# Leon Iasemidis: Understanding How the Brain Works – Bonus Episode

**Dave:** Hello, everyone, I'm Dave Norris, Chief Research and Innovation Officer at Louisiana Tech University, and this is Beyond 1894, the Louisiana Tech University podcast.

**Dave:** Now, way beyond 1894, in the year 2013, the Obama administration, through the National Science Foundation, launched the US BRAIN Initiative. BRAIN is an acronym for Brain Research through Advancing Innovative Neurotechnologies. The US BRAIN Initiative is part of the International Brain Initiative and is taking a comprehensive approach to understanding the brain, which is the most complex biological structure on Earth, probably by a lot. And despite great advances in neuroscience over the decades, there's still much we just don't understand about the brain and this BRAIN Initiative holds great promise for addressing fundamental neurobiological questions about how the brain works and how to treat it when it doesn't work.

**Dave:** But also, as we understand the brain, because it's so sophisticated, the things that we learn about how the brain works can help us in developing other innovations and technologies and other aspects of society. It's probably a consensus in the scientific community that when we do ultimately figure out comprehensively how the brain works, however long it takes us to do that, that will probably be considered the greatest scientific achievement in human history.

**Dave:** I'm here in our studio with Dr. Leon Iasemidis. He is the Rhodes Eminent Scholar Chair in Biomedical Engineering at Louisiana Tech University. He is also the director of the Center for Biomedical Engineering and Rehabilitation Science. He is a Fellow in the American Institute of Medical and Biological Engineers. He is a Fellow in the National Academy of Inventors, and he's also been nominated and selected by his international peers as a Fellow to the IEEE which is the world's largest, technical professional organization for the advancement of technology for humanity.

**Dave:** The IEEE Fellow status is the highest level of membership conferred by the IEEE, on persons with “extraordinary records of scientific accomplishments.” Dr. Iasemidis is considered one of the founders of the field of seizure prediction and control and has collaborated on this work with the Mayo Clinic, Cleveland Clinic, Barrow Neurological Institute, among others.

**Dave:** Leon, thank you for being here this morning and welcome.

**Leon:** Thank you, Davy.

**Dave:** So, your work since you started your graduate studies at the University of Michigan has been on the leading edge of neuroscience and trying to understand how the brain works. Can you give us a sense just…. What have you learned? What have we learned in the scientific community about how the brain works and what do we still need to learn? What do we not know?

**Leon:** Well, it was challenging when I started, and it is still challenging now. So, over all these years, 30 plus years, what we know about the brain we have gathered from animal experiments and from patients with diseases that need to be cured. The BRAIN Initiative, as you mentioned, was launched about eight years ago with funding for five more years and strives to understand better how the brain operates, in particular the diseased and the normal (healthy) brain. The implications of that to our life and technology are huge.

**Leon:** So, what we know up to this point is the neuronal networks, how they are constructed and how they operate at the basis at the microscopic level. But what we lack for sure, at this point, is how they operate at the global level when they coordinate to execute particular operations, either these being sensory or motor, and so on. So, there are a lot of areas that we have to concentrate on and advance. In general, I think that we are looking at a horizon of 50 years from now.

**Davy:** So, we understand at a micro level what little micro sections of the brain are doing, how they work, but then at a network or a systems scale—the whole brain—that's where we're really struggling to put all that together systematically,

**Leon:** Right. So, I would say that, structurally, what the brain consists of…, is composed of, we have a pretty good picture of. But, functionally, what kind of operations, when they coordinate, what kind of critical operations they execute, is a matter of research, especially for cognition, memory, and higher-level functions.

**Davy:** So, you made reference to things we learned from looking at a healthy brain and then things we learn, different things we learn, from looking at a brain that's not functioning normally or healthily. You're the lead scientist on the NeuroNEM project, which is a $6 million National Science Foundation funded project based here at Louisiana Tech, and it's part of the national BRAIN Initiative. Tell us about NeuroNEM and kind of where it fits. What are you working on, and where does it fit in the big picture?

**Leon:** NeuroNEM stands for Neuronal Networks in Epilepsy and Memory. And when we applied for that grant, obviously, we had some preliminary results over the years. What we were missing and we wanted to have support from NSF, the National Science Foundation, to look into, was how our macroscopic findings would correlate with microscopic findings. So, we asked for funds to look at the brain at the macroscopic level dynamically, how the macroscopic operations evolve over time. And that we would accomplish this by recordings from the brain of animals and people over time --over a long time, it would then be longitudinal data that we're going to have over days and months, continuous recordings of the electrical and magnetic activity of the brain, and relate those to concurrent microscopic recordings of molecular activity (neurotransmitters) that we would detect with special electrodes, biochemical sensors I would say, that we develop here at Louisiana Tech. This is a collaboration of three universities. We're the lead in this NeuroNEM consortium, and the other two universities are the University of Arkansas (at Little Rock) and the University of Alabama at Birmingham.

**Davy:** It’s a big medical center there in Birmingham.

**Leon:** It’s a big medical center. The other one too. As you said, Davy, these are the medical centers and they provide human data to us.

**Davy:** And we’re the engineers.

**Leon:** Yes, in particular patients with epilepsy, recordings from them (we call these electroencephalographic and magnetoencephalographic recordings) when they perform tests, (e.g. different memory tests), also when they experience seizures (epileptic seizures). About 20 faculty members in all three institutions are involved in this big project and about 40 undergraduate and graduate students. And we're on the fourth year on this grant.

**Davy:** So, just backing up a little bit. Neuroscience, neurotransmitters, neuromodulation, neurons. Early 20th century, a Spanish neuroscientist, Santiago Ramon y Cajal, draws these branching, tree-like, structures of neurons, and in 1906, he wins a Nobel Prize. It was kind of the world's first view of what these cells of the brain look like. And now we have modern microscopes, and robotics, and machine learning, and all that stuff.

**Davy:** So, we were developing this much more sophisticated image of what the brain looks like, kind of like the Human Genome Project. This, we call it the connectome or something--the map of the brain. When are we going to have a complete picture of what the brain really looks like the way we have a picture of the human genome?

**Leon:** At this point in time, in Hughes (Howard Hughes Medical Institute) laboratories, medical laboratories, as you said, they are working on the connectome for the brain of drosophila, and they are pretty sure that they will develop the complete map of about 100,000 neurons that the brain consists of in this fly in about two years (https://www.hhmi.org/news/unveiling-the-biggest-and-most-detailed-map-of-the-fly-brain-yet). Then, they're talking about….

**Davy:** So, 100,000 neurons in the brain of a fruit fly?

**Leon:** Yes.

**Davy:** How many neurons in the brain of a human?

**Leon:** 80 to 100 billion neurons.

**Davy:** That's a lot.

**Leon:** This is a lot. And I would speculate here. Things are accelerating: after they developed, and they now have in place, all the automated process with new techniques to image the different layers of the brain, which I think took them $50 million to do, it is going to be about $500 million for the next brain, which more probably is going to be the brain of the mouse.

**Davy:** We are moving up the scale.

**Leon:** Moving up the scale. And so, I would say in the next two or three decades, that will be possible. But I have to point out here that these are images, which are static. And the dynamics of the connectome are not addressed through this process, and the dynamics -- how networks collaborate over time, how they change, how they adapt -- is a bit bigger task. And that was the original pole of attraction for me in research. So, we concentrate mostly in the dynamics.

**Davy:** So, you grew up in Athens, Greece. Athens is sort of this iconic city in the history of Western civilization, birthplace of the Academy, the University Study of history and philosophy, mathematics, physics, engineering. And the remnants of all that and those characters are still in that city, and you grew up there. And so as a child, you become attached to science, to learning, to physics. How did you end up evolving from that to where you are today? How did dad feel about theoretical physics?

**Leon:** Hey, right, right. So actually, as far as I remember, it was my Mom who was always asking the question, “why,” in anything that I was telling her. And she instilled in me that question for anything that I was learning.

**Leon:** So, always physics was something that attracted me at most because I thought, and I still think, that this is the science that sets the foundation in the questions of why things are the way they are and how they work. And then biology came into place in my last year of the undergraduate studies. In Greece, there are five years of (undergraduate) engineering, and in the last year we do what we call here the senior design project. So, my senior design project had to do with speech, the human speech processing, and that was my first encounter with real biological signals. And I loved it. And I knew that combination of physics, engineering, and biology would be my best joy in life; and actually, there is the saying that you have to love what you're doing job wise so that you are happy, and I'm still happy.

**Davy:** And engineering is a little stronger path from your dad's perspective than physics. Right? Because you can get a job making more money.

**Leon:** Yeah, yeah, Dad was always concerned about...

**Davy:** Getting you off the payroll. That's dad's main job in the world, right?

**Leon:** And what he worried about was my success in life, financially too...

**Davy:** Follow your passion, but get off my payroll as quickly as possible.

**Leon:** Yeah, yeah, right. He understood my quests and curiosities, and he proposed engineering as a kind of compromise, electrical engineering in particular, because it has to do more with physics, and signals. So, yeah. I graduated with an electrical engineering degree, and then I pursued postgraduate studies in USA.

**Davy:** Tell me, tell me about…. You skipped over your movie producing career.

**Leon:** Yeah! Well, I also did have... some different, multiple interests: into music and humanities. I had a private illegal radio station at that time, in Greece. At that time all private stations were illegal, because we were in the era of the dictatorship in Greece when I was growing up.

**Davy:** So you…. Okay.

**Leon:** For some time, and then also my interests were also in movies, in cinema, directorship, and these kinds of functions….

**Davy:** Can I google any of the movies on YouTube, or Netflix, or anything I could look up?

**Leon:** Not really. Not really. At that time, I never continued along this route because I got very busy with school and I wanted to succeed (in academia). So, that took a lot of my free time.

**Davy:** But you were fascinated by human interaction, and relationships, and…?

**Leon:** Exactly

**Davy:** And that's in humanities and the movies, but it's also in the work you ended up….

**Leon:** Yeah, yeah. So you can say that I am fascinated with how neurons in the brain collaborate for a particular common goal, and then how humans do the same thing. So, I was really attracted by this, and I really wanted to see how humans communicate and what is the optimal ways to communicate right, and so, I wanted to produce movies along these lines and see how human society would be at a better stage, more happier and so on. I was intrigued by that. I wanted to produce movies along these lines.

**Davy:** So, you get from Athens, to Brown University, to Michigan, to Florida, to Arizona, to Louisiana. You have a position at Louisiana Tech that's kind of interesting. Our former president, Dan Reneau, started one of the nation's first biomedical engineering programs here at Louisiana Tech, and the University was very much identified with that. And in the process, he helped build the Research Enterprise at the university. And that biomedical engineering program was, by its nature, very interdisciplinary. And you're the director of CBERS, the Center for Biomedical Engineering and Rehab Science, and that's where the NeuroNEM project is based.

**Davy:** So, you work on some very complex science, extremely sophisticated techniques, tools. These are all difficult challenging questions that take years and years to really make progress and try to resolve. Try to boil that down to a listener and how your work on the brain impacts people's lives, people with epilepsy, people with traumatic brain injury or stroke or other neurological conditions. How is that impacting or impacts people's lives?

**Leon:** So, my personal research focuses on dynamics of the brain, and epilepsy is an ideal disorder because there are, what we call, seizures, epileptic seizures, transitions of the brain function into pathology and then recovery. So, from the right beginning, I was intrigued and attracted by the ability of the brain to recover. And of course, there are many questions (associated with this), like which area of the brain starts to become pathological (first), because this is important for treatment and diagnostic purposes, and also, over time, if we can develop a warning of an upcoming seizure. And then, what are actually seizures themselves (accomplishing)? What chemicals in the brain they produce so that the brain could recover--what we have called the resetting of the brain function. So there are questions of diagnosis and treatment. For example, if you are able to predict that it is going to be happening within the next one hour, then you have enough time to intervene.

**Davy:** In your work, you want to be able to predict when a seizure is coming before it comes and then intervene in some way that prevents that seizure.

**Leon:** Exactly. So, in modern neuroscience, you can intervene through electrical or magnetic stimulation, or you can intervene through increase of a drug dose if you have enough time, and avert a seizure from happening. So, this is called neuromodulation. So, you can modulate, mainly you are able to modulate the neuronal networks and avert their synchronization that happens much before a seizure, and then the seizure would not happen.

**Davy:** You spent a big part of your career working on epilepsy and seizures, right? And it seemed like you just described the impact of your work is relevant, certainly, for epileptic seizures. But because you're studying the brain going from normal functioning to, I think what you described as pathology, to some recovery, back to normal functioning, that process is something that's relevant for all kinds of brain conditions or functioning. Right? Because you're going from normal to pathology to recovery. So, it's not just relevant for epilepsy or seizures.

**Leon:** Yeah, yeah, so, we have to point out here that actually epilepsy, or better epileptic seizures, the pathology (of brain’s function), may be an epiphenomenon of another underlying pathology. Like epileptic seizures may develop in patients after stroke, or cancer, or traumatic brain injury. So, in that sense, any findings that we are going to find in this (research) area could be applicable to multiple other brain disorders.

**Leon:** Actually, lately, they have discovered that Alzheimer's patients experience seizures (during their sleep) that were not able to be identified before. Scientific investigations in the overlap between epilepsy and Alzheimer's, and many resources, are now started to be devoted to this new research area. So, epilepsy is so attractive as a research field as it overlaps with so many other brain disorders.

**Davy:** So you've founded, or co-founded, a couple of companies in the area of neuromodulation in an effort to help ensure that the benefits of your work get out into the commercial market and impact people's quality of life and health. You've co-authored four awarded, one pending, nine provisional patents. I may not have all those numbers right, but there's a lot of intellectual property generated around this, and your goal is to help get that out into the commercial market. Tell us a little bit about the products or methods that you hope to get out into the commercial market from your work.

**Leon:** Yeah, two main products at this point. One has to do with prediction, well ahead of seizures onset. So, it is a software that works by analyzing signals from the brain, electrical signals like EEG, or magnetic signals like MEG, and it gives warning of an impending seizure. The second product is also a software, a diagnostic software, that can diagnose where the focus, what we call the epileptogenic focus, is, that is the area of the brain that is responsible for the pathology and the development of seizures; to be able to localize this region in the brain, ideally by noninvasive recordings, like magnetoencephalography, and without a patient having seizures, without the patient having to have seizures, that is, during the seizure free periods, is very challenging.

**Davy:** So, the idea is a noninvasive method that identifies where a seizure is coming from in the brain without having to have a seizure.

**Leon:** Yes.

**Davy:** And the alternative is…. The alternative to that is…

**Leon:** The alternative to that is….

**Davy:** deep penetration into the brain with a neuro stimulator or some kind of sensor, and you have to have a seizure.

**Leon:** Right. So, as you said, the alternative is for the patient to be in what we call epilepsy monitoring unit for one week and have seizures, a couple of (their) typical seizures, and the doctors would see which region of the brain is leading the discharges. And the other alternative is to implant a neurostimulator, which, as you said, (nowadays) is not only a stimulator but usually also a sensor, and that would be a long term with capability of recording. Also….

**Davy:** That goes down into the brain.

**Leon:** It goes into the brain and stays there for months or years. And, in this case, you do have a lot of data (collected) from the patient, and you can identify, hopefully, where the focus is. And this is very important (information) because you could then (reliably) remove the focus by surgery. And the surgeon should really know where the focus is, which could be different (region) per patient, in order to remove it, and ideally also know the network of the focus, as we call it, the epileptogenic network. These are important diagnostic questions and (together with) the seizure prediction very important parts of (prospective) treatments.

**Davy:** So you also have a lot of interaction with students, and you teach classes somehow...

**Leon:** Yes, yes.

**Davy:** in between all this. I heard that you were recently selected by the students for a very prestigious award related to your teaching. Can you tell me, tell us all, just a little bit about that?

**Leon:** Yeah, yeah. So, I teach undergraduate and graduate courses, and a few weeks ago, I got a surprise. The Alpha Eta Mu Beta Society of Biomedical Engineering students, which is a national biomedical engineering society that actually our former University President, Dan Reneau, helped establish and served as its first president. And that was about 1979….

**Davy:** This is one of the oldest student organizations on campus.

**Leon:** Right. That was 1979. The oldest biomedical engineering society too. So, it is now 51 years (young). They do have annual galas and, at the latest one, they surprised me with an award, and the award was...

**Davy:**  Very, very prestigious.

**Leon:** Most Likely to Keep You in Class Late.

**Davy:** Most likely to talk too long in the lecture. Okay, most likely to keep you in class late.

**Leon:** Which is true. I really like the students to be… to give the students as much material and knowledge as possible. Usually, 15 minutes over time -☺.

**Davy:** That's no problem. There’s plenty of time. Now, is that because you're not watching the clock? Or is it because you're just too into it and you just keep on keep on going? Do you know you're going over time?

**Leon:** Yes, I do. I have warned them. One of the first questions I ask when the course starts is, “Okay, who has another class after this one?”

**Davy:** Because you might be late.

**Leon:** Accordingly, I decide how many minutes I would be.

**Davy:** Well, on the Beyond 1894 podcast, we do not go over time, and so we're gonna wrap this up. And, greatly appreciate you taking the time to come talk to us. Thank you for all the work that you do, for the work you do with our students, and the impact you're having on people's lives. Thanks for being with us.

**Leon:** Thank you. You're welcome.

**Amy:** Thank you for listening to this episode of Beyond 1894. If you liked what you heard, please rate and review us. It will help others find our podcast. If you would like to learn more about today's guest or find details about the episode, check out our show notes. To find our podcast webpage, go to 1894.latech.edu/beyond. If you have suggestions for future episodes, email us at 1894@latech.edu. We would love your input, so tell us what you want to hear!

**Amy:** Beyond 1894 is produced by the Office of University Communications, with help from The Waggoner Center and The School of Music, at Louisiana Tech University. Dave Norris is the executive producer. I, Amy Bell, am the producer and chief editor, and the music featured was arranged by Kaelis Ash.