AI and You

Transcript

Guest: Olav Krigolson

Episode 66

First Aired: Monday, September 20, 2021

Welcome to episode 66! We are going to finish the interview with Olav Krigolson today. He is a neuroscientist at the University of Victoria, where he runs the Theoretical and Applied Neuroscience Laboratory. He has developed a unique mobile electroencephalography (EEG) system to investigate what's happening in our brains when we're tired, stressed, oxygen-deprived, struggling with dementia, concussed—or on Mars. We heard last time how Olav has worked at the HI-SEAS habitat that simulates a Mars encampment to observe useful and potentially life-saving information about astronauts' brains. And we heard some about brainwaves. I met Olav when he was speaking at a TEDx in British Columbia, the year after I spoke there, and you can catch his TEDx talk, Bringing Neuroscience Outside the Lab, on YouTube. Now we're going to hear more about the state of the art in brain-computer interfaces as we get back to the interview.

Do you think that you will personally see, at any point, a model of the human brain, human cognition system, that goes all the way from synaptic gap to "pawn to king 4"?

I hope so. And definitely, people are rushing in that direction. The Google DeepMind project, right now, it's very good at Go and a couple other things. But it's sort of the Holy Grail, if you will, which is if you could build a good mathematical simulation of the human brain, there are so many questions you could answer. And, of course, this is where people start to get scared, because, you know, "What is it? What if it takes over? What if it's smarter than what we do?"

Right.

I do think so. It's an interesting field because, in some areas of science, I feel like we've plateaued a bit. If you look at flight, there was this period where the improvements in airplanes was massive. And then it's, you know, every year there's a new, exciting plane, but I don't think the rate of change is the same as it was when you went from the Wright brothers to what came next. And I'd say in this area of neuroscience, we're still in that rapid increase. We're still accelerating rapidly. If anything, I think the acceleration is picking up because more and more people are entering this area, and there are more cool projects going on. So I hope so.

And one of the things about progress is that when another field of technology advances to the point where it starts overlapping this one, then you get the synergy that enables it. So for instance, artificial intelligence is already enabling synergy with neuroscience because you can use deep learning to analyze EEGs and tell you things that would be much harder to figure out any other way. Now, are there fields aside from artificial intelligence, where you're looking at the possibility of development in those apparently unrelated fields, giving you capabilities in neuroscience you didn't have?

Yeah, I think this is a really important point because when I started out, the assumption is you were an all-in-one unit, and you just did everything you needed to do. I think these fields are so complex now that it's a collaboration. So yeah, we've worked a lot with mathematicians and statisticians, a lot with computer scientists, a lot with psychologists. Those are probably the key areas of collaboration. We also talk a lot with economists mostly because economists have given us a lot of theory about how people make decisions in my area. And the question is, "Is it right or not?" We've all heard about rational choice theory and loss aversion and things like this. And we know these are true given human behavior, but part of it is how does it work in the brain and what drives it? And then if you get on the AI side, which is how do you simulate it, and how do you capture that phenomenon? So yeah, multidisciplinary is definitely the future, obviously, anything in the medical space, which overlines with the neuroscience and the brain piece. Haven't gone much further afield than that, but it's definitely an area where there is a lot of collaboration. But the tech I do also spills out into other fields, which is I've been working on a project with our local school district because they're very interested in monitoring learning in the classroom, which you would argue is a collaboration with social sciences to some extent. So I think that's sort of the way ahead is these sort of multidisciplinary teams solving problems.

And one of the things that's on fire at the moment is synthetic genomics and protein synthesis and things like that. Do those fields have any overlap with neuroscience?

They do but that would be the building block end of it. Neuroscience is separated into sort of a hierarchy, which is cellular systems and what I call cognitive neuroscience. The cellular type people are probably very excited about that kind of stuff and then what it means for neural function at that level. I can honestly say, I haven't thought a lot about how it impacts stuff at my end of the spectrum. I know it does. If you change neural function at a basic level, it's going to change what happens with what we measure, but it's just a question of… yeah.

Right. That's like me as a software person saying, "I'm not a hardware guy. I don't want to touch the hardware. Never was any good at that." You were talking earlier about zapping your brain with TMS and producing some effects that no one would want. Can you go the other direction - hack the brain to produce beneficial effects in any way, maybe not so much with TMS except if you've got some pathology that that's the best solution to? But for people interested in improving their brain performance, is that a thing?

It is. There's technology like tDCS, where they're basically pushing an electrical voltage through the brain.

What does tDCS stand for?

Direct current stimulation. And there's also tACS, alternating current stimulation. So one of the cooler papers I've seen, which was in my area, which is they're basically turning your head into a battery in a sense - they had a current going in on the bottom and current coming out on the top. And they were measuring learning signals in the brain, which is what I do, one of the things we do, and they found that when the current was flowing, the learning signals were bigger than when the current wasn't flowing. But what was very interesting is they found performance benefits after the fact. So the people, when the stimulation was on, had learned more than the people when the stimulation was off. Now, that's one study. The replication needs to be done extensively. But there are definitely people that believe that that kind of tech is beneficial.

Our listeners can't see the faces I'm making when you've said things like zapping your brain or turning the brain into a battery. We should probably issue some sort of qualification before you got a lot of emails from people asking how to electrify their brain to get a better score on the SAT. Do you want to modify that?

I definitely do. So, first of all, you need a very specific device. So you can't just run out and get a battery and have this happen. You actually need a machine that's designed to do this. And these machines are medical grade and need to be purchased. Believe it or not, some of these devices are commercially available but you don't want to do it yourself. The other thing to remember is these are extremely low voltages and low currents. You can't play around with this stuff. It's kind of like they say in the ads, don't do this at home.

That's exactly what I was about to say. This is the point in the podcast where I haven't had to say it before, but now I will: Don't try this at home folks.

Yeah, but like I said with the TMS, there are people that are using these things clinically. The EEG versions, which is the direct current stimulation and the alternating current stimulation. These are sort of in their just the very infancy stages, whereas using TMS to treat depression is quite a well-established practice. Basically, they use the TMS pulse, and they provide a treatment regime. They believe if they fire the pulse at a certain frequency in a certain position, it helps with depression. There is scientific research to back that. Not everyone's doing it because it's an expensive technology in its newer stages, but there are medical doctors and clinical neuropsychologists that use this as a treatment protocol.

Wow. Let's jump from that to prostheses. Most parts of the body, you can get a prosthetic replacement for - the hand, like Luke Skywalker, the heart even. A whole brain, that's a whole different, other topic. But where does neuroscience stand with respect to the development of prosthetics for the brain?

Well, there are two things that jump to mind. There is using the brain to control prosthetics, which is an exciting line of research, and then there's also putting implants into the brain to do things. So one of the ones that's gained a bit of momentum and a bit of press, in terms of the latter, is using deep brain stimulation. So one area where I've seen it used quite a bit is with Parkinson's disease. So the idea is you insert essentially, it's a form of a pacemaker, it basically fires-- The whole goal is to regularize the brain functions. So the brain function is erratic and by firing an electrical signal - and this is deep within the brain, not from the surface - you can sort of regulate brain function. And there are some fascinating videos you can find on this treatment with Parkinson's patients, whereas prior to the stimulation being turned on -- so they put the implant in, and then they can control it externally, if you will. And when the implant is in, and the stimulation is not on, the person has sort of the gait pattern you might expect with Parkinson's, they're shuffling a little bit, there's tremor, you can see the limbs vibrating. And then they turn on the stimulation and the tremor goes away and the person starts walking normally. Now, it's not a cure for Parkinson's disease. Every time I talk about this tech, I have to emphasize that it does not cure Parkinson's disease; it helps with the symptoms. But the idea is you can improve quality of life for these people. So you can't stop the progress of Parkinson's disease, but you can improve quality of life. And that's the one I'm most familiar with. But there are other people that are looking, you know, there are people that are imposing EEG electrodes deep into the brain to pull signals. So there's sort of these kinds of technologies like the deep brain stimulation, where they're actually actively modifying brain function. And then there's this other range of technologies, which are more listening technologies, whereas electrodes within the brain will get you the most accurate EEG signal you can get. You get so much signal loss by putting electrodes on the surface, that if you can measure directly, you're going to get a more accurate measurement.

And I think we all know the sort of things that Elon Musk has been saying in this department about Neuralink, he's very good at raising money, attention, and getting people to work for him. There is an idea out of philosophy that predates many of the things we've been talking about, called the Extended Mind Hypothesis, which holds that any device that forms part of our cognitive processes, or part of our act of cognition, should be considered to be part of our mind. And this predated computers to the extent that the examples that they were using were telephone books, notepads, and things like that. It's a lot easier to see in something like a smartphone that we can't do without and that we use for things like figuring out how to get from point A to point B. The sort of thing that we're talking about here would be held by the originators of that hypothesis, Clark and Chalmers, to be extending the mind further through the types of hardware that we're using, which don't have to be hardwired into the brain any more than our cell phone is. But do you foresee something further down the road that Neuralink would like to go, where we are hooked up to some kind of implant that is there expressly for giving us a direct brain-computer interface connection to improve our ability to do that kind of thing?

I guarantee it's going to happen. I would be shocked if it doesn't. The brain-computer interface world is really interesting and exciting in a lot of ways. In my lab, we have a little Lego robot you can drive with your brainwaves. So you just have to think that you want it to go forward and it goes forward, but it's very rough control. You can basically make it go forward and back. You can't make it start doing figure-eights. The EEG signal just isn't that accurate, although people are working on that specific problem. The key to EEG for these things is getting the cleanest signal possible. EEG is inherently noisy, which is why it's not great at control signals or why it's hard to use it in a lot of other ways. So by putting those anything in the brain and on the tissue, you want to measure, you're going to get the cleanest data possible, which means your control gets better. So as opposed to making the robot go back and forth, you might be able to do those figure eights and do whatever else.

Okay, engineer question time. How much of the noise in an EEG signal is attributable to system noise, actual noise, like temperature in the circuits versus things that the brain is doing on purpose, but we don't understand them?

It's a bit of both. I hate to sit on the fence but with the low-cost systems we work with, the mobile systems, a lot of the noise is from the hardware itself. The reality is, if you buy a $250 headband, you're not going to have the same quality as if you buy a $100,000 research-grade system. So on the lower end of the spectrum, a lot of the noise is due to the system itself. In terms of the brain, one of the problems with EEG is that the signal propagates instantaneously across the brain. So just because you, say, have a sensor on your forehead, and you see a lot of activity there, it doesn't mean that the brain region right underneath that is the one that's firing the most. It could be somewhere in the back of the head and it's just the way the signal propagates. So by getting inside the brain, you're reducing that a little bit because you would presumably be measuring from the neural tissue where the activity is actually happening. Now, you're still going to be impacted by that other signal that's coming through, but in principle, it should help solve that problem a little bit more. So the noise you see in the signal, like I said, it's other brain regions firing, because even right now, as we talk, part of our brain is going, "I'm hungry," part of our brain is going any number of other things. And that all combines plus the part of the brain that's trying to, in your case, process what I'm saying, in my case, trying to generate words. And that all overlaps into the same EEG signal. So separating it is a tricky problem.

My brain is doing a lot of things at other levels, like processing touch senses from my fingers, listening to my digestive system, and this sort of low-level thing, including probably some sort of regulation of autonomic systems of some kind that I know too little about to use long words. Do those more physical low-level biological functions of the body, show up as the same kind of signals - the alpha, beta, delta gamma - or is it something else?

No, they do. A lot of the autonomic nervous system, is controlled from the midbrain. So one of the questions that's in the EEG world is how much of that can escape? How much of that signal is present on the surface? And there's debate about that. It's probably present to some extent, but it's quite a small extent. So all of that would contribute to the noise. And yeah, all of the electrical brain activity is generally between about 0.1 and they used to say 30 hertz, now it's up to about 100 hertz. In different brain regions, you definitely see different oscillations and patterns. The problem with the midbrain stuff, like I've said, is it's so far from the outside, and it's got to go through a lot of different types of material. So the general assumption is we don't get a lot of signal from those midbrain structures. But how true is that statement? The reality is, the only way to know that is to do combined surface midbrain recordings. And there are people that do that, believe it or not, there are a very small number of studies, where they've got pre-surgical patients, and they're opened up and then they basically say, "Can we can we record?" They get paid an incredible amount of money, but right before your operation, you know, we want to do a research study. So there are a small number of studies that record from within the brain into the surface. And then the whole point is to look at how the signal aligns.

“As long as we’re in here could we take advantage of your brain while we’re looking at it?”

And there’s usually a pretty large financial incentive to take part in those studies.

Have you seen a brain uncovered while it’s in use?

I have indeed. Not while it was in use. When I did my neuroanatomy class during my PhD days, it was in the morgue of the local hospital, and we dissected a human brain. But other than that, I have never seen an uncovered brain.

Anything surprising about that brain to you, on first encounter?

It always looks more colorful in the pictures. The color was really flat and kind of boring. And I don’t know if that was a product-- I never did ask if that was a product of the embalming fluids, or whatever there was. And it’s just amazing because conceptually I knew that there are billions of neurons in there, but you can’t see any of that. It just looks like a slab of tissue. So it was amazing to sort of stare at it and think, “Within that little region right there, there’s literally millions of these things, and you just can’t see it,” it just looks like a slab of tissue.

You mentioned on one of your sites you have a son. How old is he now?

My son, Owen, is 13. I’m hoping he’s interested in what I do. He actually uses the Muse EEG system for mindfulness, he finds it quite relaxing. So he’s on the periphery of getting into my world.

And what do you think the world will be like in this field when he’s ready to enter the job market?

That’s a great question. Neuroscience is definitely an area where the advances are coming rapidly. I think we’ll know a lot more about the brain when he gets to that point than we do now. The technology is always improving and getting better, new technologies are emerging. The holy grail in human neuroscience is being able… I say space and time… being able to measure where in the brain something is coming from very precisely, which is what fMRI does, well, at least two millimeters by two millimeters by two millimeters, which is still a lot of neural turf. And then time, which is what EEG does. So the problem with fMRI is, the response takes about eight seconds to go from start to finish, and a lot happens in eight seconds. And with the EEG, the response is instantaneous. When you give someone feedback, you can literally watch the signal go from the visual cortex through the brain, and what’s happening. The problem is you don’t know where it’s coming from at any given point in time, it’s just a surface thing, a voltage and an electrode. So, if a tech ever could solve that, we would learn a lot about the brain very quickly. But there are efforts, and one of the new emerging technologies we’re playing with in our lab is called functional near-infrared spectroscopy, and it’s basically firing an infrared beam into the brain. And it comes out of a sender and goes into a receiver and it measures human blood flow in real-time. So it’s kind of like fMRI, in a sense, but you can wear it anywhere. And the problem is depth, it only goes in a couple of millimeters, so you only capture the surface level of the cortex. But we’re already getting some interesting data out of it, and these technologies will just keep improving is my guess.

Wow, I could talk about this stuff all day. I wish we had all day. We don't. I hope we've done something to educate more people and maybe take some of the mystery out of neuroscience for maybe people whose earlier thoughts were of someone yelling, "No Igor, that's not the brain I asked for." "Sorry, Marster." And it's fascinating. You have a number of ways that you're active on the internet, and that people can find you and follow you. Can you tell us about those?

Yeah, if you want to see what my lab is doing, the research stuff, it's just www.krigolsonlab.com. And I try to be active on Twitter, and usually, it's always about neuroscience, so it's @thatneurosciguy. And I've got a podcast, *That Neuroscience Guy* on Apple, Google, and Spotify, and whatever else it could be on. So a couple different places where you can hear more about what I do and the research that Krigolson Lab does.

Just a bonus question here I'd like to ask. Being in this pandemic for the last 15, 18 months has been a lot of being stuck in a rut, looking at the same things over and over. This is the longest time I've spent since I was a teenager not taking a plane flight. And it has not helped my creativity. I feel too much like I'm going down the same cow paths in my brain all the time. So it could help me and presumably a lot of other people as well to know what we might be able to do with our brains from a neuroscientist's perspective to increase our creativity. Do you have any thoughts on that?

I do, yeah. A lot of people have asked me this question, given my day job. Well, first of all, with the pandemic, it's literally the worst thing you could do for creativity. Locking people in a small space and not engaging with the world around them is not really a good thing for creativity, traditionally speaking. Once you've got your creative idea, you might want to lock yourself away to follow up on it. But in terms of generating ideas, not so great. But I always call this the kind of mom advice because the reality is, to promote better brain function, it's the things we kind of know, which is you need to get a good sleep, there's no doubt that helps with brain function, which will help with creativity, you need to eat healthy because high sugar diets or things like that have been shown to have a negative impact on brain function. And you need to exercise, there's no doubt that exercise promotes better brain function. So those three things alone would help increase creativity.

Right. Now, to see if we can take this in a deeper level, the parallel here with artificial intelligence is the training phase, the backpropagation phase of a neural network, and then it becomes used to generating a particular result. If you want it to generate different ones you have to retrain it. And so this is perhaps the dark side of neuroplasticity, is it, that we get too used to going down the same paths. Is there something that we can do cognitively to shake our brain out of being too used to something? Like going to a different environment; travel always gave me new creative perspectives even though there's no otherwise logical reason why being in a different country should make my brain better able to, say, write fiction. So there's some kind of parallel there.

There is. Well, it's novelty, our brains crave at some level novelty. So what you're saying actually makes perfect sense because just by putting yourself in a novel environment, something new happening, it's going to promote different neural processes. So the key is you sort of have to force yourself out of the situation where there's no new stimulation and create new stimulation however that works for you. Whether it's traveling, whether it's trying something new, reading something different, anything to promote different patterns of thought. And this is why sensory deprivation is a form of torture, right? Is because there's absolutely zero novel, there's no input. So when we get our regular input, our neural function say is firing at a certain level, but when you get novel input, it ramps up even more.

There's got to be some kind of balance there, though, because meditation is supposed to be sensory deprivation, and my times in an actual sensory deprivation float tank have been very productive for my mental health. Presumably, one wouldn't want to overdo it, but two hours in one of those leaves me feeling far more relaxed than two hours doing anything else.

True. With that kind of stuff there's definitely a sweet spot, and there are some individual differences there. So you're right, in the short term, these sorts of exercises are good for us. And I use sleep as a parallel when I talk about this. The right amount of sleep is perfect for you, but oversleeping is actually bad for you. It's true with these things, too. I 100% agree, Peter, that two hours in the tank probably had a very positive impact on you. Obviously, it did, it wasn't probably, it did. But I would hate to see you at 40 hours in that tank. You probably wouldn't be feeling creative or rested, you'd probably be feeling a little loopy.

I think so too, plus too expensive. So in terms of a balanced mind diet then, any suggestions for what could have that same sort of associative effect of increasing novelty in one area helping with creativity in other areas? Have you suggestions for any particular kind of novelty? I think I saw something recently that said crosswords aren't all they're cracked up to be for that kind of thing.

Variety is the spice of life, right? So I think for most of us, changing it up and trying different things is going to help the most. So if you do your daily Sudoku, mix it up, try a crossword, you know, different things, try different things to engage your brain, and that's the key thing. I think to promote creativity, you have to give your brain a lot of experiences, a lot of different things. So if you're used to reading a particular genre of book, read something different. If you're used to watching this show on TV, watch something else, try different walking routes, anything, because you just want to increase the range of input to the brain.

Anything you want to say to people who are at the beginning of their career choices or higher education choices, thinking about neuroscience, maybe on the fence? What do you want to tell them, the good, bad, and the ugly that might inform their choice?

The good part is you're literally learning about why you do the things you do. I think it's fascinating. When I make decisions, I'm thinking about what's going on in my brain. If I have trouble with my golf swing, I'm thinking about what that means. You can learn literally about yourself and about people and why they do the things they do. The bad is it's a lot of work. The students in my lab typically need to know computer programming, they need to know neuroscience, and they also need to know statistics. So the advice I would give would be for anyone that's interested in neurosciences, really get good with computers and computer programming because that's really where most of my time is spent in front of a computer writing mathematical algorithms to analyze data or interpret data, most of it isn't spent staring at brains or brainwaves. So I would definitely say that one of the best skills to learn would be computer programming, followed by statistics. I would say learn the neuroscience part third.

And computer science plus statistics equals introduction to AI. So many fields have turned into working in front of a computer 90% of the time, and I like to hope that AI could free us up from being quite so slavish to it, but that's the nature of it. Or at least make it a little more transparent because here I am and here you are sitting in front of a computer, but at least we're having a conversation. So, Olav Krigolson, Thanks for coming on the show. This has been wonderful.

Peter Scott, thanks so much for having me. I've loved our chat.

That's the end of the interview. I hope you enjoyed that as much as I did. It's incredibly exciting how this field of neuroscience is exploding – the media is running constant stories about brain-machine interfaces, the research seems to be progressing by leaps and bounds. I don't know how much of that is due to Elon Musk's Neuralink, but he certainly did elevate it in the public eye. Are you inspired now to go out and hack your brainwaves with one of these new mobile EEG headsets? I got one and I've been playing with it. I'd be interested in what you find out or what you can do with it. Of course, reading our thoughts at the level of what I'm saying right now is who knows how far off. I used to tell people who came to my classes that when we had fully working brain computer interfaces I'd be able to send them the whole class in a few minutes and then we could spend the rest of the time goofing off. Actually, what would we spend the time on? That's another one of those huge questions about our future with AI that's just waiting to be explored.

In today's news ripped from the headlines about AI, in a story from Interesting Engineering, Israel has demonstrated fully AI-controlled drone swarms. Now we've seen AI swarms before – if you watched the Olympics you saw a beautiful demonstration at the end – Closing Ceremonies – where 1,824 drones maneuvered themselves into shapes like the Earth, to make a spectacular light show. Obviously no one programmed each path individually, there was some mass control guidance software, but it didn't use AI. So the Israelis have been using AI and supercomputers to identify locations of Hamas activity and plan strikes with drone swarms to remove any strategic advantage. And those drone swarms are reportedly fully autonomous. Of course, if you've seen the *Slaughterbots* video – and if you have, you would remember it – if you haven't, you can google for it, be warned, it is disturbing, intentionally so – then it's hard not to think about that. And the technology in that video is not a stretch by any means. We've had discussions about the movements trying to limit the development and use of autonomous lethal weapons on this show before – go listen to the interview with activist Peter Asaro in episodes 40 and 41, for instance. I think we can only expect this type of technology application to continue developing, however.

Next week, I'll be talking with Olivier Caron-Lizotte, the CEO of explor.ai, a Montreal-based company that provides AI developers and teams, and he has some fascinating insights into how that work is going right now. That's next week on *AI and You.*

Until then, remember: no matter how much computers learn how to do, it's how we come together as *humans* that matters.

http://aiandyou.net