coordinate information between the two implants to ultimately provide patients with better binaural hearing. Our ultimate goal is to improve patients' quality of life through better spatial hearing in noisy settings. This also means that patients can expend less cognitive resources as they learn, socialize, and communicate in their daily lives.

What inspired you to work in this area of scholarship?

When I began my PhD in 1987, I sat with my advisor Rachel (Clifton) Keen in the anechoic chamber and experienced the compelling auditory illusion known as the precedence effect. This phenomenon instructs our brain to weaken the weight assigned to information arriving from echoes so that we can accurately localize sound sources in our environment. The precedence effect is absent at birth and emerges with maturation of auditory cortical mechanisms. My PhD dissertation focused on how spatial hearing, including the processing of echoes, emerges during early childhood. During my postdoctoral training (1991–1994) with Tom Yin, I sought to understand the neural mechanisms underpinning spatial hearing.

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By recording responses of neurons in the midbrain of cats, I gained insight into the fundamental auditory processes that support mammalian binaural and spatial hearing.

After gaining training that combined psychophysical and physiological acoustics, I was fortunate to work in two outstanding environments in Boston, Massachusetts: Steve Colburn's laboratory at Boston University and Bertrand Delgutte's laboratory at the Eaton-Peabody Laboratories at the Massachusetts Eye and Ear Infirmary. The role of the binaural system in human perception became the focus of studies with my students and collaborators. Since my arrival at the University of Wisconsin-Madison in 2001, I shifted focus to the field of cochlear implants, with a commitment to studying how we can provide better binaural and spatial hearing to patients who are deaf and receive two (bilateral) cochlear implants.

Of all your contributions during your career, which are you most proud of and why?

Choosing the field of hearing science meant learning how to adopt different behavioral techniques to extract meaningful data from human subjects, including very young children. The challenge came with delightful rewards, discovering that the young auditory system adapts to ongoing changes in sensory inputs and that these changes are driven by both biological maturation and the response to the environment. The spatial hearing system offered opportunities to probe development of perceptual mechanisms that are extremely important for everyday function. I had anticipated discovering that children's spatial hearing abilities would be rather poor during the early years of development. I had not imagined that our work would demonstrate how capable children would be at localizing sounds and separating speech from noise by the early age of two to three years. Note that auditory development is incomplete in early childhood. Indeed, emergence of sophisticated spatial hearing mechanisms depends on whether the auditory system receives binaural cues with fidelity, especially early in life. In children who are deaf, it is important that cochlear implant processors be able to capture binaural cues and provide these cues to a child's binaural system. If children have access to binaural cues during development, there is a greater likelihood that they will be able to have good spatial hearing abilities.

When my laboratory pivoted to investigating the effects of bilateral cochlear implants on spatial hearing, we learned that children with a unilateral device do not perceive the auditory world as emerging from specific locations in space, a perceptual capacity that most people with normal hearing take for granted. By working closely with children who are deaf, my students, trainees, and I gained long-lasting insights into the everyday challenges and triumphs experienced by cochlear implant users. We studied the emergence of spatial hearing after activation of bilateral implants, with a focus on how psychophysical methods can inform best practices in the medical field. Although bilateral cochlear implants were shown to provide a benefit over a single implant, we found that none of the implantees were able to localize sound or separate speech from background noise as well as their normal-hearing peers. The problem is that cochlear implants are not designed to function in bilateral modes and preserve binaural cues that are so naturally captured by the normal auditory system.

The issue of auditory plasticity became an important consideration in our research questions. Over time, the auditory system of children who hear through uncoordinated bilateral devices loses the ability to process and use binaural cues, in particular interaural differences in time (ITDs). For this reason, our laboratory took a deep dive into the world of reverse engineering, whereby we use research processors to design novel stimulation strategies to test ideas about how to best capture and restore binaural hearing to cochlear implant patients. To conduct this work, we have built interdisciplinary teams in the laboratory and collaborated with many engineers and scientists across the globe, all fascinated by what it takes to improve spatial hearing abilities of people who are deaf and rely on cochlear implants. Importantly, when research participants spend time in my laboratory, our team makes an effort to learn about their experiences and perceptions. We have come to know children as they grow up and learn about how they adapt to new challenges and experiences. My laboratory has forged bonds with our research participants because they are more than just research subjects; they have become part of the laboratory's larger family.

An important part of continuing to grow as a scientist and to bring new ideas to the field has also been the commitment to remain nimble in embracing newer research tools to expand our discovery of auditory perceptual mechanisms, for example, by using eye tracking and pupillometry to study the complex nature of decision making and effortful listening that participants undergo when engaging in our auditory tests. We embraced functional imaging to study how different brain regions engage during auditory tasks and to understand the benefits of hearing through two ears versus one ear.

It is impossible to describe my contributions without expressing my gratitude to my mentors, students, and colleagues. I was very fortunate to have received outstanding mentoring early in my career and to have forged deep friendships with collaborators and colleagues in the field of auditory science. As I advanced in my career, I focused on creating a sense of "family," not only in my laboratory but also with the larger scientific community. I will be forever grateful for the intellectual and personal connections that I have forged and that provided motivation, excitement, challenge, and sustenance over the decades. I am extremely fortunate to be in a position of loving the work that I do, in part because I encounter unanticipated challenges and always feel that there are more questions than answers. What I find most rewarding is not only the discovery of factors that drive human perception and communication but also the process of going about the route of scientific discovery and determination of what new tools and approaches should be harnessed.

What are some of the other areas in which you feel you made substantive contributions over your career?

As a woman in the field of acoustics entering the subfield of binaural hearing, I had to accept the fact that this discipline was dominated by White male scientists. I clung to the belief that being accepted by an existing group means participating fully, focusing on contributing interesting ideas and findings and discovering a community of like-minded colleagues and friends. The mentors that accepted me into their laboratories and gave me life-long advice became important anchors in my attempt to forge ahead as an independent investigator and to shift my research questions into novel and somewhat risky directions.

As I began to extend mentoring to students and postdocs beyond the immediate network of my laboratory and institution, I learned that trainees are hungry for open conversation about how to navigate careers, publications, grant writing, and life. Over the years, I've loved being able to offer mentoring opportunities through formal avenues such as workshops at conferences. These began as conversations for women in science/engineering and clinical domains. We moved beyond holding women-only events as it became clear that everyone is searching for mentoring relationships.

Part of the mentoring process led me to advocate for our support of trainees, in particular focusing on individuals from underrepresented minorities. Choosing to be a scientist can be both the best and hardest career decision; there are so many opportunities to succeed and take joy in our work and there are equally many times when we can be crushed by rejection or failure. Opening opportunities for discussion, support, and mentoring was not only a way for me to give back but also a place where I could reveal my inner worries and discuss the never-ending "imposter syndrome."

Most of all, I am proudest of my personal collaboration with my husband David Baum, an evolutionary biologist and botanist. As a dual-career couple, we concentrated on making decisions to honor our wishes as individuals and as a family unit. As we raised our three amazing children, we juggled combinations of fun and challenging commitments and opportunities. Finally, my family and I share a commitment to look outward and to be mindful of our responsibility to our extended families and communities around us.

What do you think are the most pressing open questions that you would like to focus on over the next 5-10 years?

Harnessing my experience in binaural hearing to understand compromised communication in special populations, including individuals with Down syndrome (a common genetic cause of intellectual and developmental disability) whose high incidence of hearing loss is underdiagnosed and appears to be related to cognitive and language delays. Similarly, the role of binaural hearing in the normal aging process. There is growing evidence to suggest that active and effortful listening is "costly" to cognitive function. Gradual declines in hearing may contribute to exacerbated dementia (loss of memory, attention, executive function). I feel compelled to apply my experience toward better diagnoses of auditory decline that might help improve communication and quality of life in one's later years.

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