>> From the Library of Congress in Washington, D.C.

>> Hi, I'm Steve Mencher for the Library of Congress and I'm talking with Dr. Charles Limb Assistant Professor of Otolaryngology, a hearing specialist at Johns Hopkins University in Baltimore and also on the faculty of the Peabody Conservatory of Music and you've just given a fabulous talk here at the library, talking about your brain on jazz neural substrates of spontaneous improvisation and we'll talk a little bit more, we'll sort of break that down in a few minutes, but first I want to find out a little bit more about you.

>> Charles J Limb: Sure.

>> When did you first become interested in music, what was that like?

>> I have to say that I don't recall a time when I wasn't interested in music. Ever since I was a, I think a toddler I was playing some form of music. We had a piano and I played, my parents taught me to play very early and it's just been something I've lived with my whole life, in fact, to be very honest with you it's something that I'm really consumed by. Music is something that it's so much a part of who I am and what I think about. I feel like I think about it to a certain extent all day long, every day I feel I dream about it, I wake up thinking about it, you know, other than my family and my children, really it's much at the forefront of my mind and everything that I've done, and as a hearing specialist my interest in music I really have to say that it was fueled by my just deep curiosity about music.

>> As a student, let's say, when you started obviously also to have an interest in science.

>> Ah hum.

>> Did you feel those were two different pulls, someone who's interested in science I got to be a scientist, I've got to study these sorts of things; I'm interested in music which is creative which is an art form and those are two separate things.

>> Right, you know, there are a lot of people that are in science and medicine that are very musical, and I am certainly not unique in that, and I think that there must be some link between the two, some reason why people who have analytical minds also have musical minds, and maybe it has something to do with the underlying mathematics of music as you see is very structurally, you know, it's ornate, you can almost look at it from an equation perspective. Me personally, I have never had a problem resolving those aspects of my life in a sense that, you know to me I mean with, like every part of the world, I mean, everything offers something different and unique, and you know as far as being artistic or being analytical, I'm not a kind of person to over classify or to kind of compartmentalize these things, I mean I feel like they're all part of the same human experience. I will say that as a general trait knowing myself, my science tends to be very humanized and my humanized, and my humanities works tend to be very scientific and so I really do kind of I think

straddle the barrier between the two, or at least the intersection between the two.

>> Great. Before we get a little more deeply into the science just tell me again a little bit more about the music, in other words, ask someone who cares so deeply about music, are you listening to music all the time, are you, do you set aside time every day to play music, do you play music with other people? How is music part of your life?

>> Sure. It's changed a lot as my life has changed, you know, from a very practical perspective, you know, my day job is truly as a surgeon and that does require, you know, being a physician at Johns Hopkins does take a lot of my time. I'm fortunate in that, as an auditory specialist even when I'm doing surgery, you know, keep in mind for me my surgery is on the hearing bones, it's on inner ear, it's on the nerves, and to me it might not be, the problem may not be one of music it may be one of tumor, yet, fundamentally I'm dealing with a system to me that enables something as transcended as music, so to me it's all kind of parts of the same puzzle and, you know, I would say on a daily schedule, my wife would probably know better, but yeah music is very present in everything that I do in terms of listening, thinking, writing, reading, surfing, I mean, playing instruments. I collect instruments and I play, I'll have an instrument in my hand almost the moment I can get one. I do have two small children at home, including a 7-month-old and that's hampered my ability to play saxophone at home at night that's for sure.

>> Ah huh. On TV sometimes we see that the surgeons like are wearing headphones or that there's music in the operating room. Do you guys listen to music when you're operating?

>> I personally do most of the time. Ear surgery is often very loud because of the drill it's constantly ger noise, you know, and it's a little, it can be off-putting if that's all you're hearing and so usually I have a low-level of kind of comfortable music on in the background, it's not a distracting thing, I can say overall it probably calms people down in the room and it just makes, for me, it makes me a little more focused. It's always been that way. I've always studied with music. I've always done my best thinking, writing, whatever with something music happening in the background.

>> When you were talking to the group just a few minutes ago, you started out by telling us sort of how we hear, and I think that might be a good place for us to start as well. Is there a way to do that without using too many words that we don't understand or too many things that are very complicated who are just listening?

>> I think so. I think that there's kind of really two parts; one is the ear and the other is the brain, and you need both to hear because the ear is what collects the sound, but the brain is what interprets it and so I think that if you really want understand hearing, you have to look at both, I mean one cannot go without the other. Of the two, the brain is the one that's more of a mystery in a sense because peripheral auditory output it's really fascinating, but it's fairly well understood and it's a mechanical transducer meaning that it takes vibrations from the air,

sound, and it converts them into nervous impulses and those are sent to our brain. It's really remarkable and I would say that in terms of our understanding our meaning of the scientific community at large and the physicians at large, we really have very little understanding of really how complex stimuli something like music are truly heard. We have a lot of ideas and data on the elemental aspects of sound, but when you get at the level of, you know, Beethoven's Eroica Symphony it's just another, you've just reached another level of questioning that we're not at yet.

>> I guess there are lots of medical specialties that sort of take what happens to be body and have it lead to the brain, but it seems that hearing, especially in the way that you look into it that you have worked on it in your career, takes that connection and really makes is central.

>> I feel fortunate that I've been able to focus on this question, that to me is fascinating, you know, with hearing there's both an incoming and an outcoming aspect of to it, you know, depends on what aspect of music you're talking about; just take dancing for example right, you know, just to dance to music requires you to hear that music, process it, and then coordinate with your movements or your motor system. Automatically you're talking about something that is both incoming and outcoming, it's very, very complicated and that's why something like playing a musical instrument, which is again the same thing, it requires you to actively survey what you're playing and also react to what's coming in, but also to what's coming out, I mean, it's all systems are intermeshed in one, it's pretty remarkable.

>> Alright, let's jump right now into improvisation, cause that's some of the research that you were presenting to us, and I want to know what was it about improvisation that grabbed you and said I've got to take this subject and really delve into it as deeply as I possibly can in terms of my understanding of both hearing and the brain.

>> Right. Without overstating my own history with that, I would say that I've always been an improviser. When I was a kid learning to play in middle school and junior high school, I would come home from school and I would improvise, and to me it was very natural because I wasn't particularly good at reading sheet music and I was by myself I didn't have a band to play with, I was just playing by the piano and I became consciously aware that I was doing it at some point when other friends or other musicians said; "hey, you know, what are you playing" and I said "I don't know". I'm just playing, I just made it up and then they said, "oh", you know, and so that's when I started learning about jazz and the tradition of jazz and, you know, when you're a student and when you're young, I think that it's hard for a teenager to play the blues the way a 50-year-old plays, it's like, the music reflects who you are at the time and, you know, I felt that as well. When I was young I wasn't, you know, my view of jazz has evolved as I've evolved and I think when I was younger, it was more like "wow" look at these, you know, you listen to jazz like "wow that's amazing", or you look at transcripts of the songs and say "wow" that's amazing I can't believe they did that, and so you know, I've always my whole life been kind of fascinated by that process and then as I became a hearing specialist, and this is again, we're talking about 20 years of my career condensed into a few sentences, as I

progressed I realized that we really have scientific methods to actually try to ask a question about jazz which I never really thought I would be able to do.

>> So what was the first question that you asked and wanted to answer?

>> It was a lofty one; it was what in the brain takes place when somebody is spontaneously generating creative output? When you're improvising, when you're coming at it with something that's never been played before, how is that neurologically possible, and I talked about this at the lecture just a little while ago, I mean, I think it's important to say that musical productivity is a neurologic behavior just like speaking, just like singing, just like writing and so forth, meaning that there is certainly a lot we don't understand about jazz and, you know, all of the whole mysticism of the music and especially like spontaneous creativity, yet it's coming from the brain, it's neurologic process and looking at it that way I think is very important as kind of a first to have to say "okay" it's far game for study. This is something that, this is a product of the brain, let's treat it like any other processes of the brain, you know, I mean walking is pretty magical yet, you know, we can study how the legs are coordinated with the vestibular system and so forth and so I think with music it's the same thing, well it may not have an obvious survival benefit, but as far as understanding what makes us tick and what makes us human, I think it's a pretty nice glimpse into that mysterious black box of our brain.

>> Okay, let's break improvisation down a little bit which we didn't so much do before, because so many things are happening.

>> Right.

>> You know, when a jazz musician is improvising, they've got sort of a structure, there are chords there, there's a melody that is going on the their mind they just probably played that melody, they've played those chords with their teammates with their band mates and so now it's their turn to turn that melody into something brand new and they're using the chords to guide them and they're using also all of their training that they've ever had.

>> Absolutely.

>> They're practicing scales, they've been practicing patterns.

>> Ah hum.

>> All of these things are sort of baked into their brains.

>> Ah hum.

>> And out the other end comes something brand new that they then have to transfer back into their fingers, back into their breath and out the instrument.

>> That's right.

>> So, you were looking at all of that activity in the brain.

>> Ah hum.

>> And tell me, you know how you looked at it and tell me what you found.

>> When you put it that way it sounds so intimidating and daunting kind of on a sale level, but I think that, so you're absolutely correct, but that's what makes jazz great and it's filtered through the individual and that's why jazz is such an individual art form and when you hear a jazz soloist you can really see their musical identity to their personality, their past, their victories, their sufferings, their love's, their hates, I mean, all of it comes out in great music and I think that with improvisation, to a certain extent, more so than when you're playing somebody else's music even with great pathos when it's your own music, you really connect to it, because you're trying to tell your musical story, and so I think that I kind of wrapped the whole process up into a ball and said, okay, we know that all of these amazing phenomena are taking place, yet, in the end we can say lets' take 5 jazz musicians and let's just have them improvise, let's see what takes place without getting too caught up in the fact that a million things are actually taking place; that is the case, but as I said earlier, you know, you got to start somewhere. You have to try.

>> Okay, so what did you do?

>> So, we did something called functional MRI and that's a way to take a person, put them in an MRI scanner that measured blood flow in their brains so rather than getting an anatomic map, it generates a functional map so basically you can see areas of the brain that are regionally active or underactive. So, using this technology basically you can study a lot of complex human cognitive functions. So, what we decided to do was to take jazz musicians, piano players, and then to have them play on a specialized magnetically compatible piano keyboard in the MRI setting and image their brain when they were playing both something memorized versus something improvised, and that was the structure of our experiment in a nut shell.

>> Okay, and what did you find?

>> So, we found several things and, you know, again it's just one study, but the findings were fairly robust and fairly consistent from subject to subject. I think the most unique findings, or compelling findings were within the part of the brain called the frontal lobe, the front of the brain, particularly called the prefrontal cortex, and that's the part of the brain that kind of separates humans from animals and it just really where a lot of the kind of higher order human kind of processes like cognition and self-conscious awareness are really where they take place, where they reside. And so what we found was that area of the brain does this interesting thing where the medial prefrontal cortex kind of the central portion right in the center, when it turned on it went up during improvisation whereas the flanking area above it called the lateral prefrontal cortex shutdown broadly, and so if you kind of distil those

two things down we call this a disassociated state of activity where one part of the brain is both up and down right next to each other. We think that that is neurologically in the frontal lobe what's happening to allow someone to improvise, and if we further sort of take a look at what those regions do, keeping in mind that they're multifunctional and that this is interpretive, a very reasonable interpretation is that the part of the brain that goes up well that's the part of the brain that relates to oneself, it's involved in what we write as neural instantiation of the self, it's autobiographical narrative, these kinds of things that what we call the default mode of the brain when you're being introspective that area went up. So, when you're improvising these self-expressive areas are going up, that's fairly intuitive, but this also flanking region called the lateral prefrontal areas, they are self-monitoring regions things that put things in an appropriate context and allow you to evaluate whether or not what you're did was correct, incorrect, right, or wrong it's in a way it's a self-monitor, a self-sensor and that area shut down and so we had this kind of loss or lack of inhibition or disinhibition if you will combined with this self-expressive self-introspective related area going up and that unique combination I think is what enables you to both be creative meaning to generate novelty without warning about whether you're right or wrong or getting caught up in the details, and also to have what you're saying musically be relevant to who you are as an individual and I think that that is, you know, probably the ultimate goal of jazz improvisers is to play something unique that reflects them. I mean, jazz is all about one's identity.

>> Wow, now we talked about, you know a sort of an explosion of new ways to look at the brain.

>> Ah hum.

>> Is this part of that, is this something that we could have done 5 years ago or 10 years ago? Did we know how to do this? Could we have seen these things would we have known what to look for?

>> So, I think that it's, in the past 10 years of so is really when this technology evolved. The first paper described, and this was really in the early 90's, this ability to use functional MRI, now predating functional MRI there was something called PET scanning which was very powerful, but a little bit less, you get less data per time and you have to have ionizing radiation injected into your arms, so it's a little bit more invasive, so we've had methods to analyze these things, functional MRI is not invasive, very powerful and the resolution both spatially and temporally is really pretty good considering what it is and so it's just opened up a whole new line, it's kind of really led the charge of this whole new line of cognitive studying. There's other techniques transcranial magnetic stimulation event related potential study of magneto-encephalography all these other ways to study the brain, but if you use them altogether and each one corroborates the other, it's pretty powerful and so I would say that we're in the midst of a relative modern golden age of neuroscience right now where some of the most challenging questions that were formally not really considered legitimate for scientific inquiry, well we're now able to try to say well how would we go about answering this, let's take a stab at it, and so I think we'll

see it continue to evolve and hopefully our own work will reflect that as well.

>> Great now as, before we close let me take this in sort of two different directions, cause one of the things you sounded most excited about was that this could be the key to our sort of understanding and even literally seeing how creativity works in the brain and that was just looking at you when you were talking like that.

>> Right.

>> Seemed like one of the things that really turned.

>> Right, you know so I view improvisation as a model of one type of creativity which is spontaneous musical creativity. There are a lot of forms of creativity and you can, you know, keep bringing it down into intellectual, scientific, athletic and so forth, and each one has its own unique kind of constraints, problems and kind of insights, overall I would say broadly speaking creativity is to me essential to the human species, it's allowed us to evolve and advance, I mean, where would we be without flashes of brilliance that are essentially intuitive moments of creative genius where novelties derived, you know, I mean how do we do that? How do we lateral think and have these kind of eureka moments where suddenly, you know, one moment you don't know something the next moment you do know something or you've developed something new, and it's intrinsic to human beings. I think that we're geared to seek and to try to generate knowledge. You can see it in children, you know, you watch children at play, solving many problems all the time in ways that you wouldn't have thought to solve it, and I think that it's just so fundamental that so many human processes that in a way even though for me jazz in improvisation as a goal in and of itself is compelling enough. The fact that it relates to this much deeper process that's fundamental to a lot of human behavior, to me it's icing on the cake.

>> That's great. Now, I just also want to bring this back to your kind of as you say your sort of main day job as a hearing specialist and the use of music as a way to understand hearing better, as a way to help people hear better.

>> Absolutely.

>> Tell me about that.

>> Sure. You know, when you think about the auditory system and its job is to transduce sound a lot of people automatically assume or kind of emphasize language as the main sound that we need to transfer, because from a practical perspective language is really first and foremost in terms of priority for human communication and that's well-deserved; language is crucial. I would say that both my own personal experience and just from an acoustic perspective music is in a way more challenging, it's the acoustic features of music are very heterogeneous and in a way not nearly as narrow as those of language, the semantic implications of what the music means are vague and so music is harder and I always describe it as the ultimate auditory challenge; I say it's the pinnacle

of hearing, I really believe that. For my patients, well you know where I'm getting to is now if you take somebody who is, let's just take somebody who's deaf and had their hearing restored with a cochlear implant, if you can get them to perceive music, not only did you enrich their life, but you have actually, you've really restored their ability to hear the hardest of sounds, and it can't get any better than that and so I use it as kind of almost like a landmark like a goal to shoot for. I know it's not realistic in a lot of cases. The other thing is that music can inform us on the auditory system because, you know, a lot of our hearing tests the clinical methods that we use to evaluate hearing, they're very simple and in a way crude; there's a certain necessity to the simplicity from a practical perspective and it gives us certain fundamental information, but it's more like looking at the bottom level of the performance rather than the top level of performance, and I'm very interested in the top level of performance and I feel like well music is the key to understanding what that top level of performance is and so I often also treat musicians that kind of like-minded that they've hearing is essential to them for their music, that is the main purpose of their hearing, I mean without it, they wouldn't be the same person and so as a physician I take that world, you know, pretty seriously.

>> Well, thank you very much for joining us today, Charles Limb Assistant Professor at Johns Hopkins University.

>> Thank you for your time.

>> And I'm Steve Mencher for the Library of Congress.

>> Thank you, appreciate it.

>> This has been a presentation of the Library of Congress, visit us at loc.gov.