of their cells carried the change. Moreover, the cells had their own mind on how to repair the change, with a quarter of them using endogenous templates, while cuts in off-target locations were also observed. The high likelihood of unwanted reactions led the authors to conclude that the system is not ready for clinical application yet. Ironically, they backed up this conclusion by citing both the statements of concern from Lanphier and colleagues and from the Napa meeting, which had been triggered by the rumours of their own endeavours.

Criticism of the publication has claimed that the method used was not up-to-date and that the paper was rushed through publication, with an acceptance date only one day after receipt. However, the journal has defended the review process and stated that the paper arrived with peer reviews from previous submissions to other journals and that it was fast-tracked due to its high relevance.

While the Chinese paper shows that designer babies are not going to be born soon, it has also alerted the world to the realisation that, once the technical issues are resolved, it may be impossible to police a global ban on germline modifications. Even if most of us don't want to live in a world of genetically optimised offspring as described in GATTACA, the impact of technological progress may already be driving us in that direction.

The Nuffield Council on Bioethics, which has already played a key role in shaping the UK's policy to permit mitochondrial replacement therapy with a report published in 2012, is now setting up a new project to explore the ethical issues attached to genome editing. The council's assistant director, Peter Mills wrote in a blog post: "The escape of genome editing from the laboratory into the public sphere — especially following the development of the CRISPR–Cas9 system — suggests that contained use, at least in the sense of reserving questions about the use of genome editing for researchers *qua* researchers to address, is no longer possible." Pandora's box has been cast wide open, and we, as a civilisation, now face the challenge of deciding how we are going to deal with its content.

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## Q & A

# Barbara Shinn-Cunningham

*Barbara Shinn-Cunningham is a Professor of Biomedical Engineering at Boston University. She graduated from Brown University in 1986 and earned her Ph.D. from the Massachusetts Institute of Technology in 1995. She joined the faculty of Boston University in 1997, initially as a member of the now-defunct Department of Cognitive and Neural Systems. She is a Fellow of the Acoustical Society of America, a Fellow of the American Institute for Medical and Biological Engineers, and a lifetime National Associate of the National Research Council. She is currently Director of the Center for Computational Neuroscience and Neural Technology, which promotes interdisciplinary research at Boston University. Her research uses behavioural, neuroimaging and computational methods to study auditory attention, individual differences in hearing ability, cross-modal interactions, and spatial hearing, both in healthy adult populations and in individuals facing various challenges, including hearing loss, autism, and blast injury.*

***What turned you on to biology in the first place?*** Actually, the only biology class I ever took was when I was 15, in high school. I studied electrical engineering and mathematics as an undergraduate, then went to graduate school at MIT thinking I would learn to design computers. Once there, I discovered groups of engineers studying auditory perception, speech, and related areas. As a semi-serious musician (I play oboe and English horn), I was immediately seduced by the idea of studying hearing. Well, actually, not immediately. I spent a couple of weeks soul searching. I had always thought of myself as a hard-core engineer, doing heavy-duty mathematics. To switch to an area that was just plain fun felt wrong, as if I was selling out somehow. But I got over that. And I have been having fun ever since. With each step of my career, I've been drawn to looking deeper and deeper into how information is encoded in the brain. Somehow, I now find myself a neuroscientist. But I still suffer from gaps in my knowledge. That is why I like collaborating.

***How did you end up studying auditory attention?*** My career path is a series of happy coincidences. As a master's student at MIT, I did my first research project, on spatial hearing, under the guidance of Nat Durlach, Steve Colburn, and Pat Zurek (three fantastic mentors and an all-star team in the world of hearing). I worked briefly at MIT Lincoln Laboratory as a hardware engineer, but decided I really liked pure research, so I went back to MIT to do my PhD in the same research group. My son Nick was born three weeks after I defended my thesis. I spent the next two years working as a part-time post-doc, joining the faculty at Boston University when my son Will was two months old.

Because there was no anechoic chamber at Boston University, I couldn't do the carefully controlled studies of sound localization I had been doing at MIT. So instead, like making the proverbial lemonade from lemons, I began studying how room acoustics affect auditory spatial cues and how we localize sounds in the real world. I was struck by how messy and noisy spatial auditory cues typically are (nothing like the textbooks suggest). This observation got me interested in the fact that spatial hearing has a big impact on our ability to communicate in everyday settings, even though the localization cues are unreliable,

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moment to moment. This, in turn, led me to studies of 'scene analysis' (how we parse the acoustic signals reaching the ears into distinct auditory events corresponding to different acoustic sources) and selective auditory attention (how we focus on one sound source and perceptually filter out competing sources).

About five years ago, we noticed that ordinary listeners show great variation in how well they can focus selective auditory attention, especially in realistic, reverberant settings. These differences correlate with differences in the strength of neurophysiological responses in the brainstem and are likely a reflection of 'hidden hearing loss', a loss of auditory nerve fibres in listeners who have clinically normal hearing thresholds. It is a lot of fun, quite honestly, because we meandered into this topic just as interest in it started exploding. The field is undergoing a transformation with the realization that such supra-threshold hearing loss is likely very common, and may underlie communication problems that have seemed mysterious before now.

***How, if at all, do you think your career has been affected by the fact that you are a woman and a scientist?*** I never gave it much thought early in my career. I never had to deal with any overt sexism — never had to cope with someone telling me I couldn't do something or didn't belong. Then, just after I got tenure, I found myself at an intimate three-day workshop in Europe. I was the only woman of 35 invited speakers. But I was so used to that it didn't bother me — until the women graduate students pigeonholed me at the closing reception to pepper me with questions about "how I did it". I realized I was a role model simply because I was competent and a woman and a mother.

That same year, I went to a talk on implicit bias. I was in the middle of writing a recommendation letter for one of the most creative, brilliant, and independent post-docs I've ever had, when I realized I was late. I dashed off, leaving the half-written recommendation open on my computer. The talk was eye opening. And when I got back, I looked at the letter I was in the midst of writing: it was full of adjectives like "collaborative", "helpful", "supportive", and "generous" — all the kinds of words that are the 'right' superlatives for my female post-doc — without any mention of her sharp intelligence, her exceptional creativity, her ability to critically analyse complex problems and point out flaws in my logic.

These experiences changed how I think about the role of gender in science and in society. I realized that I was lucky because I had been oblivious, optimistic, and blind. I just did my best and that got me where I wanted to be. But a lot of women, especially early in their careers, are not oblivious. They need role models like themselves, either overtly (like the grad students in Europe crowding round my table) or covertly (like the women trainees who join my lab in higher-than-expected numbers, probably for reasons that they themselves don't even recognize consciously).

***Do you believe there is a need for more crosstalk between biological disciplines?*** Especially in neuroscience, collaboration now feels almost necessary. Historically, each neuroscientist became expert using a particular set of approaches (anything from patch clamping to functional magnetic resonance imaging to psychophysics) applied to one domain (vision, memory, motor control, language) studied in relative isolation. The expertise required to do research in this way is no small feat in itself, and leads to advances. But every one of your thoughts or actions arises from interactions across the entire brain. A single-unit neurophysiologist can talk with great precision about how a particular neuron in the brainstem computes differences in the time a sound reaches the left ear versus the right ear. But it is a huge leap to go from that kind of description to understanding how the billions of neurons in the brain work together to allow you to orient to a talker on your right at the crowded bar and extract the meaning of what they are saying — something that requires coordination of spatial auditory processing, attention, motor, language, and memory systems (just as a start). I think the way to really push discovery forward is by being open to all different levels of description, by collaborating with people whose expertise differs from your own.

We scientists tend to be so passionate about what we are studying that sometimes it can be hard to understand why anyone is focused on anything else. When your interest is in understanding how individual place cells in hippocampus encode information as a rat navigates through a maze, you may see no value in using electroencephalography to measure the activity of a human brain as a subject undertakes a task requiring spatial attention (all you see is some horrible mixture of activity, not even knowing where it is coming from!). Yet these measures are related, and you can learn a lot by trying to see the connections. When I start working with someone from another subfield, the differences in points of view often lead to wholly new insights. And collaboration is just plain fun: I constantly get to learn and reinvent myself through collaboration.

***Do you think there is too much emphasis on big data-gathering collaborations as opposed to hypothesis-driven experimental research?*** In neuroscience in the US, there has been a massive investment in the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) initiative to develop new tools that will produce monumental data sets. Selfishly, as an experimentalist, I admit I felt a bit depressed about this push at first, conscious that the effort is likely diverting resources away from hypothesis-driven experimentation. But when I step back, I think that the time is right for such a technological push. We are at a point where we have the computational power and storage capacity to approach brain research completely differently; we can utilize 'big data' approaches to making sense of complex neural responses, if only we have enough data to allow us to extract meaning and pattern from the seeming chaos. Exciting new approaches — optogenetics, emerging *in vivo* imaging techniques, invasive neural recording and stimulation in humans, and more — are being developed

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that we are just beginning to utilize, which will give us new windows into neural function. If we are successful in exploiting all of these techniques, it will fundamentally change the kinds of questions we *can* ask. And when those techniques are in hand, there will be a new explosion of hypothesis-driven research that can be undertaken. So, is the emphasis too much? Not as long as there continues to be a significant place for hypothesis-driven research, which will be needed to interpret the wealth of data that will be produced by success in this drive to new neural technologies.

***Do you feel a push towards more applied science? How does that affect your own work?*** There is definitely pressure by funding agencies towards applied science, but some of that push is justifiable. We have stewardship over resources that are precious, in grant dollars, facilities, trainees, and so on. Especially at this point in my career, I feel a strong moral obligation to do work that has impact — although, to me, that includes both fundamental, basic research as well as applied work. At the start of my career, I pursued ideas that I found interesting without a lot of regard to what anyone else thought or whether it had practical application. While some might think that sounds intellectually noble, in all honesty, my approach was probably driven as much by insecurity — seeking a niche where there wasn't a lot of competition — as by some intellectual ideal. I have enough experience now to realize that there are always going to be people smarter and more capable than I am. But just 'showing up' and doing the work is 90% of success. That realization keeps me from taking myself too seriously; I don't let worries that I might fail stop me from tackling hard, important problems.

***Do you think there is an increased need for scientists to market themselves and their science as 'a brand'?*** Not many of us got into science because we wanted to promote ourselves (although I could name a few folks who did…). In all seriousness though, I think most of us find it a bit uncomfortable marketing ourselves. We carry this ideal that science is about finding Noble Truth. We associate marketing with ego. But being an effective communicator is an important part of science. Yes, building a reputation as a good scientist and gaining the respect of your peers (building your brand) influences publishing and funding (themselves, inextricably linked). But effective marketing of your science is not just about advancing your career. It allows your science to have impact, influence how people think, and advance the field. If you make a discovery that you don't ever tell people about, it is impotent, no matter how brilliant or clever it is. It is a waste. Learning how to be effective in telling your story and getting people excited about your results is not just self serving; it is how science works.

That said, it does feel as if the need to market one's science has increased over time. One reason for this is probably the increase in competition for limited funding. But another key factor is the advent of electronic media. We now have web sites that promote our labs and our work. We can immediately track and quantify and advertise our accomplishments on everything from Google Scholar to Facebook. These innovations demand that we spend time curating our online presence — something that can feel distasteful and mercenary, especially to someone who 'came of age' before these tools were ubiquitous.

***What advice would you share with a young scientist starting their own lab?*** I know all sorts of successful scientists. Some are careful, meticulous, and encyclopaedic in their knowledge. Some are creative whirlwinds who make grand discoveries without bothering to run down every detail. Some manage huge labs with a small army of post-docs, while others work intimately alongside their one or two students in the lab every day. Some are showmen while others aren't comfortable as the centre of attention. Some work 100 hours a week; others make important contributions within 'only' a forty-hour workweek. And each plays a useful role in our ecosystem. To be effective and happy, you have to figure out what works for you.

This philosophy is especially important when it comes to managing the pressures of work versus the rest of life. I've been on a number of panels about work–life balance. But how I approach those now is tempered by a conversation I had with one of my former grad students, after she came back from a similar panel discussion utterly demoralized. She pointed out that the panellists were all fantastically accomplished superstars. Listening from the audience, she wondered how she would ever manage to have a family and be successful, given the models of 'success' in front of her. I think it felt to her like listening to a panel of supermodels talk about how they deal with finding clothes that make them look attractive.

The thing is, as researchers, most of us have the freedom to choose our own balance, our own measure of success. The best you can do is to make your choice mindfully. And let's be clear: there are trade-offs, no matter what you decide. You will publish fewer papers in order to be there for your son's piano recital and your daughter's basketball game. You may have to miss the family dinner one night to get the grant in by the deadline. But it is up to you to decide: figure out what works for you, and resist the impulse to measure yourself by someone else's standards.

I personally work more hours than my husband would like, and I don't see either him or my friends as much as I would like. But I also play in a local orchestra one night a week. And I spend three nights a week fencing saber — a hobby I started when I got tired of carting my sons back and forth and waiting for them at the fencing club. Back when my sons were in grade school, I took afternoons off to chaperone field trips. I schedule my work meetings around my high-school son's musical performances. Sometimes I miss out on work opportunities because of these other things in my life. But I can't imagine giving any of these things up, and am happy with my hectic schedule.

And my former student? She is now a successful mom and postdoc.

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