# "Know Thyself: Well-Being and Subjective Experience" with Joseph LeDoux

## Transcript of Cerebrum Podcast

**Guest: Joseph LeDoux**, Ph.D., is the Henry and Lucy Moses Professor of Science at NYU in the Center for Neural Science, and he directs the Emotional Brain Institute of NYU and the Nathan Kline Institute. He also a Professor of Psychiatry and Child and Adolescent Psychiatry at NYU Langone Medical School. His work is focused on the brain mechanisms of memory and emotion and he is the author of The Emotional Brain, Synaptic Self, and Anxious. LeDoux is an elected member of the National Academy of Sciences and the American Academy of Arts and Sciences. He has received the William James Award from the Association for Psychological Science, the Karl Spencer Lashley Award from the American Philosophical Society, the Fyssen International Prize in Cognitive Science, Jean Louis Signoret Prize of the IPSEN Foundation, the Santiago Grisolia Prize, the American Psychological Association Distinguished Scientific Contributions Award, and the American Psychological Association Donald O. Hebb Award. His book Anxious received the 2016 William James Book Award from the American Psychological Association. He is also the lead singer and songwriter in the rock band, The Amygdaloids and performs with Colin Dempsey as the acoustic duo So We Are.

**Host: Bill Glovin** serves as editor of *Cerebrum* and the *Cerebrum Anthology: Emerging Issues in Brain Science*. He is also executive editor of the Dana Press and *Brain in the News*. Prior to joining the Dana Foundation, Mr. Glovin was senior editor of *Rutgers Magazine* and editor of *Rutgers Focus*. He has served as managing editor of *New Jersey Success*, editor of *New Jersey Business* magazine, and as a staff writer at *The Record* newspaper in Hackensack, NJ. Mr. Glovin has won 20 writing awards from the Society of Professional Journalists of New Jersey and the Council for Advancement and Support of Education. He has a B.A. in Journalism from George Washington University.

Bill Glovin: Welcome to the *Cerebrum* podcast. I'm *Cerebrum* editor, Bill Glovin. This month's guest is Joe LeDoux, one of the authors of our most recent *Cerebru*m article, "Know Thyself: Well-Being and Subjective Experience." We're starting this podcast off a little differently. The music you just heard is a composition by Dr. LeDoux called, "What It Is To Be." Dr. LeDoux is the front man in a popular band called *The Amygdaloids*. They play mostly original songs about the mind and brain, and mental disorders. He's also in an acoustic duo called *So Are We*. You can check all their music out at The Amygdaloids.com.

Dr. LeDoux has been working on the link between emotion, memory, and the brain since the 1990s. A recently *Psychology Today* article refers to him a neuroscience legend, and credits him with putting the amygdala in the spotlight, and making this previously esoteric subcortical brain region a household term. Dr. LeDoux directs The Emotional Brain Institute at NYU and the Nathan Kline Institute. He's also a professor in the Center for Neuroscience, and in the departments of psychiatry, and child and adolescence psychiatry. He's the author of *The Emotional Brain, Synaptic Self*, and *Anxious*, and of the forthcoming book, *The Deep History Of Ourselves*. His book, *Anxious*, received the 2016 William James Book Award from the American Psychological Association.

Joe, welcome, and thanks for the article. Let me start off with why you thought it was important to write the article with three other authors, Richard Brown, Daniel Pone, and Stefan Hofmann.

Joseph LeDoux: The topic is rather general with implications that are obviously philosophical, given the title. I had my philosophical partner, someone I've recently written another piece with on something called "A Higher-Order Theory of Emotion," where we use the philosophical approach to try to bring the science of emotional consciousness into the present way of thinking about things within the philosophy and neuroscience of consciousness. The topic is also relevant to psychiatric and mental health issues. I have been writing with two other fellas, one, Danny Pine, who's a psychiatrist, and we recently wrote an article on *The American Journal of Psychiatry* about a two-system model of fear and anxiety.

The other fella is Stefan Hofmann, who is an expert in cognitive behavioral therapy, an intellectual leader in that field. I wanted to kind of cover the basis, and cover various angles from which this topic is explored, and also give me an intellectual backup in making the case.

Bill Glovin: Okay. Tell us a little about your career path and how you came to publish what has been called a potentially earth-shattering new paper, "A Higher-Order Theory of Emotional Consciousness."

Joseph LeDoux: Okay. My career path starts way back in the swamps of Louisiana, where I grew up, and left my small town, Eunice, Louisiana at the end of high school, and went off to the big city, Baton Rouge, to study something. My parents wanted me to stay in Eunice and be a student at the local junior college, which was just opening at the time. A branch of LSU. I didn't really ... I was done with Eunice, I wanted to move on to bigger and better things. We negotiated a deal where I would go to Baton Rouge and study business, come back to town when I'm done, and be a banker in the little town, and that would be that.

Of course, I agreed, just to get out the town, and went off, studied business, and was kind of bored. This was the late 60's, and so business wasn't a cool thing to be studying. But, I did the deal and ended up getting a degree in marketing, I guess was the major that I pursued. But while doing that, I got interested in the topic of consumer psychology and why people buy stuff. That took me into psychology in general, and then to explore mental psychology.

And ultimately, I think while I was working on a masters in marketing after that, I ended up working in the laboratory for a guy who was studying the brain and learning and memory. I had no idea you could actually study the brain. I didn't know that was a career path or something people really spent their time doing. But, I kind of fell in love with what he was doing, and ended up applying to graduate school, and the only place I got in was Stony Brook, so I went to graduate school there. My professor at LSU knew someone there so that greased the wheels and helped me get in since I had no background in the field at all.

I went on and ended up studying split-brain patients and conscious awareness in the two hemispheres of these split-brain people, and got fascinated by that topic. My advisor, Michael Gazzaniga, was really one of the great thinkers in psychology, and he encouraged me to think big like he thought big. We did experiments on consciousness, we wrote a book about all this called *The Integrated Mind* at the end of my Ph.D. work.

That got me into the idea of what I wanted to do, was to pursue emotions because what we had studied in the consciousness area in split-brain people was how the talking, left hemisphere reacts to behaviors that are produced by the other side of the brain, the right hemisphere. For the point of view of the left hemisphere, anything generated by the right is from an unconscious system. One of the kinds of things we thought might be important in everyday life is the fact that our emotion systems maybe are generating behaviors non-consciously in us, but we kind of generate a narrative to explain that through our conscious minds.

When you graduate from a lab that's been studying split-brain patients, you don't go off and find your own split-brain patients because they don't exist. To develop a career path, you have to pursue something. What I wanted to pursue was the possibility that these emotion systems are generating behaviors non-consciously. Ultimately, I wanted to get back to the question of consciousness, but I figured I needed to know a lot about the non-conscious systems first.

So, I turned to studies of rats and began studying how a rat will respond to a tone that's been paired with a shot by freezing, and its blood pressure and heart rate go up, hormones are released. I thought, "This is a pretty good method for trying to figure out how the stimulus with no meaning acquires a meaning." And because you'd have a very discreet stimulus, like a tone, and a very discreet response, freezing, or blood pressure, or heart rate, the idea was to simply connect the dots in the brain. Right about that time, the methods of tract tracing, anatomical tract tracing, had been refined to use chemicals as a way to trace connections by way of axonal transport. That seemed like a very useful technique, and I'd learned how to do that in graduate school.

What we tried to do was start with making lesions in certain parts of the brain, and we started with the auditory system, because that was the part of the system that's bringing the stimulus into the brain, and asked which parts of the auditory system were required. The answer was that the stimulus had to rise to the level of thalamus, but not go all the way to the neocortex, to the auditory cortex.

That told us that the conditioned response was based on processing. That was an output of the thalamus, but that wasn't the auditory cortex. So, where in heck is the auditory thalamus going to, if not the auditory cortex, because that was the textbook story? We used these tracers by injecting them in the thalamus, auditory thalamus, medial geniculate area, and found that they went to a number of other areas besides the auditory cortex. We lesioned each of these, and only one of them had an effect on the learning, and that was the amygdala.

That suggested that the thalamus connects directly with the amygdala. The amygdala was known to have all these connections to species typical behavior response control areas and autonomic nervous system control areas. That quickly suggested the whole pathway from the ear to the responses. What I've been doing ever since is studying that circuitry, especially within the amygdala. Long way of answering you.

Bill Glovin: When someone says, "That wasn't a conscious decision," can that be true?

Joseph LeDoux: What wasn't a conscious decision? Anything?

Bill Glovin: Yeah, anything. When people ...

Joseph LeDoux: Yeah. I think that many, many things, most of what the brain does, it does non-consciously. I don't say unconscious, because that implies a Freudian and devious, unconscious thing. But, instead what we're talking about or what came to be called its own point, the cognitive unconscious, stuff that is simply non-conscious because of the way the brain is just naturally wired. You have a reflex response that is just triggered automatically. We have a lot of species typical behaviors that you see in animals that are just stimulus' there. They praise, or they flee, or they do other things in the presence of biologically significant stimuli, unconditioned stimuli.

We have some of these too, and we all tend to have a tendency to be able to learn quickly about snakes, and spiders, and other things that were dangerous to our ancestors. We'd all not necessarily have a snake phobia or spider phobia, but these are latent threats that are burned into the brain's circuitry that makes it very easy for us to acquire meaning through seeing those. You see someone being bitten by a snake or even see a snake in a magazine, that may be enough to get your juices flowing and your circuits rewiring on the basis of that.

A person, like me growing up in Louisiana, should be sensitized to snakes and not very afraid of them, but I had the opposite problem, which is I became very sensitive to them. I remember one day, I was a young kid and my father had a meat market. There was a guy working for him that sometimes would just after school take me somewhere. I was very young at the time. I remember we went out to an old bayou area to do some craw fishing. I'll never forget the image of the banks of that bayou, just covered with water moccasins, really poisonous snakes. From that moment, I don't know if that was the cause, or it just fed into my natural tendency. But from that moment, I had a snake phobia. Today, it doesn't bother me that much. I've outlived it, I guess. But I used to not be able to ... If I see a snake in a magazine, I would really, wow, jump back from it.

We have these natural tendencies that get exacerbated. They vary from people to people, but they're in there anyway. But in general, we make decisions, we do things without thinking about it. You just put your head in your hand, you didn't plan that, it's just something you did. I'm speaking in reasonable English sentences that are roughly grammatical.

I'm not planning where the subject and object go, and yet those go in the right place. I'm looking across the room, I see some things are in front of me, and some things are in back of those, or in front of you, and further back in the room. So, my brain is computing the geometry of the room to give me depth perception. But it's not actually ... I'm not computing that geometry. The brain probably isn't either, choosing other cues to give those geometric relations, but it's relating to the geometry of the room. All of these things are happening outside of our awareness, under the hood, so to speak.

Bill Glovin: When you talk about the snake story, that makes me think of your work with emotion and how emotion is so fascinating in terms of how we remember things, in terms of memory. When we look back at our childhood, for example, that's something you remember because it was, I guess, an epiphany of some sort. How closely tied is emotion and memory in your view?

Joseph LeDoux: Well, I think that it's pretty clear that things that we call emotional, situations that we describe as emotional, are remembered in a stronger, more intense way than other kinds of experiences. Now, that doesn't mean that the memories are more accurate. And in fact, research by my colleague at NYU, Elizabeth Phelps, has shown that emotional memories tend to be no more or less accurate than any other memory. But, they tend to be highly intense. You have tremendous confidence in your emotional memories. But, they're not necessarily especially accurate. There have been studies during disasters and so forth where researchers would get to the disaster relatively quickly, interview the people, bring them back in a year later, and interview them again, and their memories are ... it's like night and day in some sense. They're not exactly the same. The general memory is the same, but the details are very distorted from time to time.

What happens is you might have a little bit better accuracy for the central focus of the memory, but the peripheral details are the ones that come in and out of focus over time and change over time quite a bit. Now, what the interesting thing about childhood memory is though, is I think a lot of the memories we have that seem so strong, if you think about it, are probably things we have family, photographic albums about. We see those pictures, and those pictures are what we remember as if they're actual experiences.

This gets into the topic of memory reconsolidation, which is that every time you retrieve a memory, you update it on the basis of the current experience and things that have happened to you since that time. So that when you see a picture of you three-years old, like in my case standing next to a bike in diapers, maybe I wasn't three if I had diapers on, I'm not sure, but I was in diapers standing next to a bike, and I can almost remember that time doing that. But really, what I'm probably remembering is the fact that I've seen that picture a few times, because I don't remember other things around that time.

Bill Glovin: How does subjective experience fit into the equation?

Joseph LeDoux: That's a big topic, and that's obviously what our article is about. I think for a long time, maybe forever, we've misunderstood fear in a sense. Certainly since Darwin's time. Darwin talked about emotions as states of mind that we've inherited from animals. From that point on, that's how emotions have been viewed. After Darwin, there was a tremendous amount of activity in the late 19th century trying to study emotions in animals. The assumption was that if an animal and a person react the same way, that must mean they have the same internal feelings because as Darwin said, "Emotions are states of mind that control our behavior." He wrote a lot about facial expressions and other innate kinds of responses.

But the assumption was what William James called the common sense view of emotion, which is that our emotions cause us to respond the way we do in the presence of certain kinds of stimuli. So, in the presence of danger, James pointed out we run from the bear. He asked, "Do we run from the bear because we're afraid or are we afraid because we run?" I think his part of the question ... the first question was really on the mark, why do we run from the bear? He said, "It's not because of fear." I totally agree with that, that fear is not what causes us to run or to express facial expressions that indicate fear or other emotions. Fear is a slower process that involves our cognitive interpretation of the situation we're in.

I disagree with James in the sense of the second part of his question, which is his conclusion was that we experience fear because we run away. I think that the bodily response is that occurred during running away certainly will contribute to the intensity of the fear that you experience, but not the cause of it. For me, the cause of fear is your cognitive awareness that you are in a situation of danger. Now, my part of the brain that I've studied all these years, the amygdala, is responsible for the detention and the response to threats in the case of these kinds of innate, automatic responses. You can learn new stimuli that's going to get into the amygdala, activate those same innate responses, but the responses were not learned.

But there's no need for fear in any of that. So, when learning takes place, as neuroscientists, we understand that learning to be a process of, for example, Hebbian plasticity, where two stimuli come together in the brain, and converge upon individual neurons. And the first stimulus, let's say a tone, is then associated with a second stimulus, a shock, because the tone and shock converge onto specific cells. Now, one place they converge is the lateral nucleus of the amygdala, which is what I've studied for quite some time. Once that convergence has taken place, and the pairing is over, the tone now can get into the amygdala and flow through that circuitry much more effectively than it could before the conditioning.

After conditioning is over, the tone comes in, goes to the lateral part of the amygdala, then it flows to the rest of the amygdala, and then out go the responses. It's that conditioning process that changes the way the tone is processed by the amygdala. There's no little experience of fear in there that's producing all of that. Fear is what happens if you are the person who is responding that way and you interpret your bodily responses, your physiology, your behavior, stuff that's happening in your head, memories that are being retrieved, and all sorts of things. When you provide that interpretation, that's when you experience fear.

I think it's been handed down wrong to us from the time of Darwin and perhaps even before, that fear is the cause of these kinds of responses. It's a kind of folk psychological notion. It's probably been something that humans have had in their minds from beginning of having minds, because danger is such a salient kind of experience. And so why, if you're feeling afraid and running away, wouldn't you think that the fear is causing you to run away? It's a natural kind of inclination.

But scientifically, we have to go beyond our intuitions if we want to understand something. The purpose of science is to figure it all out. We go into the brain, and we see that there are these subcortical circuits, and because of that intuition, scientists have assumed that if the circuit that is controlling freezing behavior in the presence of a danger is active, that must mean that the fear that you experience is coming out of that circuit.

I think that's where we've made a mistake, that our conscious minds are processing information at the same time as the amygdala is processing information. But my proposal is that those are two separate things that the build up of the conscious experience, and the generation of the quick effect of body response is the freezing and so forth. Those are not one and the same. They happen in parallel. They will interact. The feedback from the responses will make the conscious experience stronger, and the conscious experience may prolong. Once you know you're in a situation of danger, you may consciously and intentionally say, "Well, I better stay still," and so that will prolong the situation.

But, I think it's the wrong thing to do to call all of that fear, because fear is only the high-end stuff, the stuff under the hood I prefer to think of in terms of defensive behaviors and defensive survival circuits that have evolved to allow us to protect ourselves in the situation of danger.

If you start looking backwards in evolution, how far you can find organisms that respond to danger, you never stop, because the first organism that ever lived, a bacterial cell, a kind of bacterial cell had to be able to detect nutrients and separate those from toxins in its environment. When it encounters a nutrient, it wiggles towards it, and when it encounters a toxin, it tumbles away. Detection and response to threat is not something that's there for psychology's purpose. It's there simply for the purpose of keeping the cell or the larger organism alive.

Bill Glovin: Has there been a lot of pushback in the neuroscience world to your theory?

Joseph LeDoux: Yeah, there's been some pushback from other researchers in the field who prefer to keep the word fear, I guess, for a couple of reasons. One, it's traditional and so everybody knows what the field is talking about when they talk about that. But the problem is that unless you're really in the know, you don't really know what fear means in this case, because fear is used to describe the circuit that controls behaviors non-consciously, but also is used to describe the conscious experience of fear. So, you have a fear system that both is responsible for something called fear and for other stuff that's not exactly fear, but you're also labeling as fear. It's a big conceptual mess.

Just for the pure simplicity of the semantics, my preference is to use fear for its common meaning, which is the conscious experience of being in harm's way and to use other terms for the non-conscious things like detection and response to threats. Now, that rubs some people the wrong way because they feel that, again, that it's worked okay so far, but I think we should try to clean it up if we can. But also, that it might be some diminution of the importance of the work in the mind of, for example, NIH funders or the public by not calling it fear because fear is ... That makes it sound like it's really relevant to human behavior. But I think it's more important that we get it right and that we change the terminology so that it doesn't lead to confusion, because I think we're all better off if we're not confusing the audience.

Bill Glovin: Is most of your research done with rodents? Have you been able to transition to human subjects?

Joseph LeDoux: My lab works primarily with rodents. Now, I've done a lot of collaborative work over the years for probably, I don't know, 25 years or so or 20 at least, worked with Liz Phelps at NYU. Liz has done a lot of things, but one of the things she's specialized in is developing human analogs for the kinds of behavioral tasks that we study in rodents. That's been incredibly useful because we've been able to really develop tasks that are parallel.

She's shown to a first approximation that the amygdala's involved in all these behaviors that we find that it's involved in in rats. But also, there are things that you can study in animals that you can't study. But also, there are things you can study in humans that you can't study in animals, for example, more cognitive kinds of things. She's shown that the learning by observation, for example, that you can watch someone being conditioned, and then when you see the condition stimulus, you'll have a response. So, just by picking it up in a social situation. That kind of thing is very important to be able to extend.

There's lots of complicated things that the human brain can do that other animal brains can't do. If we want to understand the more complicated aspects of mind and behavior, we have to do that in humans, I would say. And especially if we want to study consciousness, we have to do that in humans. That's not to say that animals don't have some kind of experience, but there's no way to go inside an animal's mind and know what's going on. All we can do is infer, and when we infer, what we see is that, basically we're talking about behavioral responses, and if what I've been telling you is correct, that the conscious experience of fear is going through the cortical areas and being created in these more complicated circuits, then the behavioral and physiological responses are happening subcortically. Then, if we're looking at behavior, then we're not really seeing the conscious experience in the animal. There's no way to know what we're seeing in the animal.

But I think this has had an impact on the poor success of the psycho pharmaceutical industry. Drugs are developed to help people feel less fearful or anxious by putting animals through challenging situations. When you do that, what you find is the animals, when given drug X, may be less timid in the presence of the threat, danger. You give it to a person, and the person, let's say has social anxiety and goes to a party. When they get to the party, they still feel anxious. But maybe they found it a little easier to get to the party. In other words, maybe they were a little less timid on the way to the party.

If that were true, then it means the drug would be doing the same thing in the animal and the human, but the expectation about what it should do in the human would be wrong; that it should be able to help you get to the party more so than to make you feel great when you're there. But if you know that, and have the right expectation, then when you get to the party, you can say, "Well, okay. It was easier to get there. That's good. Now I can go in and maybe it'll make it easier for me to get into the party and expose myself to some of this, and I can step out, and go back in," and so forth.

If you had that expectation about what the medication was going to do, it would be a very different experience than going to the party and feeling disappointed. It's all about expectations about what we can and can't expect from animal research, and how we interpret that and how we sell that information, so to speak, to the public and to the funders.

I think we could just do a better job in cleaning up the language. Maybe I don't have the right terms, but I don't think there's any question that would be better to have cleaner terms that are not leading to confusion.

Bill Glovin: Why do you think it's ... In terms of drug development for anti-depressants let's say, nothing new has come along in decades. Do you have any theory about that?

Joseph LeDoux: A lot of the drugs were discovered by accidental findings in humans, right? Some drug is given to some patient for something, and the patients getting this on the ward seem a little less depressed. Oh, maybe that's an anti-depressant. Let's give it to people. Then you take that kind of drug, and you start giving it to animals. Let's find something new like that. That has been what's happened. You take drugs that work, and then try to use that to explore new ones, when really all you find is new versions of the same thing. So more monoamines, more benzodiazepines, but no new classes of drugs.

Okay, so you say, "Let's take these tests that the benzodiazepines or monoamines have some effect in, and try to find new drugs." The problem is that the benzodiazepine or monoamine effect in humans may also affect the animals, but not necessarily for the same reason, right? That might not be the gold standard for then taking a test that's sensitive to benzodiazepines and then say, "That must be a drug or a test that's going to tell us about the next anti-anxiety medication," because benzodiazepines do a lot of things in the brain. There's side effects and lots of effects. So just because it's a test that's sensitive to benzodiazepines, doesn't mean it's a test that's going to tell you how to cure anxiety.

The fact that these tests have been used in, I can't tell you how many thousands of studies, developing new drugs and billions of dollars, but now the pharmaceutical industry says, "We're not getting anywhere, so we're stopping. We're not going to do any more anti-anxiety or depression research, or we're going to do less because it's not paying off. We're not getting any new results." Again, it's all about the expectation of what the animal model can give you. If you think it's going to change fear and anxiety, you're probably barking up the wrong tree. What it's most likely to do is change behavioral timidity, because that's what you're doing in the animals.

Bill Glovin: Do mammals, for example, have all the same areas of the brain that we do?

Joseph LeDoux: No. Well, if you take the lobes, they have all the lobes. But, the prefrontal cortex in different mammals is quite different. The prefrontal cortex is one of the key areas that we know is involved in consciousness, for example, perceptual awareness, and is involved in sense of self, and all sorts of high level things in the human brain. There's cells in the prefrontal cortex of the human brain that don't exist in other animals. There are kinds of circuits that are unique. For example, connections between the prefrontal cortex and certain high level areas in the parietal cortex are much better developed. In other words, these prefrontal and parietal areas are more extensively interconnected than they are in other apes, even.

The connections between prefrontal cortex and parietal cortex in humans is more developed. The connections are more extensive than even in apes, much less rodents. There's a lot that's known about relatively unique aspects of human prefrontal cortex. Todd Preuss (at Emory University) a neuroanatomist who has studied this extensively, and has written wonderful articles on the unique features of the prefrontal cortex, and its connectively, and so forth. One of the things he's pointed out is that a number of psychiatric, or let's just say, psychiatric conditions, for example, schizophrenia and other conditions like that, with circuits involved in the prefrontal cortex, may be the ones that are particularly prone to these kinds of disorders, perhaps because these unique features of the prefrontal cortex in the human brain are relatively new evolutionarily, and haven't been fully tested out, and weeded out. The problems haven't been weeded out over the course of long, zillion years of evolution the way other parts of the brain and circuits might have.

Bill Glovin: How about imaging advances? Could further imaging advances help your research, or have we come as far as we can go with that?

Joseph LeDoux: One of the reasons the animal research is so important is because we can get into the nitty gritty of the circuits. In the human brain, you can identify the amygdala's being involved, but not the different parts so well. The techniques have been refined to the point where it's okay. I mean, I think you can probably get some general nuclei within the amygdala or different locations now. But we'll never, I don't think the ... I think it's a physical limit of imaging as to how far down, how much finer the resolution can get. I think we've butted up against that, at least with the current methods. I'm not an expert, but that's what I'm told.

Maybe we need a whole new kind of imaging technology that will take us to the ability to get deeper in the human brain, just as CAT scans couldn't do functional imaging. Pet scans could, but they weren't very precise. MRI's allowed you to get much more precise, but they've hit a limit now. So, maybe there's something waiting down the road that will allow us to do all of this in the human brain non-basically.

Bill Glovin: All right. A couple more questions for Joe. Emotion seems a fear, a threat, anxiety, seems like such a hard thing to quantify since people tend to react differently to the same event, let's say. Is it our environment that shapes us emotionally, or differences in the brain, or both in your view?

Joseph LeDoux: Both. Both.

Bill Glovin: Both?

Joseph LeDoux: Yeah. It is. I mean everything is both, right.

Bill Glovin: Everything's both?

Joseph LeDoux: Yeah. Every person is different, and as you said, we react differently. But every rat is different as well. You can take genetically homogeneous animals that they've been bred to be as close to as possible genetically, and they will still show individual differences in behavior under the same kind of conditioning experience.

There is something about the way the brain develops that is going to introduce variability. They may be less variable, genetically homogeneous animals may be less variable than genetically diverse animals. But, they're still not going to be identical behaviorally, because behavior is a complicated readout involving different systems. Let's say you have 1 percent difference in each nucleus of the brain, and as a stimulus has to go through the brain, through multiple stages to get to a response, those one percents might be adding up over the course of that.

You might have differences due to the sensory processing that makes the animal more sensitive to the stimulus, or differences in the motor outputs that makes it more reactive for some reason, or even differences in the ability to associate the conditions in the environment that ultimately link the stimulus to the response.

Bill Glovin: Tell us about your band, *The Amygdaloids* and if music has helped inform your research at all.

Joseph LeDoux: The research has informed the music. I can't say that the music has informed the research so much. *The Amygdaloids* originally was a group of scientists that got together, and started playing. It started out with me and Tyler Volk. Tyler is an environmental biologist in NYU, and we got together over a beer, and we were just chatting, and we found out we both had Stratocasters, so we started playing together at Christmas parties and stuff. We, for fun, started calling our genre songs about mind and brain, and mental disorders. We would play *Manic Depression*, or *Mother's Little Helper, 19th Nervous Breakdown*. They were kind of classic rock songs that had that angle.

At one point, we found out that a new post doc arrived, who was a drummer. So, we invited her to drum with us, and so she played with us at some party or something. Then we got an invitation ... I got an invitation to give a lecture in Brooklyn at The Secret Science Club. November 1st, 2006. I actually remember. At the time, we needed a bass player, and the drummers who had just arrived said, "Well, my research assistant is a bass player," so she joined us. We had two guys and two girls.

Bill Glovin: Perfect.

Joseph LeDoux: Looks good, gender balance and everything. This was written about in *Newsday*, in the Long Island newspaper and said kind of, before the show announcement, LeDoux will speak on fear and the brain, and the band, *The Amygdaloids* will play after. The title of that, the blurb was "Heavy Mental." So, we adopted that as our genre, and that's what we do. We've been writing songs about mind, and brain, and mental disorders, and released, I don't know, seven albums or so.

I feel that it's getting harder and harder to write these songs because we've used all the buzz words up. Mind-Body Problem, Theory of Mind, on and on. These are not like geeky, science songs. They're really basically love songs that happen to have some element that relates to mind and brain. So, the title of one song off one of our albums is called *Theory of My Mind*. It's, "Why are you so blind to me?" And blah, blah, blah. The Theory of My Mind. It sounds like that rather than ... A lot of science cover bands are taking classic hits and then changing the lyrics. We had a principle we weren't going to do that, we were going to write our own stuff.

Bill Glovin: Right, right. Right.

Joseph LeDoux: Partly because I think we weren't good enough to do the cover, so we just could write songs and ... I'd write songs that I can sing in my limited range, and songs that we can play. Tyler's a great guitar player, but yeah. It suited us to write our own material.

Bill Glovin: I've seen some of your videos, they look very professionally done.

Joseph LeDoux: We've had very good luck with some people volunteering to make videos for us. We've been very fortunate. We've had a number of really well known artists to play with us or record with us. Rosanne Cash sang a couple songs with me on one of our albums.

Bill Glovin: Wow.

Joseph LeDoux: It's been a lot of fun to just explore all this and have a good time with it.

Bill Glovin: Okay. Anything you wish to plug or talk about in terms of your research going forward right now, or…?

Joseph LeDoux: I just want to make a clear statement about when I talk about animals and the difficulty in studying consciousness in animals, I'm not saying that animals have no conscious experiences. I'm saying that scientifically, it's difficult to study that. Given that the parts of the human brain that seem to be most involved in consciousness are the parts that differ most between humans and other animals, I think it's important that we consider the possibility that there may be something special about human consciousness that won't be present in another animal. And certainly the fact that human consciousness is so tied up with language will make it different from what it is in any other animal.

Bill Glovin: Well, I think that's a great place to end. Thank you so much for the article and for coming in to do the podcast, and your work is fascinating. Best of luck going forward.

Joseph LeDoux: Thank you.

Bill Glovin: This is Bill Glovin again, from the Dana Foundation. You can find Joe's article at Dana.org, and we'll see you next time. Bye bye.