Introduction to Dr. Ryan Neely and Elemind

Hello, everyone. It's Dr. Wells again. You're host of the Sleep Deep Summit, New Approaches to beating sleep apnea and insomnia for our next speaker. I have a lot of excitement.

I'm going to introduce you to Dr. Ryan Neely. He is the vice president of science and research at a company called Elemind And they develop neurotechnology to induce drug like effects on the brain.

But without ingestion of any chemicals or side effects. Dr. Neely studied neuroscience at Harvard and the University of California, Berkeley. He developed new technologies for brain machine interfaces, and he's now turned his attention to leveraging noninvasive neurotechnology to improve both the quantity and the quality of sleep.

He's the author of numerous scientific publications and an inventor on ten patents. Welcome, Dr. Neely. Thank you. Thank you for that introduction. It's great to be here talking with you.

Yeah, that's great. And, you know, I think before we get started, what I want to do is start off with having you define Neuromodulation and specifically what Acoustic Neuromodulation means.

Sure. That's a great question and something that's really exciting for me. So I've been working kind of in the field of Neuromodulation for several years now, and this term can really encompass a lot of things.

I think, you know, maybe Neuromodulation as a clinical concept goes all the way back to maybe the sixties with this idea of kind of doing spinal cord stimulation.

What Neuromodulation and Acoustic Neuromodulation Mean

There are things like deep brain stimulation, which are used for conditions like Parkinson's disease. But really, you know, the concept is using some kind of stimulus to affect the nervous system, whether it's the brain or the peripheral nerves, and kind of modifying the electrical activity of the nervous system to accomplish a goal.

So, for example, in the case of deep brain stimulation, trying to reduce these sort of pathological effects that occur in Parkinson's disease, or maybe in the case of things like spinal cord stimulation, you're really you're trying to interrupt these pain signals that are associated with chronic pain.

And, you know, one way to do this would be sort of with an electrical stimulation because, you know, the language of the brain in the nervous system is electricity.

But this can sort of be a really sledgehammer approach to doing things. Essentially, you're you're just kind of shocking the nerves and getting them to do something different, interrupting signals or creating new signals in something that that's really been interesting to me, especially recently, is kind of new approaches to doing Neuromodulation.

So how can we sort of change the activity of the nervous system in a way that's not so? I guess, you know, invasive and sort of potent doing something a little bit more nuanced.

And so you bring up this concept of acoustic neuromodulation, which is something that I'm I'm currently working on at mind, which is, you know, using sounds to create signals in the brain that interact with kind of this ongoing neural activity that in such a way to kind of, you know, nudge the brain into a certain state and we can get into kind of how that how that works in a little bit.

But that's really the concept, which is you know, any sort of sensory stimulus that you observe, whether it's a flash of light or a pulse of sound that is going to create its own sort of like ripple, if you will, in your neural activity.

And it's really timing those ripples in such a way that influence the ongoing brain waves. And again, we can kind of dig into that a little bit later, but that's that's the basic concept.

So interesting. And one thing that comes to my mind is the effect that music has on the brain. An analogy that I like to make with sleep and wake states and the circadian rhythm is that there's lots of influence ideas for sleep and wake, and different parts of the brain are like the different instruments in a symphony, and you kind of want things to come in at the same at their cue play at a certain volume to make the music predictable, to make it sound pleasing and you know, I wonder when you talk about Neuromodulation, to me that indicates a bi directional signal.

So the neuromodulator is taking in some kind of stimulus and then coaxing that brain wave or a set of brainwaves as an output. Do I have that right? Yeah.

So that's exactly right. And the way we kind of describe that is, is it's a closed loop system. And so you can do neuromodulation with an open loop system.

Closed-Loop Brain Sensing for Sleep Detection

And this is kind of like the examples I was talking for with this deep brain stimulation where you're just sort of driving a signal into the brain and it has its effects.

But it's, you know, it's a one way system. So the type of neuromodulation that that we're currently working on is a closed loop system in which we're reading the activity of the brain, and then we're responding to it with this acoustic stimulus.

And and that's really that's really key for for this this to work, because we need to understand the state of the brain in order to deliver the stimuli at the right time to really have the effect that we want to have.

That makes sense. And you're sort of alluding to a device, some sort of detector. Can you describe that? Yeah, exactly. So so this is something that it's been in development for a while now.

You know, initially it kind of started out it's this kind of bulky box that sat on a desk. But we are kind of proving out the concept. But we've over the years kind of iterated this into a wearable headband.

So it's a design for sleep. So it's a soft fabric headband. And we've managed to to pack all of the sensors and electronics into this system that you can wear and sleep with and, you know, it's comfortable because obviously don't want to interfere with sleep.

That's very important. And so, yeah, it's a that's what it is. It's it's like a portable headboard wearable device. That sounds really accessible. I've seen some had been like devices out there.

I'm wondering with the Elemind device, what sort of sleep signals are detected? How does that look and how do you differentiate between sleep and wakefulness?

Yeah, really, really interesting question. So let's kind of take a step back maybe and talk a little bit about what we look at in the brain when we're we're looking at sleep signals.

So, you know, I think there's a lot of sort of mysteries about about sleep, you know, what is it for? What are the biological functions? But we do know a lot about sleep and some of the physiology that that takes place when you're asleep.

And it and certainly it's a full body process, but really that's orchestrated by the brain. To kind of go back to your analogy here in the brain is the one that's kind of driving this process, deciding when sleep begins, perpetuating

sleep, and then also deciding when sleep ends.

And, you know, it's true that you can sort of you maybe a smartwatch or smart ring or smart device that that can sort of guess at sleep states based on how much you're moving around or whatnot.

But really, to understand what's happening during sleep, you have to look at the brain. And so, you know, sort of in the scientific community, when we discuss different sleep states, it's really about like what are these brain signals?

And, you know, one thing that that happens as you fall asleep is essentially, you know, during wakefulness, you have all this ongoing brain activity. And essentially the way we detect it is, is especially from outside the head sensors that are measuring what will be called brain waves.

So it's essentially changes in voltage and they sort of oscillate at a certain frequency. And I just want to interrupt you here. And you're talking about the EEG sensors.

Correct? Yeah. I think anybody out there who's had a sleep study remembers all of the sensors placed on their head and on their scalp. So that was the EEG.

And those are detecting brainwaves. Yeah, exactly. And if you've ever seen them, you might have seen a picture of somebody wearing what looks like a swim cap with all these wires coming up over.

That's kind of the classic setup. And so what they're measuring is exactly, you know, all these neurons sort of changing their voltage together and creating these brainwaves.

And that's kind of what we're measuring. And so sort of talk in generalizations, you know, during wakefulness, you have a lot of very fast brainwaves.

They're they're moving very quickly, maybe up to 100 times a second. And as you fall asleep, you sort of get this slowing of brain activity. So now, you know, instead of 40, 40 cycles per second, those neurons are creating brain waves that, you know, maybe on the once per second or even once every couple of seconds and really deep sleep.

And so so that's really the signals that we're measuring. And one of the things that we're particularly interested in is this type of signal in the alpha range.

So it basically ten cycles per second and this is something that's present and is really visible as you close your eyes and you're sort of falling asleep.

You have this alpha signal, but then as you kind of drift into sleep, it kind of dissipates, except for in some cases of insomnia, where this signal is especially strong and then persist throughout the night.

And then there's actually been studies that have shown when this signal is stronger during the middle of the night, the person is much more easily woken up by a sound or a light.

And so really we decided to focus on the signal and to kind of come back to your original question is how can we detect when somebody is, you know, sort of awake or drowsy?

How Elemind Uses Sound to Reduce Wakefulness

And it's really looking at these ratios of these faster signals, these slower signals, and that really does a great job of predicting how asleep somebody is, is this ratio between like the we call it the high frequency, activating the low frequency activity.

And so if you can kind of measure how much that the brain is slowing in sort of a really simple, simplified way, you can kind of tell how how sleepy somebody is.

And so you can kind of build a machine learning classifier that can get look at these signals and determine if someone is, you know, kind of ruminating, you know, very awake, call it like a blazing alpha, a very strong or if they're kind of drifting off to sleep into this kind of half awake, half asleep state.

So interesting. You know, I'm picturing kind of a spectrum where you have deep sleep on one end with the massive delta waves synchronized and slow and then alert, maybe even hyper vigilant on the other end.

Right. And what you're describing is being able to quantify the brain's state of alertness in between those points and almost report objectively where a person is on that spectrum.

Yeah, exactly. Yeah. And it's and I think I think it's important to do that. It's not just sort of a curiosity. I think that when you're talking about doing Neuromodulation, especially the kind of responsive kind of closed loop Neuromodulation that that you you are asking about, it's really important to know the state of the person in their kind of sleep sleep journey because, you know, early on as they're trying to fall asleep, but you really want to see is this attenuation of this high frequency activity, the sort of very alert signals.

And as they get deeper into sleep, you brought up these delta waves, these slow waves, which are really associated with this deep restorative sleep. Maybe in that stage, the Neuromodulation should be focused on enhancing that slow wave sleep, and you really want to target those really slow signals.

And so you're kind of understanding the state of the brain throughout the sleep cycle is is really important for doing these things in sort of an intelligent kind of guided way.

Right, right. And you mentioned the sort of sledgehammer approach of doing a deep brain stimulator like hitting the the nervous system with electricity, which is one sided medications, induce different effects for the brain.

I think that's another sort of crude tool that we have in order to influence sleep or wake states. Yeah. Can you describe how the mind is not only assessing where the person's state of alertness is, but then working to kind of enhance that or shifted to a more desirable place?

Yeah, absolutely. So. So, yeah. I'm glad you brought up a pharmaceutical approach, which, you know, certainly certainly works well for for a lot of people, but a lot of people it doesn't work well for.

And there are a lot of side effects associated with that. And I think I think the reason for that is, is, you know, there's essentially a temporal component and a spatial component.

So when you when you take a medication, it really kind of goes everywhere in the body. It's especially a pill. You digest it, it's going everywhere. And, you know, for example, one popular over-the-counter sleep medication, diphenhydramine ingredient, Benadryl, which of course, like effects can be used for your allergies.

It can help you sleep. You know, there's all these numerous side effects. Um, and then, and then the second piece is that the time component? So, you know, drugs are really, they're digested over time.

It's sort of an hours long thing and it's not very responsive to kind of the state of the person. It's like you've taken this medication, it's going to have its effects, it's going to wear off.

And, you know, you're just kind of along for the ride. And what we've done here at mind is really kind of develop a system that is is responsive to the brain state in real time.

And let me just kind of describe how that works. So the device the device we built and this is talk to you a little bit about the results of a clinical study that we've recently completed called the Sleep Study.

It was registered on clinical trial psychologists. If you'd like to read a little bit about it currently that those results are in peer review so will be published soon.

We have another paper that actually just came out this morning about the device itself, and that's in the Journal of Neural Engineering. Anyways, the way it works is that you, when you put on the headband to go to sleep, first thing that it's doing is is reading the brainwaves that are being produced by your brain.

It has EEG sensors in the forehead and then some sort of the mastoid burns behind the ears. And what we're doing is we're we're looking for that alpha signal that this sort of wakefulness signal that that's really associated with, you know, this kind of alert state. And it's basically locking on to that signal.

And when I say locking on, I mean, it's this if you imagine sort of a wave pattern, it's detecting where that wave is, is it is upstate, is downstate.

And it's reading that 250 times per second. And then what it's doing is every time that wave is in an upstate, it's delivering a sound pulse. And this is delivered through a bone conduction driver.

So, you know, to wear headphones that might interfere with your sleep and if you remember what I said sort of at the beginning in discussion, is that each of these kind of sound pulses is like a ripple, if you can imagine if you go with this metaphor of waves and what we have is this ongoing wave, alpha wave that we would like to reduce and we're delivering these little ripples and they're meant to collide with that wave.

So these little sound pulses are sort of trying to cancel out that alpha power wave because in reduce this sort of wakefulness signal. And what we saw in the study, which is a randomized study, four people either wore the headband and it just recorded passively or delivered these sound stimuli as it during the week where participants were received this sound stimulation, they fell asleep significantly faster.

So then we could controlled for all these different factors like day of the week, you know, order of sham or stimulation. But what we really saw was that it was the stimulation nights people found fell asleep significantly faster, about 30%.

And the other key piece of this was it. It was more consistent.

Safety, Personal Experience, and Wearable Design

So not only were they following it faster, but the sort of time to fall asleep was more consistent from night to night. And I think that's important for a lot of people who suffer with sleep disorders is, you know, you just you go to bed and you're not really sure.

You're not really sure. Is it going to be hard to fall asleep? Tonight is going to be easy. And I think that that sort of anxiety can almost be self-defeating.

And so I think this this consistency piece is really something that I'm very excited about. And I think that's a good a good sign. That would be a phenomenal application.

I work with people all the time who have lost trust in their sleep because when it's time for them to finally close their eyes and relax, sleep is not dependable.

So there's like a decoupling of what should happen and what you want to happen. And it's incredibly frustrating, which all by itself is not compatible with sleep.

So it becomes this this sort of downward spiral into chronic insomnia. This is really exciting. You you mentioned, you know, the side effects with medications, which can be numerous, you can get paradoxical effects.

You can get you know, there is suspicion now that some of the prescribed sleep aids, if used chronically, will lead to cognitive decline over time. When you talk about acoustic neuromodulation and massaging the brainwaves into a non alpha state to promote sleep, I'm wondering if there are any reported side effects or adverse events reported by the people that are using this LMI device.

Yeah. Yeah, this is this is important to us because it's something that we really were targeting at the onset of this trial, was providing something that as an alternative to sleep aids because, you know, for a lot of people, the side effects are an issue.

You know, certainly there are some conditions that prevent people from from using sleep AIDS. People in recovery from addiction, for example, usually are advised not to to take sleep AIDS.

There's some other conditions as well. And yeah, I mean, throughout this trial, we have done also numerous pilot studies as well. We have a number of collaborators at universities around the world using this device.

And and throughout all of these studies, we we have never had a report of an adverse event related to the Neuromodulation, you know, sort of persistent effects.

And I think this is kind of related to this temporal precision concept that we were discussing, is that, you know, when you when you turn it off, you take it off, it's done like it's not it's not influencing you anymore.

It's know, you can you can stop it immediately and it stops having its effect. And actually, this is related to one of the question you ask is how do we know when someone is awake or asleep?

And that's exactly how we we kind of tailor off the situation as we're measuring the person, as they're falling asleep or reading their brain activity.

And as soon as we detect, you know, they've entered sleep, we turn off the stimulation. So it's really designed not to sort of continue on into the morning, but something anything like that.

So that that was really one of the design focuses that we had was really to to make sure that there wouldn't be any sort of negative effects or lasting side effects.

And it makes sense because, you know, the acoustic part of acoustic or modulation is sound. So you're using these sound waves to to create an anti alpha wave response and promote sleep.

Right. I'm curious to know if you have slept with the online device and if you could just walk us through what that's like and what your experience was.

Yeah. So, yeah, it's so it was something that I did when I first joined the team. We kind of met, met up and it had a session. I wore one of the early prototypes and it's really interesting.

Like it's hard to kind of describe and I think people describe it different ways and you know, it you sort of lying there and it starts to kick on. And I think as sort of a neuroscientist, I was I was like really interested to see when it would detect me falling asleep and turn off and things like that.

But yeah, it's sort of a, you know, we've designed kind of a sound stimuli that's sort of a brain type sound and kind of lying there listening to the sounds and then the you can hear the stimuli in time with your own brain activity because it's reading it out and it's, you know, delivering these little parts.

And yeah, it just kind of, I think personally I found it a little bit hypnotic in a way. I think that that was my experience, but bring my experience it a little bit differently because it is tailored to sort of your own brain activity.

But yeah, I mean, it was really it was really nice. I fell asleep pretty fast and I actually tend to fall asleep fast in general. But but I think I fell asleep extra fast that particular night.

And yeah, I mean, I think using the device everyone in our team has been using and I think that's really helped us to really make sure that it works well and it is comfortable.

I think that's really a big goal for us, as is the comfort piece, because, you know, you don't want to wear something

uncomfortable while you're sleeping.

But yeah, it's really exciting to kind of see this technology kind of come together in something that can be put on your head. Because, as you mentioned, you know, in all the work that I've done before, EEG has been this big swim cap with many wires all over the place and, you know, connected to a big machine and a computer in a laboratory.

And to kind of, you know, we're at this place now with technology to kind of bring these elements into something that that is wearable in a comfort level.

And you can use it in your home.

Comparing Elemind with Consumer Sleep Trackers

And it has a smartphone app that you use to control the system and kind of look at the brain data from your native sleep and get some analysis there. It's pretty exciting.

It really feels futuristic. It sounds futuristic. And, you know, this this is kind of an exciting time because as sleep is kind of elevated into the conversation as necessary for health critical for your brain and so important for your body, your immune system and your longevity.

Wearables and miracles are giving us feedback, right, about, you know, where are we on the scale between health and sickness. I wonder if you can maybe do some comparison to the wearable devices that are consumer available right now watches, rings and the like.

How does l.a. Mind measure up? Okay, yeah, yeah. That's a great question because i think as you mentioned this, I think the sleep tracking space is really exploding right now as people understand how important this is for health in a number of conditions.

Just to make a little aside here, that I think I think every major psychiatric disorder has an association with sleep disturbance, Alzheimer's disease, schizophrenia, depression.

All of these things are associated with sleep disturbance. And it's probably this bi directional push and pull where, you know, one thing is sort of causing sleep disturbances, but the sleep disturbances are making that that thing worse. And I think people are really appreciating this now and understanding like, hey, I really want to understand my how my sleep is.

Is it good enough? You know, I think that's really pushed a lot of people towards these wearable devices. And, you know, I think there have been studies that have looked at most of a lot of consumer wearable devices, especially comparing them to what's considered the gold standard, which is a polysomnography system.

And I think you describe this for, you know, if you've ever if any of your listeners have been hooked up to this, it's, you know, electrodes on your head and chin and there's an EKG to measure heart rate and sometimes on the legs to measure, you know, movement of your legs, etc..

And, you know, I think the wearables do an okay job at sort of giving you like a sort of rough sketch of your sleep. But again, this is sort of making an educated guess about your sleep based on how much you're moving or maybe changes in your heart rate.

But but as I said before, sleep is really orchestrated by the brain. And, you know, the way the way you sort of analyze sleep is from the brain signals.

This is how sleep stages are defined or defined by what is the brain look like throughout these different stages. So that's why we've built a system that does have an EEG set of EEG electrodes built in.

And we also measure movement and heart rate to sort of make that tracking even even more precise. But it's really about the brain signals. And it's not just, you know, the sleep stages that that we're interested in, you know, if you're familiar with them, of course you are.

But and one and two and three REM sleep or sort of the dream state, we can do a really good job of telling when the person is in the States, but but also looking at the micro structure of sleep.

So there's some really interesting brain activity that that we can pick up during sleep that that goes beyond these sleep stages. And I'm talking about things like sleep spindles.

So these are associated with memory formation. So when your cortex is talking to your hippocampus in a hippocampus where short term memories are formed and kept for a short amount of time, and then there's this transference where they sort of become encoded as long term memories.

And there's this this crosstalk between the cortex and the hippocampus so that we can detect in the forms of these sleep spindles. And this is like a really characteristic of 1 to 1 to 4/2 bursts of activity, and we can pick those up and see how many you're having throughout the night and other things like that.

And I think really gives you this rich understanding of, of sleep and the processes that are occurring and that that's kind of why we, we really focus on getting a good EEG signal from from our device.

And this has gone through a lot of iteration, making sure that's a clean signal that we can really give this this like, you know, like I said, really rich understanding of sleep through these signals.

Fantastic. You know, the the wearable devices, the the most accurate ones on the market right now are only about 70% accurate. And they tend to be better at, you know, determining when somebody fell asleep and when somebody woke up.

But the things in between are kind of a moving target, I'll say. And I think things will get better over time. But to your point, they are not measuring brainwaves, which is how we understand the different stages of sleep.

Yeah. Yeah. And I think also, too, I mean, in conditions like sleep apnea, where, you know, one of the issues that those patients struggle with is this kind of fragmentation of sleep.

And, you know, if you kind of look at the brain signals, what's happening is that they're during these obstruction events, they sort of the brain sort of wakes up enough to to clear the obstruction.

And that's associated with these like transient kind of bursts of high frequency activity that that you can detect and you can measure fragmentation that way.

But you really need to look at what's going on in the brain to see that. I couldn't agree more. And I'll tell you that one of my areas of interest is obstructive sleep apnea in women.

When I look at the sleep studies for women and I'm talking about sleep studies done in a sleep lab where the EEG sensors are applied, oftentimes I'll see a very low threshold for arousal from sleep with a relatively small reduction in breathing.

In other words, women tend to wake up out of sleep much more easily compared to, you know, men in with similar characteristics and such.

Sleep Phenotypes, Apnea, and Personalized Treatment

So I think there's a there's probably a different phenotype that women have for obstructive sleep apnea, that kind of circles in more symptoms, symptoms of insomnia or light sleep or broken sleep, that's not really appreciated in the way that we measure sleep apnea currently.

So anything that's going to have more sensitivity to sleep quality as we also detect breathing events I think will serve women and people who have low arousal thresholds.

Yeah. Yeah, I totally agree. And I think you brought up this different different phenotypes. And that's something that's really I think, under underexplored in the sleep space for insomniacs.

I, I think there was a study in The Lancet a couple years ago where they they did this huge meta analysis of all these individuals with sleep, with insomnia symptoms or diagnosed insomnia.

And, you know, through this complicated analysis, they said, I think there's actually I think I think it was five different. We can classify five different types of insomnia and it's you sort of bucket these people into sort of one one bucket.

But there's really many different reasons that people might have had these symptoms. And I think, you know, in my my opinion, I think being able to really dig into these detailed brain signals because, you know, if the brain is typically the one orchestrating this event, you know, how do we can we look into the brain and really understand, like, might might this be someone who benefits from a certain intervention and this person might benefit from a separate intervention?

And being able to kind of help people make those decisions, I think would be really, really powerful. I love it. Any any way that we can personalize the approach to people's needs and disorders, I think is a real advance for medicine.

Ryan, it's been a pleasure to speak to you. And I wonder if you can tell people where to go if they want to learn more about Elemind. Yeah, absolutely.

So so, you know, we're we're currently working on this this device that I've been talking about.

Where to Learn More About Elemind

And you can learn more at elemindtech.com is our website and you can sign up for any sort of news. And as I mentioned, we just had a paper published today in the Journal of Neuroengineering.

And if you really want to get into the details of the technology and the algorithms that we're using, please check that out. And I also want to mention again that you mentioned that you said the Sleep Fast study was available at clinicaltrials.gov So.

Correct, that's another source for people to look at. Yep. And as I mentioned that the results are written up in there in peer review and I hope to have that out soon.

Fantastic. Well, it's been a pleasure to speak to you. Thanks for letting us know about this great new technology. Absolutely. Have a great time. Thank you.