Brian Katz: Reconstructing Notre Dame's Acoustics

Charlie Morrow Interviews Brian Katz

Acoustican, CNRS Research Director at Sorbonne University's Institute Jean Le Rond d'Alembert Sound Lab, a specialist in spatial hearing, room acoustics, and virtual reality.

Charlie Morrow: I had wanted to interview you for *Immerse!*, the podcast and book and immersivity in general. Our collaboration led to my work in 3D sound. It was a conversation that we had in New York that led me in this direction. I was working as a 3D soundmaker with public events, mixture of broadcasts, but not at all doing anything with electronic 3D. So, I'm curious starting with your own interests. The way I've been doing all my interviews is: I start with present projects that are immersive and then look at the history that led up to them.

Brian Katz: Currently, our work is in two major categories. The first is improving the quality of immersive audio over headphones. And that's really looking into how to take into account the individual nature of spatial hearing and how it relates to the form of your ear. And when you do a virtual rendering of spatial audio over headphones, you're making assumptions about the acoustics of the listener's ears. Previous efforts to generalize that haven't worked very well – kind of dummy head recordings. And we're trying to go beyond that and to see how with minimal effort, we can adapt rendering engines to optimize to the individual listener.

Some of the efforts that we're doing at the moment are actually how can we train or aid the human listener to adapt to the rendering engine because there's been some progress in a number of things that we've done. And so we're pursuing that instead of having the system adapt to you, you adapt to the system.

And then with a bit of training, basically kind of making some customized video games or interactions you can actually learn to listen through the ears of the machine, rather than the machine improving its ability to render towards you. And right now we're doing an experiment that's looking at that. Plus what is the impact of room acoustic rendering on the sense of immersion and how important is an accurate acoustic stimulation of the environment to contributing to senses of externalization, instability, and immersion. So, that's one big project that we're working on. And the second is really looking at room acoustics simulations.

Right now a lot of it is on a virtual re-creations of historic places and that's coming out of work in partnership with theater historians who have been interested in how the progression of the voice has been used in history and does it relate to the acoustics of the space? As one example. We also looked at reconstructions of Notre Dame Cathedral and some other cathedrals, looking at what the acoustics of these spaces are today. And can we project into what they would have been in the past when the decorations were different and the use was different. So, we're trying to get a scientific look back into history or archeo-acoustics, or archeological acoustics point of view in room acoustics. These two projects kind of work together because in order to evaluate the spatiality and the nature of these large spaces like Notre Dame Cathedral you need to be immersed in the sound so the quality of the rendering engine impacts the quality of depreciation of the virtual simulation. That's kind of an overview.

Charlie Morrow: That's very well put. I appreciate the clarity of your explanation. I've been particularly interested in the work that you've done with headphone sound localization. You

have gone through a series of projects in which you've been able to continue to improve apps for headphone sound localization. Could you talk about that?

Brian Katz: That's all kind of in the context of us improving the quality of binaural audio or the rendering of spatial audio over headphones. The first project I did on that was my Ph.D. thesis was really trying to do a computer simulation of the acoustical properties of the outer ear. Something that had been kind of talked about, but never really studied in that kind of detail. And that kind of opened up this new branch of study of looking into what is the connection between the acoustical properties of the outer ear, how that impacts spatial hearing and how to customize the rendering engines. So that kind of led into a whole direction of a series of studies. We've been looking more recently into application, like real world applications. So not so much laboratory experiments. For example, working with sound engineers and content creators, and trying to look at what are the effects or the situations that they're interested in creating and how to improve the rendering engines. Historically, binaural rendering engines would basically recreate an anechoic kind of silent space with a single sound at like two meters away.

So, one of the first things we realized was that people were doing more interactive content and virtual and augmented reality content. But also some storytelling and the idea of proximity came out as something that was quite interesting and that not a lot of people had worked on. So we've done a number of series on how to improve the sense of proximity. So, when a sound is a few centimeters in front of your ear it sounds very different than the sound at the same level coming from two meters away. So we've been pushing our rendering engine to kind of improve that. The other is just the question of externalization and listening over headphones. If you listen to a stereo recording over headphones, it doesn't take into account the acoustics of the head in the ear. When you're listening to something over speakers and the result of that is that it feels like it's playing inside your head. So, we've been looking at a number of perceptual issues and acoustics issues of how to help the listener believe that the sound is coming from the world around them and not being played inside their head over headphones.

So we've been looking at the impact of head tracking on 3D audio. If there's an orientation tracker on the headphones then you can basically update the rendering in real time so that things are stable. Because one of the issues is that it comes across in headphone listenings, if I move my head and I don't take into account that dynamic, then the world moves with me and that kind of collapses the image inside your head. But when I turn my head, the whole soundscape rests in the outside world reference frame, then that helps the perception that things are actually happening out in the real world. So we've been looking at that. We're doing a study right now on how to simulate that in the event of not having a head tracker. So, can we instill small movements in the sound scene that help give you the impression that it's stable out in the world? Even if I don't have a head tracker?

Charlie Morrow: That's terrific. Good. Well, thank you. The other part of the discussion is I'm curious about your own interest in sound and the way it has affected your life – a kind of personal history and timeline with immersive sound.

Brian Katz: Mmm. I've never really thought about it in a long context. I mean, recently with the work that we've been doing on the Notre Dame Cathedral, I was looking for some history, some documentation and we're also starting a new project on the impact of room acoustics on period music. For example, Baroque music and early classical music because there's a number of research projects and we're in one looking at the historically informed performance. You have groups of musicians who are trying to really re-create the style of playing at the time of Baroque

music, using facsimiles of period instruments and trying to reproduce the gestures and everything.

No one's really looked at the impact of the room acoustics. So, they're doing these performances in modern concert halls or things built in the 60s, which are quite different. So we're starting a new project, one of them in partnership with the Chateau de Versailles to really see what the impact of simulating some of the acoustics of the actual Baroque performance spaces are on music.

And in trying to find some information about that, I ran across some books that I had that I realized were my bar mitzvah gift. Because, at the time, I was thinking about being an architect and I received this collection of medieval and Baroque architecture books, and I've actually gone back to use them. So, it kind of brought back the memories that way. So, I think I was more interested in architecture to begin with, and then that kind of went into physics. And coming out with a bachelor's degree in physics, and then a master's degree in applied physics, I was having difficulty in where research in that domain was going. Because it was either micro-atomic physics or astrophysics. And at the same time, I'd been doing some work doing some work as a sound installer – not installer, but basically doing the sound for some bands and some music events on campus. So, I kind of was learning a bit about acoustics in a practical way. Then I decided to do a Ph.D. and found out that there was a school where you could do a Ph.D. in acoustics.

And that kind of felt comfortable to what I was interested in. And I got into acoustics that way and that then went into 3D audio. Not being really a musician, I've always been more interested in the listening of the space than the actual content at times. So, after getting a Ph.D. in acoustics, I went into room acoustic consulting and working with a number of companies that design performance spaces. And that gave more insight into how to listen to the space. I think that's really where my immersive nature of what I was doing really blossomed because, at least in my opinion, what makes a very good concert hall is one where you really are immersed in the sound. There's kind of an interesting spatial dynamic to it and that's now carried on into what I've been doing in research now for almost 20 years, in this kind of virtual acoustics field of interest.

Charlie Morrow: Yeah, that is fascinating, considering that over the last 20 years those are the years that we've known each other.

Brian Katz: Yeah.

Charlie Morrow: And our relationship has influenced my work enormously, although we haven't been actively collaborating, but here and there our dialogue came at a critical moment in my evolution, coming from being a large-scale event-maker with broadcast elements mixed together.

Then to be able to deal with installations and then room acoustics, as well as the acoustics of musical instruments and the head itself and beyond that, the psychoacoustics that it's all being built by our brains, which is indeed a fascinating part of it.

I'd like to just digress to one historical study that I read that was actually some studies from, I thought, Montpellier, where a couple of hundred years ago they noticed that people who had

had severe damage to their facial bones couldn't localize sound. I wonder if you know anything about this area, where once the head changes, it's not just the ears, but the face and the shape of the splash of sound against the head can no longer be matched against memories. I wonder what you have to say about that.

Brian Katz: No, I'm not at all familiar with that study. I mean, by looking at what we've been working on with this kind of retraining or relearning to listen with new ears or the ears of somebody else and how successful that's been, that would almost lead me to believe that in that study, maybe there was more damage to their inner ear and the auditory system than just a change in the shape of the face. I mean, we've done a number of studies – but basically just having two ears doing a recording without a head. So, you have none of the acoustic head shadowing, but you still have the effect of the pinna and you still have some reasonable ability to localize because you still have the time difference in the low frequency and high frequency difference in the pinna. So, I kind of question what the medical conditions were that were behind that study because I think a lot of what we've been working on is actually showing that you can relearn – and there's been studies that were the inspiration of our work, which were a number of people putting insets into the pinna to change the shape and looking at how over the course of a few weeks people could adapt to that change. There's an even an older study, one of the very first studies of this kind, of how well can the brain adapt, with a researcher who actually just wore a hat that had two funnels on it and crossed using just tubes so that what was going into the left ear was going into the right ear and the right ear into the left ear. And even such a huge radical change like that, he was able to adapt in, in some situations, over the course of – I think he wore it maybe a month, for every waking hour. So, I think the human auditory system is incredibly robust and malleable in order to adapt to things like that. So that's how I would, I would see as a response to that kind of study.

Charlie Morrow: Well, thank you. That was very astute. I would agree with you from what you're saying. Is there anything else that you would wish to share because you've answered all MY questions?

Brian Katz: I don't know. I mean, I think while we haven't like collaborated a lot, yea, I think there's been a lot of moments of exchanging ideas and just bouncing thoughts back and forth, which is the informal part of collaboration that happens quite a lot in research. You want to just kind of throw ideas out and see how the community responds before going further. And I think we've been able to do that a lot on things and it's been kind of fun. I think if I what I remember learning the most from our interactions, that goes back to when we were working on your studio and I learned what a Brooklyn contractor was willing to do and not do. I think that's what I learned the most and has helped me the most in my career since then, it's what to look out for, for things like that. But I don't know if that's really appropriate to the discussion.

Charlie Morrow: It's appropriate to any discussion. It's an analog of my cousin Wally's advice to me when I went to Columbia from New Jersey. He was a very savvy Bostonian, a Harvard graduate. He said, Charlie, when you go to New York and you shake hands, count your fingers.

Brian Katz: Yeah, that would probably be how I remembered that guy as well. I still remember his golden diamond dollar-sign necklace.

Charlie Morrow: I recall that he said that the contractors met once a year in Las Vegas, the whole idea of a tribe or a herd of these characters, probably snorting and laughing about the schmucks in the world.

Brian Katz: Exactly. Spending their hard earned cash.

Charlie Morrow: Yeah. I thought about him recently when we saw *Moonstruck*. It's a plumber who is Cher's dad. It was a Brooklyn plumber; they make even more than contractors. Hey, well, thank you very much. I have a project that I would like to share with you ... We've taken our software very far forward and we've begun to do work with natural sound masking, which is a mixture of equalized sound, noise plus certain natural sounds in order that the spaces we're working in people don't zone out in. We found that noise alone is not acceptable.

We're starting to get a lot of interest in this. We'd also use those noise sounds to create tones, emotional tones like in a David Lynch movie, we're scoring an experience, I think it's in Latvia. It's called the "Lost Shtetl" and it's a museum in which you go room by room. First of all, this is a country in which there are no longer any Jews and this is being paid for by a rich Swiss expat whose paying Appelbaum to build it. And visitors will first see life in the Shtetl and then in the end they'll experience being massacred like fish in the back of the truck. And so we'll be adding notes and tones and quality – what do you call it? – emotionally stimulating noise, room by room. So, I wanted to make a soundtrack out of the actual experience. And so I wanted to share a little of that with you because it relates to a number of projects that we're doing. Well, I'm going to turn this off and hope our paths cross some time soon.