Neural Lace Podcast 1

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Audio Transcription by OpenAI's Whisper

So, welcome to the NeuroLace podcast.

The NeuroLace podcast is all about neurophysics, which is the science and technology behind NeuroLace.

Neurophysics is an umbrella topic that includes spatial computing, which is the technology behind virtual reality, augmented reality, and mixed reality.

It's also an umbrella topic that includes deep learning artificial intelligence.

Some of the topics that come up in this podcast will be about computer vision specifically, about applying deep learning to medical imaging.

It's the first podcast that will attempt to unite the topics of WebVR with NeuroLace and quantum mechanics.

It's the podcast that dares ask how information in the networks of the brain are organized and how we might query that information in any region of the brain with a brain port that understands the transmission protocol of the brain.

I'm going to propose that transmission protocol on this podcast.

And we also talk about hacking into the brain's VR system to add things to your reality that are not really there.

And I actually attempt to explain how we could do that in this first episode.

And then we also chat about, in the course of this podcast, talking about the kinds of things we can download, information from the brain, like holograms of your experiences,

as if your eyes became camera, so we can capture what you saw and what you heard, and you can

share those experiences with others.

You could share those experiences in court.

We also talk about defending our brains against remote hacks, and we dare to boldly go where

no one has gone before.

So welcome very much to the NeuroLace podcast.

Your host is Micah Bloomberg.

The podcast is edited by Adam Alonzi.

And today's guest on the episode one, democratizing NeuroLace, is Shannon Aral, who is an AR-VR

enthusiast.

Shannon is also part of the Chronos group, developing OpenXR, and I wanted to talk to

Shannon in part because he's connected to WebVR and WebGL, but also because I'm interested

in creating an open standard for NeuroLace so the world can have it.

And that's why I'm giving it away on this podcast.

In future episodes of this podcast, we'll be talking to neuroscientists, and we'll be

talking to computer scientists, and we'll be talking to executives at major tech companies,

that are making EEG products, or AI products, or new kinds of web browsers, or just new

kinds of technology period, people who are working on converging technologies like applying

deep learning to all sorts of imaging, not just medical imaging.

And so there's so much technology that's converging, and it's going to result in amazing forward progress in terms of technology and science and the social good that can be achieved.

So welcome to the NeuroLace podcast, I hope you enjoy it.

So let's go ahead and get started.

So Shannon, let's explain to people maybe what NeuroLace is, and at the root of it,

you could say, let's describe that it's an advanced form of just brain-computer interface.

Hey, thanks for having me.

All right, so yeah, my name is Shannon Norell, and I'm a passionate, I guess VR, AR, evangelist

type person, kind of been here for the ride for the last five years or so, and bringing

it to the next evolutionary step, which is past AR, which is going to be NeuroLace.

And well, you could almost say NeuroLace is going to become factored into VR and AR as

we know it, NeuroLace being a brain-to-computer interface.

So we are talking about, we have, there's a lot of great ideas on how to achieve NeuroLace,

and a lot of people want to keep their ideas a secret.

And so we were talking about that in terms of, if we give away how to make NeuroLace

on this podcast, what is our objective then, and should NeuroLace be democratized so every

company can know how to do it?

And my thought there is that we should democratize NeuroLace because we really want this technology

to exist in the world, and we do not necessarily know, because it's a very complex thing to

try to solve.

And so we want to encourage as many people to get on board with helping us to create

NeuroLace as possible so that we can have NeuroLace in our lifetimes.

I absolutely agree, and everyone in the space, so far as I've seen it, are very protective of their algorithms, their techniques, I mean, talking about it openly, it seems to be like, you know, protecting their IP, they're squatting on domains already.

You know, it's kind of ridiculous, because it is a difficult problem, it's a problem that when solved will affect all of humanity, so why shouldn't we all share it?

And I think having an open source will be useful and required really to make it happen, because we have secret algorithms that are operating, we don't know how, what's going on in the background, it's going to slow the adoption rate of NeuroLace.

People will be suspicious of it, things like that.

So I think if we create some kind of an open source standard or groups that will work together to make this thing happen, I think it's a good move.

So someone remarked to me recently that in order to achieve the kind of NeuroLace we're talking about, or brain-to-computer interface we're talking about, you'd have to have a number of, like, Nobel Prize-winning discoveries that would happen pretty much simultaneously.

So one of the positive outcomes of NeuroLace is we'll be able to do, it's on the way to discovering it, we're going to have to revolutionize medical neuroscience, and that means, for example, we're going to have to figure out the transmission, let's say that the brain is organized like, the brain in the number system is organized like the internet, for example, as many neuroscientists believe.

We're going to have to figure out what the transmission protocol of the brain is.

And if we do that, you know, from neuron to neuron, if we do that, it's going to enable the kinds of products like artificial limbs that can connect to your nervous system or reconnecting the spine.

It's not necessarily as glamorous as the science fiction concept of NeuroLace, but there's

a lot of practical medical applications to being able to connect a limb or reconnect

the spine, an artificial limb to your nervous system, so you can really even create new

kinds of limbs.

So these are really positive outcomes that can come from pursuing a direction of research

towards NeuroLace.

Well, let me just back up and say kind of some points I wanted to cover.

So solving quote NeuroLace, brain-computer interface, it is a difficult task, but yes,

it's something that needs to not be overthought too much.

There are certain baby steps we can take along the way that are low-hanging fruit that are

easily solvable now, okay?

The first path, so I'm sitting here, I'm looking at an emotive headset.

If you guys aren't familiar with that, it has, I think it has six EEGs on it.

They have one model that has six, another one has 14.

And what that does is it pulls in brain waves from different regions of your brain, okay?

Now there's a section called the homunculus.

It's kind of an idealized section of the brain.

It's not really a specific region, but it's an idealized version, a region of the brain

that will indicate things like facial expression.

It'll indicate like eye blinks.

It'll indicate, I think, body posture, hand position, if we are able to accurately read these areas of the brain.

So these emotive devices are really quite primitive now, I mean, they're the six sensor one, two, three, four, five, six sensor one effectively reads skin tension and small motors up in the forehead and can infer things like eye blink, stuff like that.

So my first, sort of my first baby step I want to accomplish is to use an EEG headset, NeuroLace Alpha 0.1 to solve the problem of not having a face in VR.

So when you're in virtual reality, you don't really have, your eyes are covered, you can't, when you're looking at someone else in another virtual world, you can't tell if their eyes are blinking, you can't see if their mouth is moving.

I think that these, that particular problem is solvable in the short run, okay?

So sort of reading facial expressions, I'd like to solve that first.

The next step would be to get more involved and get actual body position and arm position, finger position by reading these sections of the brain.

Now how do we read these sections of the brain when, you know, everyone's brain is different and the placement of the EEGs may be different each time.

So these are definitely problems we have to solve.

We have to solve.

So at present, what we have, and I've seen this in action, is a way of sort of recording brain wave states and inferring meaning from that.

So for instance, let's say you put on a headset, you're in a blank, completely blank room, and I put an apple in the middle of the floor, so all you can see is an apple.

And then I record your brain wave state as you focus on this apple, okay?

Okay, next, stop record.

So we have this capture of data of what an apple is to you.

Say I give the headset to Micah, he puts it on, looks at the same apple, we record his brain wave state, okay?

So they should in theory be quite similar.

We don't know for sure at this point if they are, but presumably there will be an amount of machine learning and pattern recognition that we can feed these data sets into to arrive at what is the perception of an apple.

It's kind of, I kind of liken it to the old days of Dragon Naturally Speaking, remember that app where you had to like train the, you had to train the interface to recognize your voice.

Yeah, Dragon Naturally Speaking led to Siri.

Yeah, it's now Siri.

Now you can pick up any phone and talk to it and it knows your voice, you don't have to train it, it's not a thing anymore.

Like I say, the sort of the first step is gathering up these patterns, building up a large database of brain wave patterns, applying it to genetic algorithms, other machine learning techniques that will in effect, be able to record what our perception is of certain objects.

So that you could put it on another person and they can think apple and you will know that it's apple.

It's kind of like this, this read only extracting of data from the brain.

So step one is to do the facial recognition stuff.

Step two is to do the pattern recognition for known objects.

Step three of kind of a larger overriding step that we can be working on simultaneously is how do we do a right into the brain.

So we're working on read.

Right is another thing that's really far out on the horizon, but for now I just be happy with read.

But you know, presumably if we know exactly what the pattern, the brain wave pattern is of you viewing an apple looks like, and we knew how to transmit that wave brain wave pattern into your brain, you would visualize an apple without there being an actual apple there.

It's long and short of neural ways, I think.

It's fascinating.

There's a lot of different people with a lot of different ideas about new ways to send data into the brain.

For example, David Eagleman talks about there are strips that you can put like on your tongue or on your back that the strip is a grid of electrodes and it's connected to a camera and the camera is watching the world and takes that image and converts it into the electrical grid of signals on your back or on your tongue.

And eventually your brain figures out how to see an image from that.

That is a way of inputting data back into the brain.

In fact, just using your regular eyes is actually putting data back into your brain.

So that's another input channel to think about.

Really fascinated with all the different ways, what Shannon shared is one way of tackling the problem of solving neural lace, but there are people who are setting medical imaging with MRI machines besides EEG.

So Shannon was like, let's go to the EEG approach and there are people who are putting chips inside, they're cutting into the brain and putting chips inside the patients who have epilepsy who need their brains opened up anyways.

And then so this has been sort of like a long dream of scientists who study the brain.

What kinds of sensors can we attach?

And once we have the sensor data, how can we analyze that data?

With new techniques like deep learning, with computer vision, we can create different kinds of biosensors.

We can apply deep learning to these sets of data in new ways and potentially revolutionize medical neuroscience by combining state-of-the-art AI with medical imaging of all kinds, not just EEG, so that's my thought there.

We can totally start with some EEG products and come up with, and the results of that action will certainly yield some really awesome new neural lace products, but it's not necessarily the only direction the industry can go.

So it's definitely a broad topic and I hope we can cover a lot of those different ways in this podcast.

Yeah, I mean, certainly a wet interface is more efficient.

I mean, drill a hole in the back of someone's skull, mount an electrode, it's in a known location, you can calibrate it and train it to, you know, based on the exact brain and it never shifts, it never moves, you know, but will society adopt that?

I don't know, jury's out on that one, I think not, but, you know, I'd probably be willing

to try it, but I don't know that other people would.

So I just wanted to say that I'm really interested in creating a sort of installed wet wear sensor

for the purpose of just research, but I was at CES 2017 and I saw this really awesome

new wireless EEG system.

So that's one of the things that companies are talking about right now is, you know,

we actually could do sort of a non-invasive neural ace that gets at the core of our brain

by using a variety of tools such as, you know, like they use ultrasonic sound for surgery

now.

So there are ways to stimulate the brain and read the brain like really deep without actually

cutting into the brain.

And so that's definitely an interesting topic.

Well, I mean, it's certainly possible to embed an electrode under the skin.

So let's say you have a tiny incision behind the scalp and you just insert the electrode

under this.

So it's directly on the skull.

So that's, you know, quote unquote wet wear, but it's not exactly as invasive as, you

know, punching a hole in your skull.

I don't know how pleasant that would be.

I think that at least my goal for a manifestation of version one of neural ace using EEG is

it's going to look like a baseball cap.

It's a baseball cap you pop on and it's got all the EEGs sensors in there.

Yes, there's going to be a ton of noise that comes out of those readings.

Yes, it's going to be difficult to sort of sift out the meaning from all that data.

But I think we've been making a lot of improvements and advances in computer vision lately with

the autonomous driving vehicles and whatnot.

And the LiDAR data that comes out of that is just so full of noise.

It's incredible how much noise is in that data.

But you know, our guys with doctorates and things have been working out great algorithms

to sift through that data and pull out the meaning.

So I think some of that learning, some of those learnings can be applied to EEG neural

ways.

And definitely, you know, if you look at the supercomputer that NVIDIA is doing for self

driving cars, that's a really mean and serious machine.

And they're still figuring out how to do it.

So basically, their computer has all these sensors, LiDAR, like was just mentioned, eight

cameras besides that, and a whole bunch of other things.

And it's figuring out not only the spaces around the car, but also it's figuring out

what the objects are.

Like there is a, it's saying, well, this is a cat and this is a dog and this is a car

door and this car door is going to open or this car door is going to close.

And there's a car across the street that's moving at such a speed and it's going to intersect

the path in front of you.

These are things that they're having that require a supercomputer that's going to be

installed in the trunk of your car for driving.

But if we could take, for one minute, if we could take those self driving cars and apply

them to the task of neuroscience, we could probably create a revolution in neuroscience.

So those are the kinds of things that keep me up late.

Yeah, I've seen samples, I was at a talk recently at Stanford, and it was on LiDAR, a single

photon LiDAR stuff.

And an image that it pulls out was just literally a cloud of, looked like a cloud of dust.

It was just like smeared, you couldn't make anything out of it.

And then they did a single pass filter of it using their advanced algorithms.

And voila, embedded in that was, you know, a picture of a dog or whatever it was.

I forget what the three, but a three dimensional picture of this thing.

But on the first pass of it, it just looked like garbage.

That's what I anticipate the version one of alpha of neural lace using EG will just have

this cloud of garbage that comes out that we need to sift through to have, you know,

true meaning of.

So it's doable.

I think it's doable.

I think we just don't want to overthink it too much.

So some final thoughts in terms of, you know, recently in the news, we had Elon Musk
announced

that he has a new neural link initiative.

And so suddenly neural lace is a popular topic again.

So but big companies that are thinking about jumping into the neural lace game, what are some things that that they might need to think about in terms of, you know, making products that have that can scale and have broad commercial value.

And do you have some thoughts on that?

Well, well, at this, at this phase, we're such early days, I mean, we're just thinking about figuring out how to do it, you know, and if it can be done, then we have to worry about, you know, ethics and, and, you know, appealing to a broad range of people, not offending people, not letting them think we're using their, their thoughts to market, things like that.

I mean, so, so ultimately, there will need to come into play some kind of standards.

I'm actually involved with the Kronos group, doing some stuff with open XR happens to do with VR and AR.

And also the IEEE, there's some standards dealing with virtual reality, augmented reality.

So in particular, with augmented reality, let's say you have eye tracking, and you can see where people are looking, you can see if they look at the Coke can versus the Pepsi can.

Now, do we allow that data to be transmitted to marketers with personally identifiable information so that we know, you know, to always put a Coke ad in front of Shannon, you know, probably not.

So we will need to develop standards having to do with brain to computer interface.

So do we, do we let personally identifiable information be sent with thought patterns to servers to be processed?

No, definitely not.

So we'll need to implement standards.

Neural Lace Podcast 2

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Audio Transcription by OpenAI's Whisper

So, welcome to the NeuroLace podcast.

I'm here with Blaise Sanders, right?

Correct, yep.

He's the CTO of SpaceVR.

I understand SpaceVR is a company that makes satellites.

Yeah.

Which is like a super cool thing to do.

My grandpa made satellites.

He made the first GPS satellite.

He actually, sorry, he led the team that designed the specifications for the first one.

So, I very much admire companies that make satellites.

It's a really cool thing.

SpaceVR is a dream to allow all of us to go up and see what it's like to be in space via virtual reality.

In a real way.

There's a lot of CGI space experiences out there, but we're going to capture a full 20k resolution imagery of the space station as we fall away from it,

and just the beautiful Earth.

Wow.

So, the goal is to give every person on Earth the overview effect.

Would it be possible at some point to put the 20k camera on the rocket itself as it's going up into space?

I can.

I guess the biggest problem there would be like the aerodynamics.

Like where do you place the camera?

We did talk to Blue Origin about strapping it on the outside of the new Shepherd,

but couldn't quite figure out how to do it and not have it like break off.

Oh, yeah.

And aerodynamics at the velocity are pretty rough.

We had some really cool renders of like aerodynamic shields for the cameras, but never quite worked out.

It would be cool though.

And then, so recently I was at NVIDIA event and I ran into your friend Ryan,

who also works at SpaceVR, and he had just been awarded an NVIDIA processor for robots.

TX2, is there twice the AIs, what they say?

Yeah.

And so now you guys are really excited, or maybe happened for, since before that probably,

about building a robot for telepathy on the satellite.

Exactly.

It's a full humanoid robot about one and a half meters tall and is controlled by a VR suit, remote control.

Wow.

So how is that, what are the practical applications of that, like what would you be doing if you had to, like, hands?

I mean, you could repair the satellite, I imagine.

Yep, that's one of the use cases.

It's a little farther down the line because satellite companies need to figure out how to repair satellites.

So we're going for some Earth-based use cases in the labor market that we think we can solve.

Okay, so this is like, this is something NASA did where they started coming up with a, NASA is not just a space company,

they also have a bunch of, you know, Earth-based projects, underwater projects.

So that kind of makes sense.

You want to put everything in space, but there's a lot of verticals where you can take what you're working on for SpaceVR

and then apply them to the Earth in very valuable ways.

Exactly.

NASA has the Robonaut 2 right on the space station now, so we're going to use some of their tech for the space.

But right now we're focused on ground-based robotics and the neural lace has an important part to play in that.

Wonderful.

So let's talk about connecting neural lace to SpaceVR or neural lace to telepressants.

What are some of the, I mean, what that would mean is you have a robot that responds to your nervous system

to how your hands actually move and what your hands touch and you feel it.

So you have a true sense of presence, remote presence, as if you're actually there,

but then you'd have a different body if you'd have to get used to that.

It'd be amazing.

Right now there's a lot of gloves that you can wear for VR that give you a little bit of haptic feeling

and there's other input methods that let you move your arms around.

But with the neural lace you could think about doing something or if you were making a video game,

think about turning on your shields and they would turn on.

So in the previous podcast I laid out what I think are the two steps we need to achieve in our lace.

I'll just recap this real quick.

So one of them is we need to take a computer that's this computer vision that, you know, like the self-driving clock

or like mixed reality concept where the computer is learning the concepts of everything around it.

It says this is a cup and this is a car and this is a person and the car is moving really fast.

The car needs to know if there's not a space in front of it.

So it's categorizing objects around it and we need to apply that to neuroscience

so that we can have this neural network that's doing computer vision.

That's part A and then part B is you need to have another neural network applied to live medical imaging

and then you need a live medical imaging.

It could be a chip that's implanted in your, close to your mid-brain and it's for several chips

and we just want to focus on that.

It's medical imaging even if you do it with another type of medical imaging.

That's part B because now you have a neural network dedicated to what's going on inside your brain.

And then you have a third neural network that's at the apex of the two of my side.

So above A and B which is computer vision of objects and neural networks of brain life data.

You have a third neural network that is looking for the similarities between the world that you're seeing

and the activity of the brain.

So that means that if you're seeing a car and the computer vision is seeing the car

and the computer vision is seeing the neural cortex of your brain activity while you're seeing the car

and then the third neural network is going to figure out what that pattern is

and that pattern in terms, not just in terms of, you know, I mean really for neural life

we really have to go beyond EEG and beyond the fusion tensor imaging of MRI.

It's about, it is about getting chips to focus on the data in the mid-brain

and the reason for that is because all of our incoming senses, you know from our eyes or ears

they collide at the mid-brain first before they connect with the rest of the cortex.

So that's like the point when our senses converge in the center of the brain.

I'm making these like hand gestures which you can't see on the radio but yeah,

so just imagine that I have hand gesture for your eyes and hand gesture for your ears

and then I move my hands together and where they come together is like at the thalamus or somewhere in the mid-brain and then they connect with the rest of the cortex

which is, you know, for the eyes they're going to go to the occipital lobes and the prideal lobes

and then you've got a whole bunch of information coming back at the same time back towards the thalamus

which is, anyway, so the point is if we, so the idea is if you tried to study from EEG

which is on top of your head, at that point everything is scattered.

It's all over the place. I mean you have, there are maps of the brain that have been done

in places like Berkeley where they say, you know, you're a concept of a cat and a dog

has neuro correlates over in this region of the brain which I'm doing another hand gesture.

So it's like I'm pointing to one part of my head and then you have another concept of a house and a motorcycle

which is going to be in a different region of the head completely.

It's all scattered and distributed, sparse and distributed representations

and somehow when you're perceiving them they come together like you can perceive a dog at a house

in one picture, in one photo and that's like different parts of your brain sort of like lighting up

and then coming together and maybe they're coming together back, you know, maybe that's the back propagation

when it comes back together to the center of your brain, to the midbrain, to the thalamus

where your senses are coming in, maybe that information is coming together there.

When it's in the neocortex it's all over the place.

So the place we want to put our sensors is in the midbrain and if we do that then hopefully we can capture

a photo when it's coming together before it scatters across the neocortex or the sensor image

and the sensor image that we want to capture is electromagnetic.

Brainwaves, we'll see there's neurons that have electrical synapses and neurons that have chemical synapses

but they're all generating a lot of brain activity and the cells of the neurons have,

the cell body has all this metal that has calcium ions, positive ions outside the cell body

and it has potassium ions, negative ions on the inside of the cell body

and those, you know, the classic example in any neuroscience or computational neuroscience textbook

is these charges are separating through the activity and then what happens is they separate enough,

the cell has to depolarize this separation between positive and negative charges.

It's the same principle of lightning.

The positive and negative charges separate in the sky and all of a sudden you have lightning bolts

and in the brain you have an action potential but unlike the sky there's a path of least resistance

that is the axon body itself, the middle of the cell body.

And unlike, you know, the standard neuroscience or computational neuroscience textbook

the action potential doesn't travel directly between two neurons.

It's not, it's actually, it goes along the body of the cell and you can see this in the illustration

but then it goes to the axon terminal or the post-synapse and inside the post-synapse

the synapse is so complex, it's like a little micro-computer

and so we used to say in computational neuroscience that you have to summarize whatever goes along the axon terminal

and you can't look into like a 1 or a 0.

But now scientists have woken up to the idea that wait a second, what's being sent is a lot more complex than that because you can't just summarize it as a 1 or a 0.

It has a wave, it has an amplitude, it has, you know, it has the charges count

that there's information in the voltage in terms of like its difference between like it could be,

that's greater amplitude, that's information, right?

And then so that is sent across the, it's sent to the axon terminal

and then if it's a chemical synapse, I mean if it's an electric synapse it does transfer immediately to the next neuron

but if it's a chemical synapse what happens is it triggers a bunch of neurotransmitters, ions to pass through

but what's really changing is, see all the neurotransmitters have charges

like charges in terms of like atomic charges, positive and negative charges

and this synapse is like a computer and it's, and the dendrite itself, so is, here's the real question, okay?

So this is like one of those things, because I study like the dynamics of neural circuits, for example.

The real question is if you have, see a neuron now sending its neurotransmitters to the next neuron

but there are a finite number of neurotransmitters

and each neuron is connected to somewhere between 10,000 and 200,000 other neurons.

So when you see a neural circuit in the brain, which means the same group of neurons light up in a sequence

but it's also a feedback loop, like it's a repeating sequence,

how is it that sequence ever repeats more than once?

And the weird thing is that the neurons in a feedback loop are not necessarily directly connected

so you'll see a neuron that lights up, let's say we call that point A and then there's darkness for several connections

and then a neuron somewhere further down lights up in terms of the brain neuroimaging

and then, and then, so I'm making another illustration with my hands

so then bear with me audio listener.

So then there's a third point, now imagine a circle and there's six points around the circle

and each of those six points is a neuron that's lighting up

and they're not necessarily directly connected

but they keep lighting up in that same circle over and over again

and that's what we call the neural circuit.

But why would that ever happen? And so there's a lot of different network theories about why that might happen

but the most obvious possible solution to that is it's fundamentally about electromagnetism

and it could be that the dendrite, which is the receiving terminal of the synapse

it could be that the dendrite is, dendrites are, you know, like more than 80% of the brain

I mean they've just taken up a lot of space and they're really complex

and they're like, it's like a tree but it has like a tree with all these like notches

or these hairs on the axon fibers

and so the dendrite could be doing a lot of interesting computations

and we'll really analyze this. The dendrite itself could be like a sort of mini-computer or a micro-trip.

It's very fascinating and so, but the dendrite

does that whole feedback loop a discrete step then in some sense

or is it still analog in that feedback loop as well?

It could be a discrete step.

Each part of it could be a discrete step where the dendrite itself

could be like, so imagine you have a bunch of dendrites that are competing

like 10,000 or 100,000 dendrites that are competing for the signal that's coming from the neuron

that's in all the text books, right?

Well, it could be that the dendrite that receives it is the one that has the most negative charge in summary

and all the other ones have a slightly more positive charge

so it's creating a situation where you have like the lightning strike

where you have a separation of positive and negative charges

so the dendrite on the past, the post terminal is receiving

is actually setting up to, it's like saying,

okay, I need to receive the next call from this neuron

and it's achieving that with the polarization of electroactive

and so that's a hypothesis about how we have neural circuits

so if the brain is operating sort of like in terms of electromagnetism

that would make sense because we capture all these brain waves

so what is a brain wave?

A brain wave is a wave of ions that's flowing throughout the entire brain

and it has all these interesting properties

it has an angle, it has an amplitude, it has a velocity

but what does it mean to...

so we measure, we can see these with EEG caps

we can capture them escaping our scalp

like the solar flares escaping the sun's corona

I'm wearing a couple of those

yeah, the EEG, I had an EEG business once

and it's school technology, you kind of have to be still

because your muscle movement will create a ton of noise

and then the chip processor has to work overtime

to eliminate that noise from...

anyway, so EEG still hasn't even reached its full potential

especially when you start applying the power of a supercomputer

that goes in a self-driving car to your EEG analysis data

I mean that just hasn't done yet

so there's a lot of exciting things for EEG and for MRI and DTI

and for new brain computer interfaces

things that could possibly, potentially revolutionize medical neuroscience

but one of the great... there's a lot of great new concepts around EEG

is that you don't have to only study EEG

you can also study the eye movement

or what they call it, you know, it's eye tracking

but also pupil dilation tracking and heart tracking

you can put all of these on a single sheet there's a software called Narrow Pipe, it's open source

created by Tim Mullen and there's other software

I think NVIDIA has it around now, Microsoft has it around now

but it allows you to take multiple kinds of sensor data

and unless they're using the open source one

they're running out for a while

it allows you to combine multiple kinds of sensors

any kind of sensors into a single sheet

so it's sort of time lock

and it's time lock in the data so that you can run AI process

so the deep learning can, you know, it's great for observing

you know, like, it's great for monitoring things

like for electric companies, for monitoring power distribution over time

and predicting where that power is going to go

so you could easily imagine that as a way to monitor

like, let's say that someone, you're wearing augmented reality glasses

and you've got EEG and you've got a heart rate monitor

and you've got eye tracking of pupil dilation stuff

and all of this is, and maybe you have a watch

and the watch has like all these biocentures too

and it's all going into one sheet and, you know, enough of the heart pendant

and like all these great biotrackers

and you've got motion controllers and you've got your head tracking

and you at the same time, you've got all the computer vision stuff

going on as categorizing objects

and so then you have deep learning

it's noticing that when you see a virtual box

and a kitten jumps out of it

and maybe it'll notice your heart rate had a spike

at the same time your brain wave had a spike in some region

and then your pupils widen slightly

and then someone, a new person walks into the room

and you have another kind of reaction

between the heart and the eye and the brain and the watch

and so that's a way of, you know, when we do medical imaging

it doesn't, it should be multimodal, it's not

let's only do EEG or let's only do MRI

and this is already the trend that we're seeing in science

scientists are already combining like, okay well what can we stick

because you know the MRI machine obviously is magnetic

so you're limited in terms of, you know, what you can design to mix with that

but there are cool things that people are coming up with

and so getting back to the brain is magnetic

and that means if we can figure out

so if we're setting your brain while we're setting your environment

and let's say that you decide to build a, say that you're working on your computer

and you're working on creating, like you're just implementing

a voice recognition API for your robot

and then the computer is watching you do that

and it's watching you at the neural correlates

and the neural correlates is also, it's not only your brainwave activity

but it's also your eye tracking and pupil dilation

and the computer is figuring out, okay, so this pattern

of working on the voice recognition API for your robot

is exactly, is exactly matching, we've found the brainwave pattern

that's matching what Blaze is doing on his computer

or maybe it's, and we've isolated that from the computer itself

like we're getting very distinct, this brainwave pattern is for the computer

and this is for what he's working on specifically

and so then the computer could tell you at some point, this network

because it has these concepts of how all these signals meet together

the computer can tell you, if you turn off, if you like

put a curtain in front of the computer's cameras

so it can no longer see what you're doing

it can only see your neural correlates

it should be able to tell you from your neural correlates that you're working on the computer

and you're working on the application

and that means that we have, you know, the voice recognition application

that means we have now identified the tempo spatial ionic brainwave pattern

of Blaze working on the computer on voice recognition for his robot

that'd be sweet

I think some of the first use cases for the neural lace

will definitely be in the medical field like solving Parkinson's disease

like that seems like a great first use for it

absolutely, we have to, so the first step to solving neural lace

is to identify those brainwave patterns of decode

what brainwriters mean, the second step

is to identify the communication protocol

like a network communication protocol

so imagine if our brain was organized like a network or like the internet

which is a very popular idea

I mean packets, like packets, yeah

so is it more like TCP or more like UDP

the transmission control protocol or the user data grant protocol

in TCP it's like, you know, you need a connection

you need almost, TCP is like a feedback loop

UDP is like, you just throw packets of data it's faster, it's great for mass and multiplayer

and then those are the top two network protocols

and below that there are many other network protocols

like HTTP, right

so the question is, if we can figure out the network protocol of electromagnetism

and we can create artificial neurons or chips

that can send and receive electromagnetic information

that's your brain for it

once we have the knowledge of how to communicate with a brain

you're right, there's a lot of practical medical applications

and one of those is reconnecting the spines

because what happens is the spine is severed

and so the neurons between two points are no longer communicating

and if we know how that works

if we know how neurons talk to each other

we can reconnect the spines, it's very practical

we're not in the realm of science fiction anymore

this is just bridging a physical gap

and then also the same idea applies to artificial limbs

so if you had your arm chopped off

and now someone gives you this really great artificial limb

you can physically connect it to your nervous system so you can move the arm as intuitively as your original arm

the artificial arm

it's like Luke Skywalker's arm from Return of the Empire Strikes Back

five

so yeah, that's exactly what we want to do at SpaceVR

is let people with Parkinson's go back to work

by working through a robot

and also like vets that have had an arm blown off

like letting them go back to work through a VR robot

so what your telepresence robot at SpaceVR means

is that when we have a brain port that allows us to convert electromagnetic waves

into something the computer understands

that means someone who's sitting in a bed who can't physically move

can teleport into your robot and have the presence to walk around

and sort of like, you know, do business through that robot

and their brain would function as if it was their body

close to the movie surrogate like

the movie surrogate, yeah

it's a little scary, hopefully we don't go in that direction 100%

but there's definitely that direction

like letting people be themselves and control their own lives

another thing is we're really talking about neural life it's not just brain-computer interface

it's also, I mean it's brain-computer interface

but it's bi-directional or what that means

it's not only can you read information

but also write information

so in the medical application

positive medical application for being able to write to the brain

like if someone had some really traumatic memories

or if they, you know, I'm talking about like

you can actually, what I believe is realistic

and so, you know, memories are, again, scattered over

the whole neocortex potentially

that's what many people believe

so that might be a little bit hard to edit

but what you might be able to, through a brain port

that is connected to your thalamus

or pointed at your thalamus from somewhere outside of you

like with wireless, e.g.

with, you know, there are ways to non-evasively stimulate

like with ultrasonic sound

they're using that to do surgery

for women who

and so that you don't have to actually cut into

the womb area

and you could apply this to the brain as well

to stimulate that core part of a person

the mid-brain

and instead of actually putting a chip on there

and so now we have non-evasive possibility

in fact I tried a wireless e.g. device

the first one I've ever heard of

at CES 2017

so that technology is coming

so like the idea that you need to have a chip implanted is just

I think we're going to do it for research purposes

but this will become a commercial product

and when it becomes a commercial product

there won't be any chips that need to be installed

Elon hopes that you can just inject it into your bloodstream

not even necessary

not even necessary

you could have it completely external

and it would still work just the same

like wireless

I guess some people might experiment with

injecting robots into their bloodstream

there's so much cool things robots can do

there's a lot of blood that goes through your brain

so it'll go right there

and another thing is

potentially you could live longer

if you have robots that are concerned about your health

but one comment was

if your robots get hacked

if you're wearing a baseball cap

or if you're wearing a brand computer interface

under your nose or something that's pointed at your balance

but it's not actually

you can just pull it off if there's a problem

but if the robots are in your bloodstream

it's like how do you get them out

maybe like a residence frequency

that destroys them all instantly

and doesn't hopefully hurt any of your body cells

any EMP pulse

you press the button and it disables all your electronics stuff

yeah well I mean some of the artificial cells

we're building them out of DNA

so

that's kind of even harder to shut down

it's even harder to shut down

because now they're built out of the same material

Thanks for watching!

Neural Lace Podcast 3 (Auto transcript needs fixing)

Apr 22, 2017

Original Audio here https://youtu.be/_yKjtTVoVIU

Audio Transcription by OpenAI's Whisper

So, welcome to the NeuroLaze podcast, episode 3, with Eric Matzner

Matzner

Matzner

Happy to be here.

Happy to have you on the podcast, Eric.

So Eric recently gave a talk on neurogenesis, which was fascinating, in eye-opening.

And while he was giving the talk, we had a peek at his computer, and he had countless

documents that, countless, would you say, he studies the brain.

It's pretty obvious.

Countless research documents into how neurogenesis works, I mean, just the unbelievable amount of files.

I've never seen that many files.

That was just my desktop, I think you guys saw.

So this man studies the brain, and when you study the brain, you're a neuroscientist.

So when I found out that I would have the chance to talk to him for the podcast, I jumped at it, because that's what he does.

To be clear, I'm not a classically trained neuroscientist, but I definitely think it's been more time researching the brain than most neuroscientists, like scientists and doctors.

I pretty much, through my business of running Neutropics Company Neutro, I am basically a paid researcher all day long on enhancing the human brain and memory and learning and the growth of neurons, which is what neurogenesis is for those who don't know.

And that's something that I try to find a practical application for, instead of just doing research, I live the research.

Eric Massner is the CEO of a Neutropics Company.

So we're finding out what is Neutropics and how do Neutropics interface with neural arrays?

So that's, if we're using neuroplasticity changes and neurogenesis changes, and since Neutropics facilitate neuroplasticity, the change between connections and neurons, it might facilitate the integration of these devices.

I actually was in discussion with a couple doctors, one who's doing some biofeedback things and otherwise, and mentioned to him how these things, you know, Neutropics might offer a way for the body to more easily integrate with these devices that are people are trying

to learn and use stimulation and muscle stimulation through their devices.

We've got like Adam Gazzelli has some biofeedback devices and a couple other people I've been

interested in getting into with, but there's honestly not a lot of research in combining

Neutropics with those activities.

There is definitely some research on Neutropics plus brain training, has a better effect than

either alone.

Now, so as a researcher, how far have you dived into like the metabolism of neurons

and glia and how that functions?

So I mean, I'm interested in, you know, the mitochondria a lot, which are making the

energy in the brain, ATP, correct.

So increased brain activity does use increased mitochondrial activity.

Absolutely.

So that when you talk about brain nutrition is kind of a thing that might be required

is to increase your brain supply of the precursors that are allowing for energy building.

You also want to have the phospholipids out there, which are going to help build new cells,

including DHA, like some fish oil, because the brain might hit a physical limitation

on trying to like interact with these machinery and it may be augmented by these substances.

And I've been looking into, I haven't done enough research on them, but I'm starting

to look at cochlear implants and other type of implants and see what you can do to like

more rapidly integrate those into the brain, because I think there'll be something analogous for when we're looking at neural laces.

So I spoke to David Eagleman on November 19th, and I was, it was at an event and I just, he was talking, I don't actually remember if he was talking there, but he, I asked him about my hypothesis about how we can send VR directly to the brain.

But I was careful about how I phrased that I said, you know, if we stick all these new sensors in the brain, won't they inhibit the other senses similar to how a, well, so my idea was it won't a new sensor input regulate the intention gain of the brain and inhibit other senses.

And I don't think at that time, he was on the same page with me about what would happen because he talks a lot about, you know, adding new sensors to the brain.

So a kind of reverse example that I could show him is that if you put on a blindfold for 90 minutes, in total 100% darkness, your visual cortex seems you no longer have eyes and you may start to have like audio hallucinations if you're listening to music or a podcast and your visual cortex may begin to process what your ears are hearing.

So what I'm talking about then with neural laces is that when you reverse that process, if you take the, or even whether it's neural laces or whether it's just, you know, adding in 10 extra eyeballs, that was the correct question I approached.

If you add in 10 extra eyeballs, you're basically doing the reverse of wearing a blindfold.

And so when you take the blindfold off to your brain, you're now adding a new sensor inputs and these new sensory inputs inhibit the auditory processing back to the same levels they were at before you put the blindfold on.

So if you gave yourself 10 pairs of new eyes, it's going to inhibit some other part of your brain function that operates for your other senses.

That's my hypothesis.

At the time, I didn't get the chance to get all of that out because, you know, we were at an event, but I hope to convince him, hope to talk to him again about that topic.

And yeah, so that's, that's what I was talking about with David Eagleman.

Yeah, I've talked to Eagleman as well.

He was one of the people that I actually spoke with him after he was interviewed by Adam Giseli.

And, you know, he didn't actually, I wrote him an email and I sent him all these papers and, you know, about mossy fiber reorganization, like, and things like that in increases in like, you know, the waves in the brain that are caused by new tropos, I didn't get a response for him, but I think that he probably doesn't necessarily know the answer.

But I think that any extra usage of the brain, including 10, you know, eight more eyes or 10 more eyes would cause an increase in energy in the brain.

Fortunately, the brain is like really efficient, but, you know, weighing only 2% of our body weight, it uses 20% of energy.

And there is actually limitations evolutionarily on that energy usage, because if you use too much energy before you could get your next meal, you would die.

And so I think part of what new tropics do is they allow us to, for example, like use more of the neurotransmitter acetylcholine beyond what would be a normally okay level.

And so some people, if you don't supplement with acetylcholine or another precursor for acetylcholine, you can get a headache or you can have other issues.

So in my builds, we like put that in there, but I definitely think that shows the demand

is increased.

And, you know, also I know about neurotransmitter precursor signaling, where if you have those

precursors in there, your body will naturally amp up the production of those downstream

neurotransmitters.

So, so you were just before the talk today, you were showing me this, this was one researcher's

he has this injectable, was it injectable probe, I guess it's sort of a probe that

you inject.

And it's like a, it's like a, it just, it's a sensor that you inject and then it sends

a signal outside the brain or it looks like they're going through the brain through blood

vessels through a vein, through a vein to basically try to get in the brain without causing

physical damage.

And these are nanomachines and they're planning to inject rats with them.

I think they got them into some rats, I think we're looking at two different things.

One was a guy, I believe he's an Australian researcher who has that probe and then we

were looking at a paper called synthetic injectable synthetics or something like that.

Which looks to be pretty amazing if we can get that technology into rats, to human brains

and you know, in the rat brain, I think, you know, the brain is difficult in general to

go into because once you're in there, there's a lot of trouble you can cause very easily.

And I think that that was part of the issue with that guy with the probe is that they're

going through the blood, the vessel, so they're not going directly into the brain, they want

to like pop out inside the brain, kind of like use it as a source system and a back level in there.

I've seen some other promising technologies.

One of them was a friend who says this company was working on, I don't know if it's indiate or not, but basically they inject something in your shoulder and your collarbone basically near your neck and then they grow neurons up, they're trying to build a link from that device that sits outside the brain and build a neural pathway up your neck and back into your brain.

So that one's kind of like an interesting one to me because they're recognizing that they can't go directly in the brain as easily and they found a way to do it outside and then hook into the brain's network.

Question I have is what happens once you program into the brain, what kind of information are you going to be getting, what kind of signal are you going to transduce, are you going to be able to just come up with a yes or no the device has and maybe that's enough of a signal, are you going to be able to like wire into some other processing that?

There's a lot of different sensors and new ones that I'm learning about every day.

There's a lot of companies that have been stopped that are just announcing new sensors.

A couple of years ago I saw a sensor that's basically, it's not only a sensor, it's also a transmitter and so it senses electromagnetic waves and transmit them.

There's a number of companies that are building artificial neurons.

One in terms of like new tropics and energy demands are putting on the brain and ultimately an artificial neuron to really behave like a real neuron would be able to supply the brain with energy in terms of being a proper interface between the brain and not just like feed off the brain or interface like a normal neuron.

So that means it would need to have the similar structure and it would need to release neurotransmitter

chemicals.

So if you're making a hard machine, you're really going to have to keep resupplying those

neurotransmitters or have some way that it can what's called endogenously produced.

So it either needed, what it could try to do is potentially tap into the body system

for restoring these neurotransmitters already and put those in.

The question is, could it generate its own new neurotransmitters as things called neuropeptides

for short chains of amino acids, they can signal as if a neurotransmitter.

In my gold pills, there's something called NUPEP, which is a Russian dipeptide form

of paracetam, paracetam being the original and the tropic.

A dipeptide form being the short chain of amino acids has a much easier way of crossing

the blood-brain barrier in the stomach and other ways to the body, but it's considered

a neurotransmitter in that way.

And there are also hundreds of neurotransmitters, we don't even know all of them, and we don't

even know even the limit on how many there are, but realistically we talk about less

than 10.

People know about serotonin, dopamine, acetylcholine, epinephrine, and I don't know what other

people know about.

That's what I mentioned that biohackers working on creating artificial cells from DNA.

So hopefully that means eventually, and it's still like this hasn't happened yet.

It's sort of like one of those holy grail moments, like can we create an artificial

cell?

Actually, I don't know.

There has been some recent announcements.

I mean, there is somebody who has made, they've made an artificial life form that has its own type of programming.

Whether that is relevant in the brain, I don't know.

I think we'd be much more able to like, I think, like looking at like TCDS and like sending electrical waves to the brain.

Transcranial, direct current stimulation.

Yes.

Looking stuff like that where you're like physically stimulating the pathways or they have, you know, where they optogenetics, where they put in a light sensitive gene from a jellyfish that when you put light on it directly, actually on the brain, it turns on the brain engineering human brain cells and then injects them into the brain.

Yes.

It would involve modifying the brain's DNA.

And those, I thought, well, transcranial magnetic stimulation seems like it reaches deep into the brain from remote.

The big problem with that, I heard, is that it's actually like trying to interface with the brain with a shotgun.

It's like too big, but they're currently working on reducing it to, so it's less like a shotgun and more like a surgical knife.

Yes.

They have some that are implant in the brain for people with strokes and other types of ailments that will, you know, try to stabilize the brain or fire.

You know, we're starting to get pacemakers built into the body that automatically like gives your heart a shock if it's needed.

So I think that there's things that are making progress, but again, yeah, they are definitely shotgun type approaches.

The brain is just difficult to experiment in human brains.

Like even cracking open a human brain is not something you do lightly.

So I think we really need to figure out methods to do this in animals.

And that means from whatever's forgotten animals to humans is 10 to 20 years at the current cycle.

Hopefully things speed up.

Okay, so what I'm advocating is that we use some new wireless technologies that I know about are coming to the market.

I mean, there's a lot of different ways we can go about solving our list, but we should use wireless.

For example, let's say let's take the topic of tractography, which is usually associated with MRI and diffusion tensor imaging.

The traditional course of tractography is that you do basically an MRI scan for multiple angles, at least three different angles, and then you combine the different, you like you have an X capture and Y capture and a Z capture, and you combine the different angles.

The computer figures out the geometry of all the, it's receiving the image capture from different angles and it's creating an image in three dimensions.

That's great if you want to control your computer while sitting inside this giant MRI machine in a hospital.

So little known secret is that tractography is not, it's tensor calculus, it's not limited to the domain of giant magnetic machines or MRI.

So if we can stick multiple sensors in or near, let's say that we stuck, we can do tractography with other kinds of sensors, which is the point I'm making.

And that means that you're taking multiple snapshots from different angles of the brain and then you're using a computer program to stitch together those images and to create a 3D model of that space.

Even with, you know, the limits of what you can do with MRI though are not really reached.

Like currently MRI, you know, you're getting like the box of size could contain, you know, like a thousand neurons, for example, or many more than that.

And that's not the definition we're going to need for neural lace.

But if you're taking 3000 images from multiple angles, right, and you're doing tractography with them with a massive amount of images, and then you're thinking about something from virtual reality, which is called, which people have tried, there's, it's called photogrammetry where you can, there's an app on the buy called realities.io, where you can walk inside a virtual room that looks it's photorealistic and you can lean around when I was at CES 2017, I tried this new technology by a company called HypeVR.

HypeVR introduced the ability to walk around inside a video.

So you're moving inside a video and at the XTechExpo recently.

So the PlayStation VR chief, Dr. Richard Marx, showed me a demo of the new Sony technology being developed in the UK, which allows six degrees of freedom, position tracking at the, from a regular 3D 360 video.

And actually, Facebook just unveiled some new cameras that at F8, that actually make a lot, basically, they're not going to sell the cameras directly, but it's a hardware spec that allows you to have, you know, either an X24 or 24 cameras or six cameras in one device allows people, less professionals to capture video with six degrees of freedom.

With both techniques, though, you obviously would have some occlusion, depending on how far away you move, attempt to move from the origin point of the camera.

So these are primarily aimed at professionals to record like concerts and movies, plays, live shows, and then the concert itself, the concert hall or the producer of the film or the of the show would then do a lot of post production to fix it.

So that is the technology coming down the pipeline that allows us to do basically video grammatry to move around inside the videos in real time.

So the next step then, of course, is to take the basic, the core of that video grammatry process, which is photogrammetry and applied to medical imaging, like a massive, like your camera looks amazing.

It's massive and it's super expensive and it creates like, you know, that's light field is amazing, but it's it's also a firehose of data.

So Hyde VR has got this advantage where they're using actually just normal compression, but they're bringing down the size of that data to something you can you can download on and

watch on your Oculus, which is a huge step forward.

You got to you got to compress it.

You got to make it shippable.

But now Sony in the UK has come up with a technology where you can take a standard 3D 360 rig,

which is so much less expensive, and you can make a you can make a movie that you have

position tracking and I was in this was in this concert hall.

And I noticed that the reflections just like looked a little bit too good.

I could lean around corners, the parallax is too good.

And this is because, you know, when you do photogrammetry from a fixed point of view,

you can't see what's around the chair.

So so the solution, this is going to be an enterprise solution.

It's not immediately like available to, you know, this is for people who make it's going

to be for people who make concerts to actually, I need to get through this little bit faster.

Yes, sorry.

Yeah.

So but what are they going to do with the technology related to neural aces?

Okay, so so the point being is that this technology is coming down the pipeline so fast.

What you can do with it, though, is you're turning four dimensional video and the computer's

figuring out the geometry from four dimensional video from all these different angles.

And it's creating like, so this is the technology that we can now apply to medical imaging.

So instead of like focusing on the outside world, we turn this around and focus it on the inside world with, so we take 3000, you know, images of the brain with tractography

from different and we're combining it with not photogrammetry, videogrammetry, right?

And which is a massive, you know, computational problem, but we do that and now we can track

like, you know, basically like, you know, everything going through a specific region

of the brain, or at some point, we're going to be able to do the entire brain.

Is it still concerned neural aces if it's purely external on the brain?

Well, so the information, so yeah, because if it's pure, so we need to, we need to do

two things with neural aces.

One is sense and one is transmit.

So we need a two way directional information.

So for the research purposes, that will get us halfway there.

Then we need to transmit the stuff back into the brain.

That's the other half of it.

What I'm saying is that there's all these, so we have, so what I'm working on is new

designs for combining new forms of tractography with technologies like videogrammetry to do

the, to figure out, basically we're getting a lot of new brain data.

Then what I want to do is take 12 DGX-1 supercomputers and video supercomputers, each costs like

$129,000.00

And we're going to take that data and see, there's a lot of brain wave data that, there's

a lot you can do with a supercomputer right now that's not being done.

Current EEG has not even reached its potential.

Current MRI or DT has not reached its potential, not yet.

But I want to take this, and I want to take, I want to do sort of like a self-traffin car project where you are analyzing the biomarkers of the person, their heart rate, their pupil dilation, their eye movement, their body movement, their, all their medical, all their medical imaging, you know, their eye and everything.

No biometrics are good.

And then, and then we will need to do the environment too.

So the environment is like, you know, Facebook just announced at the F8 today that they have AR product that they're shipping and AR is computer vision of everything on your table.

Your cup, your glass, the table itself, it says this is a bag and now it's made a virtual object of it so that your apps can, with your phone, interact with your table.

It recognizes everything around you.

So we need this kind of technology, which they're taking from like, you know, in this super, the, the supercomputers that goes in the back of your self-driving car and they're making it work on a little phone, which is just incredible.

But we need to categorize the objects in, in the environment.

And then, so this is what the 12, this is what the 12 supercomputers are going to, they're all going to be categorizing what's in the environment with what's going on in the brain and they're making the links between the neural correlates between the object on the table when you're looking at it with the eye tracking and the pupil dilation and how you respond and then the, the, the, the tractography of your, of your brain and how you're, what's happening in there in terms of electromagnetic waves or neurotransmitters and so we're going to figure out what those signals are exactly.

And I think we start to translate what we're seeing and doing and feeling and the space

so that we can let this device, it's on us or in us, yeah, comprehended.

I think that's a starting point.

I think as much as you could do outside of the brain to start processing for the neural

lace is, is important.

I also think it's possible, like for example, I have something called a North Paw and it's

a magnetic, it's a band that goes around your ankle, it has like eight pager motors,

one in each direction and it has a digital compass and it constantly vibrates the direction

that North is in.

Yep.

And if you wear this for a while, you start to just know, like it's literally vibrating

all the time you have it on and lasts for like eight or nine hours.

And so all the time it's on, you know which way North is.

So your brain starts to feel this and you eventually stop feeling the vibration, you

just know which way North is.

So it becomes pretty easy to like add in information into the brain, which is something

I really believe the brain will function like a USB port.

I mean, I met Neil Harbison at a body hacking conference in Austin a year or so ago.

And he, you know, Neil Harbison is a first official cyborg.

He has a picture with his passport, went with the device in his head.

He's colorblind.

And so he actually has a camera in his head that detects color and transmits it into vibration

and vibrational signals that correspond to different color, to different sounds.

And so he actually, he's a real synesthetic where he hears color.

And so he could look at you, you have a black shirt on, he would know the tone, even without

being able to detect it, he could look behind him and he's actually able to basically feel

color in a way and feel a new sensation of how someone lights up basically how they sound

from their color.

So he's really doing something interesting and he could tell you what color it is based

on the sound.

And he has a true innate feeling that is like an add on into his brain.

So I think that our brain has the potential to pretty easily add these things in if we

feed it the data.

So I think, you know, playing off what you're saying, if you, if we figure out ways to feed

it this data, the device can like maybe understand more without having to do any processing in

our brain and it can then interpret it and signal to us what's going on.

Yeah.

And I also want to, you know, so I also want to talk about the feedback that the neuroscientists

use.

We were talking about before the podcast neuroscientists are beginning to speak up about provide feedback

about what they think is possible in terms of neural lace, you know, especially with

narrowly being a big topic.

And I've been getting feedback personally like people are like, well, you know, why would you like give away, you know, the secret, don't give the secret sauce away on your podcast and like, are you devaluing yourself?

Like what's your value proposition?

If you want to work with a company that's doing neural lace tonight.

And so I wanted to maybe bring that into the conversation a little bit because, you know, we're talking about, you know, here's the thing is that the thing I want to say is there's no secret sauce for neural lace, you know, I could talk all day about all the things we can do in terms of computer imaging in terms of, you know, but that doesn't see, you know, Google can give away TensorFlow and they did.

TensorFlow is, you know, the deep learning library.

But the thing is, it doesn't replace the fact that, you know, Google has its own chips, they have their own servers, the servers are massive, they have their own engineers, the engineer themselves are not giving away their value.

The value of creating the neural lace podcast and talking about all this stuff is that I can reach more people with this podcast who will say, Hey, man, that's a great podcast.

Here's what I've been working on.

And they contact me.

And for example, like I reached out to Elon Musk and I started, I raised a 10 million, you know, go fund me.

And I'm not relying on that at all.

I was like, why not, why not do it?

Some people are like laughing at that.

And I'm like, why not?

You know, the thing is what happened was someone, someone called me the next called me up the

next day.

And actually we're going to talk tomorrow.

And the thing is, they basically they're saying, okay, what would you say to Elon Musk and

all this stuff?

And I said, do you, and then I'm answering, or so do you know what Elon Musk, he says,

no, but I know this other guy, and this other guy wants to do, my impression is this other

guy wants to do neural lace.

So it turns out it's not just Elon Musk, it's not just Carl, it's not just me.

There are other companies in stealth mode that want to do neural lace and that's the value

of this podcast.

I'm not giving away my value, because there is no single secret.

I mean, I know my value is not just the libraries in my head.

It's also my network.

I mean, I know companies that have products that like new sensors that have, you know,

a massive capabilities that I know Elon Musk doesn't know about.

So if companies want to work with me and we can, we can beat Elon Musk to the punch.

That's what I'm saying.

Personally, I would never bet against Elon Musk.

I know George Hots is a friend of mine and I've seen him bet against Elon.

It generally doesn't seem to work out well.

I also, you know, I'm on a hyper loop.

I'm on a team building the hyper loop in the Elon Musk competition.

No, no, I'm a fan of Elon Musk.

I'm for encouraging the diffusion of these type of technologies because they offer us a way to upgrade ourselves in a serious way.

I constantly wish I was a cyborg or I could clear the internet and get an answer back.

That would be probably, you know, a whole sea change in terms of learning because at the moment I struggle with the physical limitations on integrating information into my mind.

I read at, you know, 1200 words a minute or so, which is basically at the beyond, well beyond the normal.

Nice.

Is that photo reading?

I use a form of what's called RSVP rapid serial visual presentation where it puts one word at a time.

Oh yeah.

And I've tried that.

That's an algorithm.

The company named Spritz kind of redid this algorithm and then got ripped off by everybody.

Nice.

And so you can find generic open source versions of it where other ones are just.

Yeah.

If you really want to, like sometimes when I really want to digest a book, I'll read

it the normal way and then I'll do it also with that app.

I just speed read first.

If I really felt like, you know, people say that to me all the time, but if you're reading

a book and it takes you like a month because I'm reading a chapter by chapter, I read

Ready Player One in like three hours.

So, you know, it's a few hundred thousand words.

I was able to take it in.

That sounds really reasonable because it's actually the audio book version of Ready

Player One is six hours.

Okay.

Yeah.

So the speed reading of three hours is totally reasonable.

It's your brain can handle it for sure.

Yeah.

So I mean, there is a limitation on like how fast audio processing.

I think there is not really a limitation on how fast your eyes can process if you're

able to like form the syntax around it.

I kind of use my own tortoise synesthesia to do that, but I would love for those words

of those thoughts and those ideas to pop into my head.

So one of the ideas, David Higelman talks about, he says, if you put a blindfold over

your eyes for 90 minutes straight, what happens is your visual cortex, which takes up two thirds of your brain activity, which may be part of why your eyes process stuff faster, two thirds of your brain is doing your visual stuff.

If you cut that off for 90 minutes, like total blackness, not a single speck of light, your visual cortex will then start to process other stimuli that's coming into your brain, like from your ears, for example, or from vibrations.

The light is the fastest traveling thing we know.

And so the neurons in the brain actually fire much slower than the speed of light.

But the idea, though, is that eyes evolve in nature because it's the fastest signaling and whoever's the fastest is going to survive that interaction.

So you have multiple development of eyes throughout.

But what's interesting, though, if you're listening to an audio book after you turned off your visual cortex, then you start to visualize the audio book.

And so now you have your whole visual cortex integrating that audio information and working on the audio information.

And I think that's exactly what I'm saying, though, as well with the Northpaw and these other things is that your body quickly adapts and the brain can reroute around.

When people do go blind, their sense of touch, like the sense of touch of Braille readers is amazing compared to like you or I, like we would not, you could touch us with something.

We wouldn't know it, but a Braille reader would know a lot more.

So one more thing I wanted to bring up in my podcast is that, you know, when someone does, one result that surprised scientists recently when they do MRI scans was that the brain wave pattern that when someone gets when they're looking at a real apple is different from what they get when they're looking at a virtual apple.

And they couldn't figure out why this is.

And I think there is an obvious answer to that.

So I read this book and scientists should read this book, it's called Criteria Causation.

Actually, it's called The Neural Basis of Free Will, Criteria Causation.

I think a lot of people did not read this book because it has the word free will in it, but you should read this book.

You especially should read this book because you're a hard, because you love neuroscience and this is a hard neuroscience book, The Neural Basis of Free Will.

Peter TSE, I don't want to mispronounce his name.

He's a brilliant guy.

You can watch his, well, some of his talks on YouTube.

So Criteria Causation is this, it is the answer to why you look at the way your brain is going to be different when you look at an apple versus when you see a virtual apple.

And this is important to neural lace because if we send an apple through the computer and through the neural lace, you know, okay, so we have the brain imaging, okay, if you know you're getting an image through your neural lace, then the brain wave pattern of an apple you're getting through neural lace should be different from a VR apple and it should be different from a real apple.

And the reason why is because you know it.

So it's like, okay, so, and this also, I don't know if this is going to be too much for one podcast.

So, so the idea is from Criteria Causation is that your neurons are coincidence detectors and they're only detecting, you know, like he'd be in learning, they're only detecting when a neuron receives a signal between a certain span of time, which is it's modular that neuron can adjust.

So that could be like three milliseconds, if it gets two signals within three milliseconds, then it activates, right.

And so you have this coincidence pattern and you have a network of coincidence patterns.

So let's say that in the brain, a quint when your neuron activates, well, this is this is a computational biology idea from, you know, the idea that when you're when you're in your action potential fires it's a one and when it doesn't, it's a zero.

But let's say that, I mean, it's, and now we know it's actually more, you can't summarize it so simply.

Now we know it's a little bit more complex than that.

Yeah, it is.

But you mean, because because a neuron has this, the dendrite is itself a computer and you can't just really like reduce all information to a one, besides the action potential has amplitude as a wave, and plus you're really talking about whole networks, you know, not the signal.

Yeah, I think I think part of the problem is, is beyond the such simple signaling.

Yeah.

If you look into something like quantum nervous, like quantum biology, sure, yeah, it throws all this stuff to the wayside in some way, not all of it to the wayside, but there are some complex things like quantum tunneling of the mitochondria, the observer, the observer effect.

How do you square the observer effect with neural A's?

And the, you know, I do have a proposal for that.

Yeah.

Well, I'd like to see it.

I mean, I think there's some interesting, you know, ways we might go about, you know, figuring this out.

If you, you know, when you look at like the small brain mammal preservation prize, they're like turning their brain to glass, right?

They got all the position of the neurons, but they lost all the metadata.

So my thinking is that, you know, that a particle is like, it's like a polarized wave.

And a wave is like a, the decoherence pattern that you get through the double slit experiment when you observe it is like a depolarized particle.

I mean, usually when you talk about polarization at that level, you're talking about, you know, as a particle travels through space, which direction is it, is it pointed at, you know, the electromagnetic wave, but a particle itself could be also considered a kind of polarization to different, different kind of polarization.

So my thinking is like, what if a particle is like a one and the decoherence pattern is like a zero?

Okay.

And then now, so when I observe a particle and there's a feedback loop, so this is what

I said is, is when we communicate, when you have neural layers is if the brain is like

a network like the internet, is it more like TCP transmission control protocol or more

like UDP user datagram protocol.

And so with TCP, you actually have to have a connection of feedback loop to between the

two points.

If we have a connection to what we're observing, then observation and the observer effect is

more like TCP.

Right.

It's not, we're just, it's not what we intuitively think it's not just a packet of data thrown

at us.

We're making connections to what we're observing.

It's a packet signal and something coming back.

Yeah.

And so that's why, so when we observe something, if it turns from a particle into a wave
decoherence

pattern, it's like when we're observing something, we're getting the one, the one's coming to

our brain and it's turning into a zero.

It's like the one is traveling from the universe into our brain.

See?

Yeah.

It's interesting.

I mean, there's some weird things with the feedback in the brain.

I mean, like I wanted to, I didn't want to interrupt you before, but when you're, when you're talking about the VR world being different than that, I gave a talk called, I have a talk called VR in the mind.

Yeah.

That basically looks at the neuroscience between virtual world and this world and what makes you basically embedded into that.

What makes, what are the properties that make you actually feel like you're in there?

By the reason people fall over when they're like, when they're in there and why, you know, part of it has to do with the speed, the size, the color, and if you get these like four or five different things right, the brain does believe you're in there.

But then there's a number of experiments they do where they take, for example, they'll put your arm, they'll put a heating band on your arm in the real world and then they'll project a fake arm in the world and then in the same position though with another band on it and they'll change the color of the band, depending on, and they'll ask you at what temperature does it seem too hot?

And so if they have the color as blue, which is traditionally in the brain, a signal for cold, the temperature which they feel it's hot is lower.

If it's red, sorry, the temperature could go higher when it's red, they feel it's arms burning before it's reached that same temperature.

So how do I know something is, is hot or cold or how do I have a concept of hot or cold or how do I have the concept of a cup?

Well, in deep learning a concept, which deep learning is sort of based on neuroscience, a concept of a cup basically is sort of a map of all the links between all the different lines and edges that the computer is seeing that make up the cup, that it's associating with the cup.

So it's really a map of associations, any concept in any domain, whether it's audio concept, concept, whether it's audio visual concept where it's like, you know, I have, I see a microphone and I hear, I mean, I see a tripod and I hear a tripod when I knock on it and I'm not going to knock on it because I don't want to mess with the microphone.

If you've had any kind of concept, all it is is a map of the associations between all the different lines and edges and colors or sounds.

It's just a map of bits, yeah, into a pattern, it's like a bucket of ideas, but there's a coffee cup and there's a water cup and yet one has a handle and one doesn't, but our brain knows they're both a cup, right?

So the idea is that what I'm seeing on the table though is a concept, I'm not seeing anything other than a concept.

That's why like, let's say the corner, for a human, in the corner of your eye, you don't have the same sort of color vision in the corner and you only focus on what you're directly looking at.

So what's to the side of your eye is kind of blurred out, but yet you experience a table as, you don't experience a table as something that loses color in the sides of your eye or something.

What I'm saying, the point is that what we're seeing is a concept of the table.

There's all sorts of optical illusions you can see to sort of like, you know, there's actually a hole in your eye and you can use a pencil at about the length of six inches

from your eyes to figure out where the hole in your eye is.

You're not seeing anything at all with that hole, but you don't notice there's a hole

in your eye and your everyday observer thing.

So we're not seeing anything except for a concept and the concept is actually consisting

of, so let's say that we have, you know, in the brain with criteria causation, we have

networks of coincidence detectors or networks of, so coincidence is a bit and we have all

these bits that are being, the associations are being mapped until I have the concept

of a cup.

This is in my mind and we're also mapping this with imaging.

So this is what we're doing when we see a cup as we have a map of associations of coincidences.

And then what I'm doing is taking this map and, you know, capturing it with all these,

you know, sensors and all this artificial intelligence technology.

And then once I have it, once the computer knows that, oh, this is the, okay, so back

to the apples, back to the apples is because we're running out of time.

So the idea is why should the brain image of when you see a real apple be different

from when you see a virtual apple and when you see an apple with neural lace.

And the reason is because an apple is in some sense the criteria summation of all the different

pieces of criteria that you've put together.

So because you're in an MRI machine and you know you're in an MRI machine and you know

you're seeing a virtual reality, the sum total of your experience that you're observing

is based on all this criteria that's based on all the knowledge of everything that's true and that unique brain wave pattern must be different.

In fact, because the, between the two, between whether it's a real apple or virtual reality,

because the information that's summing up to that unique brain wave pattern, that neural

correlate is has to match the, the, that's some of that information has to match the

sum of the, of what's true for that situation.

So if you're seeing a virtual apple, a virtual apple, it should have a different brain wave

pattern from seeing a real apple because it is different summary of information in your

real life, different brain wave signature.

What about every, isn't every apple you're going to see throw a little different brain

wave, like a red apple versus a granny Smith versus a, yes, yes, a granny Smith, a green

apple and a red apple should have a different neural signature.

Yeah, that's, that's what I'm, I wonder about honestly, my biggest question is how are we

going to get to like a drilled down level of the information going across into the brain

and out of the brain?

Yeah.

Like I use some of these biofeedback, neurofeedback headsets, for example, I can use where I meditate

and I can control the weather pattern and I have a game where we can measure the brain

intensity and I can hover a ball at different levels and I can move through an obstacle

course and I, there's all these things, but the, and you know, I'm ready to, I make a

joke that I'm ready to start shaving my head just so I can wear the EG headset, you know,

like, yeah, but I, you know, I'm much more at this point, I think there's a lot of stuff that could be done from the outside of the brain.

And I think that, you know, then we, we would probably move into the neural ways or something inside the brain that can, I think we should really be really good at reading before we start trying to write and like to create, but obviously that's where the big benefit is, is like, is being, but I think you can also write by, you know, there's these other trainings of brain waves where they say like, imagine you're closing a box or you're like opening a box and then that could correlate to something completely different and you just trigger that visual fingerprint of electrical activity in your brain and it can like open and close the door, you know, and so nice, I think a lot of it could be basic like that.

I mean, I have, I was thinking that the, you could also use some audio input into the neural way so you could say the thing or you could at least think the pattern it might go into your brain.

How do we get things into the brain?

So generally there's something called the blood brain barrier, which is as it sounds the barrier that stops the particles of a certain size or certain shapes or certain class from entering the brain.

However, I have seen some recent studies that might allow us to temporarily put down this barrier.

There's an ultrasound technology that's using little tiny micro bubbles to basically fire if you fired at this barrier, it puts the barrier down.

And so there's going to be a lot of other molecules that maybe had been too big or had otherwise been ruled out.

So I think also that part of the brain is actually below the blood brain barrier.

So we could target, if you like the old brain, if they've talked to a lower part of the limbic system, especially the part, you know, coming into the spinal cord area, that's another way to read.

It's just another option.

If you're trying to hit that like quote unquote crock brain, you have like some of your, that's more where your reactions are and things.

Well, I think a lot of the neural lay stuff, but it's also, so it's also actually all your incoming senses hit the crock brain first.

So that's like the convergence point of all your incoming senses.

So it's a key interest for now.

Yes, but your thought and your conception of things that are not immediately based in this moment where you're like, that's your prefrontal cortex.

It's kind of the later parts of your brain to evolve.

And where I think a lot of neural lace activity would go, so if you're trying to shock me to get up, you want to maybe use something in the cerebral cortex.

To debate you on the topic, my feeling, and which could be wrong, is that if we target the old brain, we can, we can, I want to do VR for the brain, which means VR and AR with our glasses.

So I really am focused on the old brain because I just want to be able to send an image to you that you interpret as VR or AR.

So that's why like, you know, I'm into like the sensory areas, the primitive primal areas.

You have basically a whole other area for visual processing.

I'm not interested necessarily in messing with people's high level thoughts, not yet.

The first product of neural lace that I'm interested in building, we'll just mess with the, not mess with, we'll be targeting the lower level primal sensory inputs.

That's interesting because I would probably, as a matter of debate, think that the best spot would be, would be to go to the higher levels.

Because that might offer you more flexibility in generating images or things to force feedback into the brain.

One other thought on that, on the note of that debate real quick is that the, you could sort of imagine, I imagine the brain as a feedback loop as a whole, as basically a fractal of feedback loops, if you will.

So there are, you know, grand feedback loops, a small feedback loop.

So everything comes in through like, through our senses, to the thalamus, to the old brain, it goes through the neocortex, which is the new brain, the new rind, but then at the peak of the neocortex, it actually comes back to the old brain, back to the thalamus.

As if the thalamus is both the entry point of the senses and the top of the pyramid of the neocortex at the same time, because it's a big loop.

So that-

I understand that, but some of your context of the cup and the apple, if you read about people have a stroke, they can't recognize basic objects sometimes.

Well here's another possibility is if we can just interface the brain at any point, regardless, and we can call different parts of the brain, but basically like if we have the transmission protocol of the brain, which I like to, it maybe has to alternate between, you know,

the two, like UDP and have, you know, self-authorizations like HTTP, but for the brain.

And once you have that communication protocol, if you have a brain port, no matter where

you're connecting to the brain, you should be able to request any other information

from any part of the brain.

I don't know the word.

Have you ever heard of the claustrum?

Of course, yeah.

The claustrum.

The claustrum, yes.

So the claustrum was Francis Crick of Crick and Watson.

He was working on that until he died.

I recently became very interested in it.

It might be another topic for one of my talks, but he basically posthumously had published

a paper on the claustrum.

He was working on that until the day he died.

He really believed he found the center where consciousness exists in the human brain.

Whether or not you believe that, I mean, there's some, there is some evidence that it actually

plays a role integrating information from all the different areas and could in turn

actually be related to generating consciousness.

So I don't know, you know, think we even know the real target point of where we want

to enter the brain.

I think if we want to have the neural lace, be able to like lift your arm up, you know, we might want to hit deeper in there, but we want to like imagine a spaceship floating on the table that we're going to want to hit the higher level parts of the brain.

Great.

Great to debate with you.

These are all great ideas.

Definitely, you know, it's not, it's not a really what our debate is pointing to the fact that there is no secret sauce for solving our lace.

We can talk about neuroscience all day long, but you're not going to, you're not going to get the magic trick from, from a single podcast or a series of podcast series is too much information.

I think we're early enough along in the neural lace race, the neural lace, turn to a poor mentor, but basically no one knows how it's going to be solved yet.

I think there's some leads and some, you know, hunches and, but what we can say is that we can see that there are things that we can do that have never been done before and we're going to do them.

Yeah.

I mean, I definitely, uh, I'm bullish.

I think that we'll reach some level where it doesn't make sense to, I'm talking about, I'm talking about applying self-driving car type technology, artificial intelligence, computer vision, all this stuff hasn't been done yet.

Why not?

Let's do it.

Well, Mike, I hope you do it.

I would love a neural lace.

Let me know.

All right.

Cool.

All right.

Thanks, man.

Thank you.

The Neural Lace Podcast #4 Guest: Andre Watson

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Welcome to the Neuro Lace Talks with guest Andre Watson, host Micah Blumberg, edited by Adam Alonzi.

I see myself mostly spending time between the world of engineering biological systems and materials and science,

materials science and engineering as relates to making nanoparticles to deliver genes to different places in the body.

So what I spend my day-to-day really building is my company, Ligandl, where we are using Ligands or things that stick to different markers and things like receptors

to guide these vectors for gene therapy to really specific locations in the body.

And I have spent a lot of time on thinking about Synapse Physiology.

I was going to go to McGill for a neuroengineering PhD, but I decided to come out here and work on this.

So I really love pharmacology and for me, understanding consciousness or at least a piece of it is incomplete unless we try to look at the molecular picture too.

Yeah, I agree.

So it would be really fascinating to talk about maybe how that plays a role in the future of the human experience and also how we're going to build machines that capture various aspects of human intelligence.

What got you on this journey?

What got me on this journey was a book called Unintelligence by Jeff Hawkins. He was a neuroscientist at the Reading Institute and he was also the president and founder of POMP, made the POMP pilot and the POMP 5 and the hand-spraying device.

And then eventually that sort of, you know, then iPhone came along and sort of took over the market.

So the POMP went away, so what Jeff Hawkins did instead was he started a neuroscience research institute and he wrote a book called Unintelligence.

And he started this computer company called Numenta and Numenta has their whole idea is basically create a computer that's based on the neocortex.

And so this computer uses what they call hierarchal temporal memory and they say the neocortex is like a hierarchy and the top of the hierarchy is thalamus.

And so hierarchal temporal memory means that, well, basically you're sort of describing the structure of a neural network, like as if a deep learning network was specifically structured like a hierarchy.

And so the lower levels of the hierarchy would just focus on the lines and edges and bits and at a higher level you turn the lines and edges into the computer recognizes a concept because it's like a statistically relevant coincidence pattern.

And then at a higher level of the network, you have the computer begins to put together the concept of eyes or words or, you know, it's just basically a map of the associations of the lines and edges.

But at a higher level, the computer says this is an eye because that's what the neural network represents with its weights at different levels.

So, so basically he was describing his book on intelligence he was describing deep learning, which was sort of like this.

So the neural networks that existed since since the 80s.

A lot of a lot of great designs for computers came from the 80s.

But now that since 2012, we, you know, we had some new ideas about how to make the neural networking deeper.

So they called it the deep, deep learning, because you pretty much going to get about three layers deep.

And now you can now in some cases there are networks that have 300 layers deep.

My curiosity as these technologies evolve is the level at which we'll really be able to understand and or emulate the human experience.

And that's something that would be really interesting to discuss with you because I've spent a lot of time thinking about synapses and sort of how things build from a really bottom up level just, you know, molecular pharmacology,

how different drugs and ligands and things in your brain bind to these different receptors in order to create all these different effects.

And something that I've learned through studying that is the amount of layers within even a single synapse of the gradients of state that can exist at any given point in time to represent any range of things that are not just a one or zero or an on or off.

I feel like that is something that isn't talked about very often or frequently. And I'd like to at least think about and sort of forecast, you know, as we build these technologies.

An EEG can tell you some basic things. And if you have a direct interface or some more advanced technology, you can learn a lot more. And certainly even with existing fMRIs, we're able to recreate visual imagery that our brains are seeing based on the fMRI data on its own.

And so, as a starting point, there's definitely a possibility for having some interfaces. The question is, a lot of people also speak about these technologies eventually being able to completely function as humans or transcend humans.

And while I believe that we will have different AIs that will do different things, I really wonder if we're going to see humanity become obsolete or kind of the core driver of all of the peripheral artificial components that become the future of humanity.

Sure. And I never thought about that. Because, so do you remember, Steven Spielberg made this movie called AI Artificial Intelligence. And in the movie, it was good. It was good. It was a vision of what the future might feature in the future.

Definitely worth checking out if you haven't seen it. But one thing that, in retrospect, the movie was fine when I saw it. In retrospect, I do have one small gripe with it.

And that is that the humans made the distinction between mechas and orgas to say that you're a mechanical robot. You're a mechanical person. And I'm a real person.

And so, this is like a really, see what's interesting is, you know, you say, well, what's an organ? Organ means organic. It means grown. And mecha means made in a factory or something, artificial.

But, okay, so the thing is, you know, and I've heard people describe this concept in other ways, you know, we're like, if we're robots, we're, you know, like, you know, organic robots or, you know, kind of closer being trees.

And this is like, we're not metal robots, you know, we could have a solar. So it's not possible for machines to have a solar because they don't have the same sort. These are things I've heard people say.

And I think that we are metal robots. And, and so there won't be in I said, because we're metal metal, I think humans are metal robots, because, because our, because our nerve cells, for example, are filled with metal, filled with with with any outer sac filled

with calcium ions, and on the inner sac filled with potassium ions, you know, the calcium ions are, you know, the positively charged and the, or, and the potassium is the potassium positively charged and it's also positively charged.

I guess, are you, if you're saying metal in the sense that is capable of conducting ions in the presence of a variable solution of electrolyte concentrations, then, you know, we could redefine metal for the purposes of this, though, from, you know, strictly speaking, that's not a metal.

One solution, you don't consider calcium and potassium to be metal, not if they're in solution, not if they're in solution. Okay. Well, wait, hold on. Let's talk on the table, on the table of elements, we've actually got a periodic table. Yeah.

So let's let's pull this up. I mean, yeah, I mean, they're definitely, you know, in the strict sense they are alkali metals. Yeah.

Going down from, from lithium to sodium to potassium, yes, then that's, I said, where we have the alkaline earth metals, I suppose that is a really interesting way of putting things because by moving around all these positive charges through active energy spending processes, we're able to control not only the action potentials, but sort of the, the arc of, yeah, the shape of our firing and magnetic field. Yeah. Yeah. At a really just fine, superb level of electrophysiological weirdness.

That's why, you know, I like to say I believe that consciousness is magnetic, because our brains are manipulating a magnetic field.

It's so interesting.

And that we are metal robots. And once we solve creating robots in a factory, they'll, they'll be no different from humans. They'll just be, and people will not say, Oh, this is surprising. People will say, Oh, of course, it makes sense.

The universe is a fractal. And they'll be like, Okay.

The interesting thing to consider is the, the basis of the kind of consciousness that we have versus the kind of consciousness that a machine intelligence would have.

Because we've entirely evolved even from the time of being single cellular organisms to feel the world around us in the form of receptors by these different molecules.

And you can think about the electrical part of our biology and our consciousness, but there's also at even the most baseline resolution, a physical sensing one.

And we are built out of these exquisite nano sensors that have the ability to distinguish serotonin from dopamine and a range of thousands of different compounds from each other.

And this is actually, I would argue, one of the core facets of our consciousness that cannot be adequately modeled through electrophysiology alone.

Okay, we explain that one again. You said, Why, why can't we model it?

Well, we're starting from a position of biology by its baseline interacting with its environment to use an example of the sort of sensing that biological cell can have.

You have this family of cell surface markers known as integrins integrins bind to collagen, elastin, these different extracellular matrix proteins that form the mesh of what comprises your skin and all of your tissues.

And through binding to these surface markers, these receptors, the receptors are actually mechanosensory.

As you pull on the strings, so to speak, they engage signaling cascades that are so precise that they can upregulate themselves and produce more of that specific protein or more collagen and things like that,

as well as things to remodel the matrix or break it apart and chop it up with these things known as matrix metalloproteases.

And this is just one example on describe that matrix.

So you have an extracellular matrix of, you know, we think of cells as having, you know, we have, you know, 70 trillion cells in our body.

And those cells are not just floating around freely, they're interacting through a series of proteins, glycoproteins, like sugar proteins, sugars, lipids, glycolipids,

and you name it, that are all latched together. And amidst all of that randomness that you perceive, if you were to just map what all these things are,

we're able to derive very specific information where pulling on a single receptor that is bound to by an extracellular matrix protein can trigger very specific signaling cascades that cause remodeling of the entire system around it.

And this is no different with neurons. If you think about a neuron and the axon and the dendrite being latched together, people always think of them as just, they're just sending signals and it's just electricity.

Have you ever wondered why a dendrite sticks to an axon?

Yes.

And that's, that's the same thing, actually. It's an extracellular matrix that holds them together. And you have these different surface markers that latch the axon to the dendrite physically.

So you have, for example, this family of proteins known as neturins that bind to neturin receptors, and they're one of the major extracellular matrix components that hold together axons and neturins.

What are their electrical properties? I mean, they want to, you don't want to have like, because you need this synaptic gap for the chemical synapse. So whatever's connecting the two can't, can't, you can't have an electricity running across that because otherwise it would defeat the synaptic gap.

So the properties must be inhibiting electrical signals somehow.

I think there's still a space there. I think it depends on which protein you're talking about. And I think for the purpose of thinking about how

the potentials are propagated.

It is really hard to envision scale at which this is interacting because there are, you know, 20,000 proteins and thousands of these proteins exist on the cellular surface and they don't need to be homogenously tight junctioned in order for them to be serving their functions.

You can have a distribution of a lot of things that aren't going to negatively impact the way that cell functions.

So I mean, anything that we would say about that would be completely speculative.

I guess what I'm going with this is that.

Well, someone was saying that the deep blue, not deep blue, but the guy who's working on the blue brain, he was saying that they created a model, a computer program to try to simulate where synapses would, where they would connect, where cells would connect.

And they said that basically what they found out was the computer model was able to, you know, they basically did it randomly and it was pretty much close to what actually happens in the real brain.

So they're basically, they're saying that basically in the beginning when people are born and their synapses are first growing and connecting, that it's basically like random.

What does that mean?

What does it mean for it to be like the brain? Because it's one thing to have a small set of neurons.

I'm sorry, they were specifically stimulating just how neurons would form their initial connections with each other.

It was basically, it's a controlled experiment. So in reality, there's so many other factors that could be tilting that. So yeah, you can't, when you have a model on a computer, it can't compare to the bizarre reality of a real brain.

Well, one of the things there that I really wanted to talk about is the nature of kind of, we can call it the, the now brain versus the evolving brain. Or if we want to say it perhaps in terms of pharmacology, the ionotropic brain versus the metatrophic brain.

So when you think of an action potential, when you think about these metal ions flowing in and out of the cell and being pushed around to change the way that charges work, that's ionotropic.

Oh, you're talking about the glioceles metatrophic?

No, no, I'm talking about every neuron, every receptor that generates a quote unquote signal.

You can have ion or voltage gated, you can have basically voltage gated channels for ions.

Yeah, yeah.

That can either respond to a neurotransmitter or to some voltage changing on the cell surface.

Sure.

That's all quote unquote ionotropic by definition.

Okay.

Metatrophic is everything else.

So most serotonin receptors, every dopamine receptor, if as you go through the thousands of receptors, like, you know, 800 receptors that are G protein coupled receptors, they're actually the most common protein in your body.

You have about 800 of them.

So all dopamine receptors, all but one serotonin receptor are G protein coupled receptors.

They have all these different subclasses.

G protein in itself is a ton of calculation, chemical calculation.

Exactly.

And so it is like a chemical computer versus an electromagnetic computer.

Yeah.

So think about this, right?

But the thing is all the chemicals are doing both at the same time.

Not all of them are?

No.

A lot of them aren't doing electrical things directly.

Some of them are changing the way that receptors.

Well, what I'm saying as an aggregate, as a whole, they'd be affecting the ionotropic brain.

Yeah.

And the interesting part is that if I could capture a perfect snapshot of your brain over 30 seconds of every neuron, every astrocyte firing, I would learn a lot about you.

And I could see that you're having these changes occur in your brain.

Sure.

But that exact pattern probably never happened twice.

Exactly.

So how do you model someone having more or less testosterone or being on LSD or not?

If they never have the exact same...

In your neural network, if you only capture the ionotropic part, how do you predict how each brain will change?

Well, I mean, okay, so I mean, you know, I think, okay, so I guess in terms of, you know, look at, consider diffusion tensor imaging, right?

You're basically...

You don't have to tell me more about that.

They blast a radio signal at the water in your brain, and it's a specific frequency, and it causes the water molecules to release energy, which is at a specific frequency.

And so you have a camera waiting on the other side.

So the magnet, the big giant magnet, what it does is it's getting your molecules aligned, and then they hit it with a radio frequency, and when the magnet stops, and then...

Am I doing that wrong?

But anyway, so maybe I'm describing it incorrectly, but...

Well, what is the...

So the magnet gets your waves aligned, and so they blast them, pretty sure they blast it with a radio signal, but they have to stop the magnet first.

They blast it with a radio signal, and then the result is you admit like lambo waves or something from all the particles, all the water particles that were aligned.

So the water now has to travel... It can't travel... Once it's released by the magnet, it has to travel along the axonal fibers.

It can't travel freely like it would if it was just in the ocean, right?

And so because it's admitting that specific frequency while it's traveling along a specific line, and you're capturing it from a specific angle,

you have a camera that is doing an X capture, and a camera that's doing a Y capture, and a camera that's doing a Z capture, at least three.

And then you can do tensor calculus on it and figure out the position and direction of those water molecules to become your tensors.

What resolution of data do you get from that?

So with the standard MRI or DTI image, I believe, is the voxel size, you could fit in like a thousand or more, or a lot more neurons in a single voxel.

So it's really not that detailed, but the idea here is you've probably seen division tensor images where they have these...

They're basically the really colorful images of the brain. Yeah, so they're really colorful like brain scans.

Oh, and it's MRI-based, I see. I didn't follow that. It's using an MRI.

Yeah, so the MRI is just like a two-dimensional photo.

So this is how you kind of keep track of the tracks?

Yeah.

Right, right, right. I've seen a lot of these.

So my hypothesis is if you did like 3,000 photos, you see they only need really three photos because you're just getting the basic geometry.

I think if you did 3,000 photos, sort of like using like a light field type of camera, you know, like the new light show rig where they have like 90 cameras all pointing in the same direction.

If you did that kind of DTI, and then so you're kind of like trying to figure out the light field of the brain, not only where those...

Not only like where the water molecules are and which direction they're traveling, but also, you know, you're figuring out the direction of the frequencies that are traveling towards the camera.

You know, and that's the light field. And so you could create like a hologram that has potentially a higher resolution if you're using a lot more images.

And you're going to have to use a technology-like videogrammetry, which is like photogrammetry on every single frame.

So that's the proposal for a new kind of DTI. DTI is not limited to MRI. A lot of people confuse it.

I mean, actually, the diffusion concept is MRI, but what I mean is that, oh, really, it's a tensor cataclysm. It's tractography.

And you could apply that concept to other types of sensors, whether they're inside or they're implanted inside.

So if we put sensors inside, you know, like these doctors, and you could...

If you have, you know, at least three of them, then you could calculate...

I mean, you could calculate the... Whatever you could calculate, you could do something like tensor calculus on it.

You know, just map all the ions within a specific field that you decide to focus on with your sensors.

But you could also do something like this with EEG or MEG.

Just do this with sensors that are just sort of like pointed at your thalamus from your nose.

Just point them straight up the nasal canal, you know, or, you know, shoot a sensor up the nasal canal.

As far as you can get it without, you know, breaking something.

That's really tasty.

You're drinking Urbimonte.

Sponsored by Iguayaki.

There was one thought that I had about, you know, so you and I on the phone were talking about this synapse,

and you were talking about how astrocytes and oligodendrites have all these interesting...

It's part of what you study, of all these interesting properties in terms of their networking and the back propagation and how all...

So basically there's this whole, like, people think of...

Because people think of, you know, people in computer computational neuroscience think that the brain's all about the neurons.

You mentioned that there's an iotropic brain and a...

Metabotropic.

Metabotropic brain.

There is, in a sense, you could also say there's a neural net and then there's a glionet,

and that these two nets are interfacing and...

Yeah, and there's so much complexity there, both in terms of how the neurons and the astrocytes and the microglia interplay with each other.

And does mitochondria talk to other mitochondria?

I mean, maybe there's a mitochondria on that, too. I don't know.

That would be interesting.

I mean, I'm sure they're connected via...

There are mitochondrial localization signals, like protein sequences that directly go to mitochondria,

but I mean, I'm sure microtubules connect mitochondria, as well.

But I don't know what the intra-marticontrial signaling looks like other than this sort of network of the electron transport chain, but we're digressing.

Well, sure.

Well, okay, so no...

So, I mean, really, so this podcast is about neural asin,

and there's so many different potential ways to interface with the networks of the brain.

It doesn't have to be an ionotropic interface.

You could potentially also do a chemical interface, a metabolotropic interface.

It's going to be harder.

Harder, sure.

And I think that...

But there's something special about how the metabolotropic interface is influencing the ionotropic interface, I think.

I mean, you're talking about... I think that is everything in terms of how we dynamically change throughout time.

If you imagine kind of the picture of the neural tract that you mentioned through the data of the fMRI.

Yeah.

Oh, DTI.

DTI, right.

Fusion tensor imaging.

Yeah.

Or tensor pack.

Right.

So, if you look at those tracks, how do you...

And what do you need to determine in order to have a snapshot of the person's consciousness in a way that captures the subjective experience, too?

Okay, so this goes back into... So, let's say that we're never...

Okay, let's say we're never actually going to capture the same brain signal twice.

For the same reason that you're never going to capture the same photograph twice.

And that the universe has one direction, as far as we know, because of entropy.

Or because, you know, entropy is time, right?

And so, you're never... So, it's like... But here's the thing, though. Here's the thing.

We're able to identify objects in this bizarre world.

Like, I'm holding right now headphones in my hand.

And I recognize their headphones, but I've never seen headphones from exactly this angle, exactly this way, in exactly this room, with exactly this lighting, at exactly this time.

It's all brand new.

That doesn't mean we can't identify stuff in it.

So, it's just like... That's why using neural networks to decode brain activity is going to work.

Because we can identify the pattern of broccoli in our real world.

And if we're able to look at brain waves long enough, if we had the senses to understand brain waves long enough, then we could identify broccoli in our brain waves.

What do you mean by broccoli?

Broccoli, what I mean is that... The idea is that broccoli... We learn to know the taste of broccoli.

Because, well, let's look at... I mean, a good analogy is to look at how does a self-driving car recognize if it can move forward or not?

So, you dive into this topic and it's... How neural networks work is useful to talk about because then you can start to have ideas about how our brains are working.

So, if you say, well, a neural network is recognizing that there's a car in front of its path.

It's recognizing that something is in front of its path.

Well, how is it recognizing that?

Well, you say, well, there's cameras that are pointing at this car that's in front of the car that's driving.

Maybe that's a used tree.

There's cameras pointing at the tree that's in the path, okay?

And the cameras are breaking video down and there's also, you know, lighter and a bunch of different sensors.

The cameras are breaking down the video into pixels and frames and then pixels.

And the neural network is putting together all the little different...

At the lowest level, it's putting together the...

It's putting together, you know, whether there's a line or an edge or a color.

And at a higher level, it's, you know, recognizing, well, this is a long line or this is a curve or this is a...

And then at a higher level, this is a leaf and another part of the network is saying this is another leaf.

Another part is saying this is another leaf and another part says this is a branch.

And at a higher level, it says either this could be a flower or this could be a tree.

At a higher level, this is definitely a tree.

And so the idea is that our minds are basically doing the same thing.

Your eye has tons of receptors in it.

Tons of sensors, light sensors, blue light sensors.

And you have these photons that are bouncing off your retina and they're causing proteins to flip.

And as the proteins flip, the ionic charges displace eventually.

And then eventually there's this...

You know, you have a separation of positive and negative charges and there's an action potential

and all these neurotransmitters get released throughout the network of the brain.

And people will see...

Well, signals, they say, oh, I think there's a signal traveling from the eye along the optic nerve to the thalamus

and then back to the occipital lobes and pridelobes and the rest of the brain activity.

And we're like, wow, we see this signal and we're like...

And the question is like, well, what is the brain way?

Because we see these signals and they're being triggered and what is the brain way?

And a brain way seems to be triggered by these incoming signals.

Somehow you have the incoming...

Something that you see, the idea that's popularized is that photons are bouncing off of that

and they're bouncing off your eye and then they're triggering brain waves.

And these brain waves, they have characteristics that in time, like frequency patterns

and they have characteristics in space.

And your brain as a network is processing brain waves that have their spatial and temporal patterns.

And this is the kind of information we see moving all around on the ionotropic level.

And so the basic idea is I'm thinking that if a bottle is getting translated into a brain wave

and the computer is watching the brain waves while the computer is watching the bottle.

The computer is learning the brain waves in the bottle at the same time and saying this is this and this is this.

And I'm bringing these two things together.

This brain wave represents this bottle.

This brain wave represents that glass.

This brain wave represents this table.

And even though we're never going to have the same brain pattern twice.

You still have the pattern.

You still have the pattern.

What neural networks are able to do in terms of pattern matching and the self-driving.

Even if you look at that video of what a Tesla is seeing when it is processing the environment around it.

It's fascinating.

There is some really advanced.

But here's where it gets weird.

So let's say you capture the pattern of a glass.

Now at first you could say okay well now that I know what the pattern of the glass is and I can just build that model on the computer.

Press the button and the computer sends that pattern directly into the brain.

But the weird thing is if you know that there is no glass there and the computer is trying to send you a glass.

And the glass is interfering with whatever is in your brain right now.

How do you resolve that?

Right?

You almost have to figure out like and where is the glass going to be positioned?

Is it going to be on the table?

Or is it going to be on the air?

Or is it going to look like it's falling off?

Will it cause you to have some sort of unintended hallucination?

Will it cause your reality to crash?

Like a programmer?

It's all sorts of weird things you have to think about.

The thing I really wonder about is how do you teach an AI context for the material world, the scale of things.

And the way that they interact with each other, that to humans is intuitive.

But to machines that don't have the ability to touch and feel and IDA's and understand those different things in all these different contexts.

With really the semantical brilliance that humans have despite the fact that we're really really slow at other things that the computers are good at.

I really wonder what that is going to look like.

I don't have to say that massive parallelism can make up for chemical latency.

Chemicals are slower, but if you have massive parallel capabilities, you can make up for that difference.

I think that people is often repeated that computers are far faster than human beings.

Only linear things.

That's a good point.

I actually lost my train of thought just there for a second.

The human brain, for example, has amazing metabolism.

If you take a gliosol out of a human brain and you put it into a mouse, its memory will improve.

At least that's what some studies suggest.

There are network efficiencies that our brains have because we're robots that are billions of years old.

We started with nanosensors on single cells and we've grown into fully electrically conductive organisms that still have that in them that are pretty weird.

Our network, and not only that, our brains run on the power of something like a 9V battery.

I need to check the voltage and or the wattage, but I think it was around the light bulb in terms of the wattage.

Imagine that you have a computer that has trillions of connections and it runs on the same amount of power as a light bulb.

That's a networking efficiency that does not exist on the internet and not even close.

What's so fascinating about it is that through the chemical soup and being able to sense the finest gradient of change in that chemical soup,

we're able to form such different experiences from moment to moment because even every single one of our 100 trillion synapses can possess so many states

that it's a functional equivalent of, I think people like to abstract the neuron away when they're thinking about neural networks.

Let's talk about the ionotropic for a brain for a second because ions are particles.

Now we have a massively parallel particle-based computer that sounds a lot like a quantum computer.

Imagine this, but with a massive amount of connections.

We're not even close to building something like that.

People are like, oh man, computers are so much faster.

Here's the other thing.

There's this event who's had some sort of brain injury, could have been hit by a car or just born that way,

but they can calculate numbers by seeing them and they see numbers.

He's got topological calculation abilities.

What I'm saying is that we're running programs that are dominating over other programs.

If we inhibited whatever our main program was, we might discover that we can do calculations far faster than a linear computer.

I think our brains just aren't built on needing to do those sort of things because we're so based on interactivity with our environment.

If you had to interact linearly in some way, look at even the children who use the abacuses.

They can do these insane calculations because they've developed a different tactile sense for how to interact with math.

I think that students should be learning tensor calculus before they learn algebra before they learn calculus because when you combine geometry,

which is very visual, with algebra, at the same time, I think you're giving the human brain an advantage because now we can understand math in multiple ways.

The brain is very much a multimodal system.

Having two eyes and two nostrils and two ears allows for a sensory confirmation.

Two receptors cluster together hundreds of millions of times on a single synapse with the two being not only far more unique,

but also forming their own unique signaling cascade versus the two existing in isolation.

Our very most basic signaling unit of this heterodimer or heterotrimer of two or three receptors cluster together and sensing their neurochemical environment and engaging signaling cascades that are so specific that they can influence that very receptor.

Or gene expression of a range of things that relate to that thing.

It's like the information flow has evolved so well that molecular sensing on the cell surface can directly change the way that different genes are read

to influence the environment in the way that best favors survival and evolution and proliferation of that organism.

That is incredible. If you really think about it, that is completely mind-blowing.

There's no reason in principle why we can't vastly defeat the information complexities of computers

just by changing the program that's running up here in our heads.

We just might need a lot of help at the things that they just naturally are better at.

Let's say we can figure out the communication protocol of the brain.

We can have a web browser terminal that we can access our thoughts with,

but then we can also basically say,

I want to turn off a visual program and I want to run a math program instead.

Then we start doing some amazing calculations that are beyond what can be done on computers today.

It's because we've told the brain we want to run a different program.

Can we please not have ads in our brains? Can we pause to discuss that for a moment?

Do you want the actual pause?

No, I mean...

Oh, you want to talk about it?

Yeah.

I mean, I feel like we should just mention this.

Sure.

Do you want advertisements on your retina?

Or do you draw the line?

That's one of those...

What is an advertisement on the biological level?

Humans are...

There's mating.

There's all these ads.

All these signals between people.

That's the sort of advertising.

If we got rid of...

What would it mean to say, okay, there's no ads or something?

I guess it would be like...

To want to inhibit ads is, in a sense, kind of like an evolutionary impulse.

It's like, imagine a male gorilla wants to inhibit the ads of other male gorillas.

It's so annoying, those ads are so annoying.

Have you seen the Black Mirror episode?

Spoiler alert.

Plug your ears if you care about seeing Black Mirror episodes and you haven't and you don't want the apostrophe spoiled.

We'll tell you when...

How are we going to tell them when?

You need to have a friend with you who's seen the Black Mirror episode and they'll tap you on the shoulder.

Which episode is it?

I don't remember specifically the number, but there is this one episode where there is a sort of utopia in the usual dystopian way of Black Mirror.

And in this environment, there are these credits that you earn from running on a treadmill.

You can use to buy food, drinks, toothpaste, and pay to not have ads go off.

The ads completely surround you.

When you are in your sleep pod, your room, the entire walls are this AR interface.

And you have the sound directly going to your ears.

And if you don't have enough credits, you have to watch the ads.

If you look away or plug your ears, it will tell you...

They're being on the bicycle or something.

Yeah.

If you look away or plug your ears, they'll keep making warning noises until you open them and finish watching it.

And potentially fine you for not paying attention to the ads.

Exactly.

Yeah, that's very...

So if Republicans maintain control of Congress and we have these sort of technologies, that very well could be our future.

Wow.

I mean...

I'm being somewhat facetious, but...

Maybe a little bit too...

You want to avoid a scenario in which you're forced to do something.

And you want to maintain a scenario in which you have the choice to define your reality the way you want.

So I imagine that in terms of how the universe is structured...

My hypothesis is that you're going to have a United States of Neuroscience and then you're going to have a North Korea of Neuroscience.

I'm just saying in terms of universes created by people, you're going to have a universe like living in Germany in the year 2018 or you're going to have a Neurolysis universe that someone creates that's like living in the year 1600 in Rome or where there's like Muslims and Christians and people are afraid to...

They're afraid that God can hear their thoughts or they're afraid that the governor of their state, like if you're in a totalitarian, they could potentially hear your thoughts.

And so your thoughts have to be true towards the dictator of your society at all times.

And the funny thing is that with Neurolysis, a dictator could actually in a sense monitor somebody's thoughts.

Maybe that was the part of 1984 that we missed.

I would just have to say that it seems like the universe is like instead of deciding between one possibility or another, it's like creating both at the same time.

So you end up where it seems like in a long enough timeline what could happen is inevitable.

Do you know what I mean?

So that's kind of...

People, we're going to create in our lives and we're going to create artificial brains and people won't care because they'll be like, oh yeah, well it was inevitable and the universe is fractal and it's all mathematics.

And there's this conference coming up but it's on the other side of the planet and I wish I could go to it.

It's all about how the dendrites computer and it's a Nementa conference.

And dendrites are they're hugely important.

It's like by itself it's kind of a computer.

But we're kind of like just wrapping things up anyways.

It's kind of like maybe a future podcast.

We're going to dive deeper into dendrites and dendritic computation.

And one thing, I guess I'm closing out for this podcast.

We could talk about there's a GPU conference coming up in the NVIDIA GPU conference or GTI conference and I'm planning to go there because there's many, many good talks on the topic of artificial intelligence and the latest innovations that people are discovering.

And one of those is really interesting because they're discovering that because if you want AI to take sensor data and recreate a 3D structure from that, it's actually a really hard problem.

What they found out was that if you give AI some basic 3D models first, then they're finding out that it's able to recreate the 3D model from the sensor data.

So it's like giving a, I think of it as giving a child a toy to play with in order to catch on to the concepts that are more fundamental to a human's existence.

And so they're giving this AI 3D models and it's more able to handle this.

So the idea there though is that could have to do with sensory confirmation.

Where if you have two eyes, let's say a crocodile has two eyes looking two different directions

and my arms are extended out and they're pointed in each direction.

So you have the crocodiles, let's say it's a deep learning program and like a neural network

just like we talked about earlier.

And one eye is trying to figure out the geometry of the world around it so we can notice some

animal passing that it wants to eat and the other eye is doing the same thing.

And I have to think about how a nerve has like two ends, right?

It's almost like a battery, like a north and a south, right?

And so the crocodile is getting to each eye has millions of sensors in it, light sensors,

and it's going through the neural network and it's creating like all these brainwaves

which are the sort of like a brainwave of four dimensional patterns.

It's like an electromagnetic tensor field moving with all these different parts moving

throughout this system and at some point the left eye and the right eye meet

and where they meet they're confirming each other's model

and the confirmation that each eye is getting is magnifying its ability.

So it's an argument for why two eyes have an evolutionary advantage.

There's sort of a sensory confirmation.

The first week of May, I think it's like May 7th, is about they're going to be talking about that.

And it's very interesting that would make a case for we could potentially build how we potentially might build better AI by making it multimodal.

And I think it needs to be at the very baseline level

the more we can mimic the architecture of how single synapse functions

the closer we'll probably get to capturing the breadth and the richness of the human experience.

Neural Lace Podcast #5 Guest Jules Urbach, CEO at OTOY

original audio
https://soundcloud.com/user-899513447/the-neural-lace-podcast-5-jules-urbach-ceo-otoy-inc

Audio Transcription by OpenAI's Whisper

Were at GTC 2017 the GPU conference hosted by NVIDIA talking to Otoy's Jules Urbach

he's the CEO and founder of Otoy and I'm Micah Blumberg.

This DSLR that was weighted by another DSLR that was spun around in order to do

photogrammetry and that for me that made Otoy famous in my mind and I'm

glad that I'm glad that was the thing that got you interested and it was

definitely an interesting experiment but we've been it was actually sort of a

midpoint for us I mean we've been working on on I wouldn't even call it

photogrammetry we've been working on on really high-end capture of

environments and people through a subsidiary of ours called Light Stage and

Light Stage was started out of USC you know over a decade ago and it's been

used and I mean if you see a film tape you see you know the Avengers or you see

you know Tarkin or Lea in Rogue One like Light Stage is scanning the

actors that stand in for them or that play these people and it's been used for

a long time and it's basically ground truth it gives you all the lighting information it's like if you're gonna scan something for the holodeck you'd go to Light Stage and it gives you that data back it's almost too much data for most rendering pipelines even for cinema to use and what we wanted to do is we wanted to come up with ways of capturing things outside the Light Stage.

Light Stage is like the Brunberg fly thing you're in a bubble you have to go to a facility we've been shrinking that down more and more but we also wanted to come up with ways where you know Light Stage works by having a lot of lights and a few lenses but you can also capture the same sort of volumetric or holographic light fields volume by having a lot of viewpoints and the way that this was structured with that spinning camera was just to spin the camera 1728 times and get a meter of light and a volume and then basically process that data and turn it into a true like you know light field surface in other words light feels like a white light hologram no matter where you're looking at it the pixels are beamed into your eyes so it looks like you're looking in the real world and it's a magical effect in VR it looks pretty good even in a wind-dead mode and I think that it'll look even better when you have glasses like the Amoglif or maybe Magic Leaf that have depth planes where you can really appreciate having sort of multiple rays shot into your eyes at once and and so this was just a test and since then I mean if you look at the more recent work that we've done as a company we partnered with with that Facebook and they built a camera that is 24 lenses you know they don't call it a light field thing but to me it's it captures in a similar way overlapping viewpoints that we can then use to reconstruct a scene and given that captures that in motion and that you can move the camera around or have multiple cameras you can build you know a holographic asset and that's exactly the pipeline that is a company we're turning on for them and connecting that to various different tools that we also support through our rendering platform and we make a software called octane I think some of the more famous pieces that have been done with octane include the opening Westworld if you watch HBO that was all done in cinema 40 with our render and you know as a the future of rendering as I just was giving at this talk this morning I think is real time I mean it has to be real time then it has to get into this sort of magical area where it's like when you go on the holodeck and you say arch you know you need Sherlock Holmes or jungle you know it kind of knows semantically what you want and that kind of workflow comes from capturing the real world processing it doing deep learning on it being able to have a ground-tooth renderer and those these pieces are decades worth of work and we're like seven years into that but anyway I'm glad that you saw the company at the point where we had that that I think it was an upload VR that that article on the yes it's article by randam about the spinning light field capture system and in fact if you get a lot of people excited because I think it opened their eyes to the fact that there's more than just 360 or even 360 with depth I mean there's a full holographic universe waiting to be captured and every time you're not doing that you know it's like not capturing things in color you're missing a whole dimension of experience and I'm grateful the Facebook's attacking the problem I think there's others in this you know in the space doing cool stuff light row and I also did the Facebook sort of set the bar for a lot of others to sort of follow them into like the minimum you need now to have a compelling experience if you've seen the demos that we've done with the data is depth you know like and getting overlapping depth is really really great so the way I first heard about the light row and the original name was the light row sphere and they said it's a fire hose of data there's there's like how can we how can we ever have the ship of all like you have this server array with 12 you know 12 hard drives and that only records like an hour of data so it's this massive fire hose data which I think you were talking about in the beginning like how do we get this down to you know compress it to something that's typical we have and now I've seen it so I've been to see yes and I've tried the hype VR I've got to try the the Sony the Sony has their own sort of six degree of freedom and your your project with Facebook you know six degrees of freedom freedom in a camera so this is now going down the pipeline where Facebook and Sony are are saying okay we're gonna take this this technology of volume of should we call volumetric video or fine term for that for what we're doing at this point it's still a point cloud it's got maybe multiple layers you add even more rays into it it's a light field you add a more information it's like a holographic digital asset but you know volumetric video is probably if you're able to move through it at all it's a volumetric video file I think that's a good description of it's what a lot of people call it six-dot video so then it Adobe shows off this new you can convert a 360 from an old just an ordinary like simple 360 camera not even 3d and you can turn that into sort of like a hologram and the thing that I noticed with that demo though is that it requires structure for motion so basically if anything's moving it won't work and if the cameras are moving it won't work so that means it is basically capturing is still seen and you know that's that is still super relevant and absolutely important for us to have it even in a camera I think it's an amazing piece of software I do think though that one of the things that the Facebook guys did right was that you know I want to be able to capture video I want to do it in a single small portable ball and I want it to be volumetric and it needs to be in motion so that magical experience of having everything around you all at once moving with overlapping you know you have planes is pretty cool that doesn't mean they can't be bigger and that's I'm like trust camera is a monster thing it has 90 lenses and that that is definitely capturing a full light field and it's it's awesome I just think it's you know you have a spectrum of different players putting in these different rigs and I think I haven't seen the hype the art rig I've heard is really good but I also think it's using like LiDAR and 14 red cameras and I think that this probably some fits somewhere price-wise maybe between the lightware stuff and the Facebook stuff and I think Sony stuff as far as I don't know how they captured I think it was done in a very clever way to make it work well so Sony captured it with three a regular 3d 360 rig and and so there's but they're selling it not to regular consumers but to like the producers of shows and plays and concerts because it requires a lot of post-production yeah the Facebook thing doesn't I mean what you're seeing out of the demos there is largely the raw data I mean I don't know if you mean post correction like he needs to be cleaned up or add like add reflections and different effects I mean you have to do that with the Facebook stuff too but not not quite so much because one thing I can't speak to the Sony data set I've never used it but the Facebook one I've I'm now like you know months into this thing and I spent so many hours looking at it and working on the on the different parts of it you actually get you know there's eight overlapping rays for almost every pixel that you capture with this thing and that gives you essentially glossy reflections so you actually get you when you're moving around within that you know sort of the space of your seated experience you will get glossy reflections you don't need to add anything it's in there you also get whole-filling so you don't have cavities of things that are missing and that's pretty compelling so you add that with the fact that you there's small enough you can have three of them you can also you know essentially capture the scene beforehand I mean that's probably those workflows are like you know minutes of preparation time you should you probably should do so I think that it's a good sweet spot as one reason why I was excited enough to back it as a company like you know we work with a lot of different vendors work in cameras and we want to support all of them but it's like from for us to you know commit to something this at this scale like I wanted the results to be really good and I will say the Facebook stuff is really good so it doesn't mean that others can't even do higher-quality captures the question is is it practical is it how much work is it I don't know you know the Facebook stuff is largely automated and it was it was kind of compelling to see that come out of the processing pipeline without any human intervention so recently Unity announced that they have a new tool for 360 where you can separate the video into layers and then you can make it interactive and so you would like failure you're working with point clouds and I was just trying the latest Nvidia point cloud demo over here and but the question to me was well how can we make point clouds interactive how can we make them behave like objects in a program how can programmers use them to make it a demo we did in Unity with the Facebook video data well anyway if you haven't you should check out the the video that we did at F8 and in that video we actually show exactly that workflow we don't just show it in Unity we showed in After Effects and Nuke where in fact in my talk tomorrow at Ford you know if you have time you should check it out or if others are listening to this and this guy's posted yeah basically you can drag dragon synthetic objects octane render things perfectly it's a cinematic production renderer you take the Facebook data you can match them together and actually reflections or fractures everything works perfectly and that's our offline rendering you can sort by the way render that into a beautiful light field and have that published experience were perfectly on six in six degrees of freedom and for real-time interaction weird it's you know you can actually treat the Facebook video data as a game level which is exactly what we're showing in our booth and I got butterflies flapping around the Oculus touch control is a giant light I can drop it on the ground and it you know lights things up you've got ambient inclusion you've got GI all these tools that we're building so it's a game level and in fact the most the most awesome thing I think you do with a Facebook camera is you can use it to just scan environment and you know take a few seconds of that and drop it into Unity and you've got a fully formed game level that looks really good you don't have to pay an artist to do it you just captured it and that is that's pretty powerful so it is a game option you can move it around it's just and you can scale it you can shrink it I highly recommend that anybody that has access to our demos until we put it out publicly with Facebook checks it out at our booth or at these trade shows that we go to it's it's pretty cool so going back to AWE and you had this announcement with ODG the idea was you know we can we can stream a VR experience to a headset so you can stream something from that it's processed with powerful desktop GPUs over Wi-Fi or over a 5G cell phone oh yeah well we don't need a 5G or Wi-Fi I mean the stuff that we were showing and it's not just ODG so we've shown a version on Tango we've shown a version of Gear VR we've shown a version on just a regular Samsung phone with a marker-based tracker and you know they have different resolutions but what's fascinating about these these portals is the portals I mean they're not quite as heavy as a full VR experience but looking at you know per AR and mixed reality even VR where you're looking into a portal into a different world I mean we can squeeze that down to a few megabits and it works just fine because we're you know it's basically foveated rendering in streaming form and it's very fast and we were that to me that's one of the most that one of the first first things I want to tackle is it's going to work really well and it's also how we stream life fills into you know a sort of a higher level framework Unity for example can can take that stream we can beam it into a surface and it can actually be projected and that's one of the things that makes the latency much less tricky for something like ODG the resolution is much higher the thing that we're missing with ODG is we don't have position tracking there's a there's a module on the top for lighthouse we absolutely desperately want to have that built so we can actually test full position tracking in the meantime one thing we have been testing in the earlier ODG glosses was just having a super high resolution overlay it's basically our light field stream just one frame of it without the holographic part and you know moving that over a marker it looks amazing and that's at our booth as well so that's a great demo it the resolution on those glasses is remarkable it is four times the res 16 times a res because it's four times the horizontal and vertical pixel density of the gear VR and you know it looks kind of magical we don't see a screen door effect I want that I want that and I want position tracking on a wide field of view so you know I've seen in parts all the pieces of sort of my ideal HMD and ODG cracked one thing that I just hadn't seen before which is the resolution problem and they did it all in a pair of fairly lightweight glosses so you have you have Microsoft and their HoloLens had the position tracking is pretty good a lot of people would say and I you know one of the things I wonder as why can't you take the position tracking from the HoloLens and put it on the ODG glasses and apparently it's too the power is too high and it's too big so you know that that was one of the reasons why it was it wasn't necessarily an option I heard the HoloLens is clocked at 30% of its performance capability because if you ran it at 100% it would catch fire yeah I mean you know the current HoloLens has a couple of things that I think could be better it's 720p instead of 1080p and the ODG glasses are 1080p per eye for example cherry trail which is I think the the SOC on the HoloLens is it's not a great GPU I mean it's like it's probably at this point the 835 is probably a better GPU on the way you get on most phones but it's you know it's it's a full x86 Windows device so I guess for that from that perspective it works I'm guessing that because Windows 10 that works on the 835 the x86 translator that maybe you'll see a future HoloLens on Qualcomm's SOC it might even perform better and more power performant but I do think that the next HoloLens must be having wider field of you must have higher resolution and what's interesting is I don't know if you know the story but but Ralph Foster who designed the ODG glasses I mean I think he sold a lot of the patents for HoloLens to Microsoft before you know he went a different direction into these classes that's fascinating now with

regard to going back to streaming going back to web VR and going back to the
concern of you know the the frame rates of what's necessary for VR to be
comfortable some people have said it needs to be 90 Hertz some people have
said it needs to be 120 you're talking about in order to you know I was talking
to Microsoft yesterday about you know they're also working on this sort of
like how can we solve the the streaming what we process on a GPU over the web to
a set of glasses like the HoloLens so I was kind of like well what what is the
and they said oh we're doing like 30 frames per second so it's okay for AR
but it's not really like it's not gonna be comfortable for VR and I you know
like okay well then there's phobia to render you can optimize that you can do
the reprojection maybe on the glasses themselves and they were saying that
they're there they're what was interesting to them was you know TCP is
too slow but but UDP is much faster going back 10 years or I guess it's been
that long like you know when we were doing game streaming as a primary you're
one of our primary focuses you know I have a deal with with them unity now
where octane's built into unity it's shipping this year and the CEO of unity
I first met him when he was the COVA and he was you know when John McHale was
COVA we were he was there was a period of time when it was OTOI, Digtai, OnLive all
doing game streaming and the only way to do that right was to do it over UDP so
that was we did UDP streaming in that case the problem is the web doesn't have
a great UDP mechanism you can do it over web RQC but it's not perfect it
doesn't really matter at the end of the day there's probably if you're gonna do

streaming you probably should bake it in right and I think that yeah UDP helps

you you know the way we do our streams I mean there is we built our own codecs

that can suffer a lot more packet loss and traditional video frames do and it

helps and and then there is reprojection and there's reprojection we have a lot

of data and then there's also the fact that one of the things we just showed is

that you can also send out an entire unity game inside of those you know the

you know the bits the adaptive stream and that can run locally the second that

it's there and until then it can run in the cloud and if there's not enough

compute power it'll figure it out that's just part of the staff and the reason

why it's important to author and unity with our tools and have it in there is

that we can set layers that trigger those different pieces this can get sent to

that you know to a plane that gets rendered locally or this is the

threshold for rendering it locally it's pretty simple I mean when you're talking

about video layers and you're talking about picking the right resolution or

bitrate this is even simpler than that and to your point about the the stuff

they're showing it at a vision with sort of the you know the alpha planes in the

video I mean the Facebook thing basically is is that times a thousand because it

has those depth layers you can create any sort of masking you want and our goal

is that we basically are able to beam that that piece with video file into your

unity texture and you can do what you want with it and similarly we can also

take your unity project and put it in the middle of a light field compositing

workflow that's maybe created in unity but still using our our light field rendered to do all these things together and it's kind of a you know totally you can do it from either it's bi-directional but having those tools in place matters the only thing I ultimately want to make sure of is that there's a URL and you can go to it and no matter what the platform is you see that experience I don't want to have it apified unless the author intends to have it apified but it's like a lot of experiences in the future are going to be social bite-sized things that you can share mash up and I think the unity guys also see it that way as well and that's what you know and so does Tim Sweeney of Unreal Engine I mean that guy is really one of the greatest champions for an open metaverse and that's super important for the future of all of the work we're doing. So speaking of the meta metaverse and specifically sword art online is a big is a big concept in terms of you know that ties back into NeuroLace and NeuroLace the idea of hacking into the brains VR system and accessing it like it's a special kind of hard drive so you can communicate that's sort of a read and write communication tool between the brain and the hard drive. So I went to the San Francisco HTML conference and HTML5 conference and they were this is where I was asking you how can we because I because I'm I help organize events with San Francisco virtual reality and I said how can we like create like a web VR with you know massive multiplayer and Mazzilla and Chrome are not there those teams are not really thinking about that yet they're focused on more fundamental stuff and it's a friend of mine who's Ruby on Rails guy said you know you need to do the UDP and so I said and so then I was and while I was in the conference because I do all this you know 12 years of neuroscience study and I have these great great groups like self-aware networks on Facebook it's very popular and so I'm reading I'm reading this book networks with a mind and I'm listening to this you know oh you need UDP instead of TCP and I'm like learning about this stuff and I said so if the brain is like a network what would the communication protocol be would it be more like TCP where you need to establish like a connection or to be more like UDP interestingly Mike you can definitely separate packet loss and fill in the holes there's no doubt about that I mean experience is definitely probably not even pretty linear and I also don't think that you know what we think of as linear experiences are probably our mind sort of constructs that you know when who knows what the actual the way that you know our brain sort of forms these these things by the time it gets to our level of like fully conscious understanding as far as the neural as it goes it's fascinating you know I've you know it's like I've met Elon a bunch of times and it's like the last time I saw him was 2013 or so I don't know it was it was a few years back and I remember telling us like I'm working on I want to get a holographic window for your you know your spaceship and your Mars colonies I'm really not gonna be happy in either of those without like a light field display is it always like a holographic no that's peppers goes this is way better so well let me know when it's ready and the thing is like I actually working on the softwares I don't have the holographic display but there are there's a team out of light row I try carefully is working genuinely on that holographic window this year and it's called light filled labs you know and I'm working with them because I have to see this you know this come to fruition and I do wonder about like you know the you know the sort of the the idea of the neural laces is super fascinating I don't know how it would work honestly I'm not sure we don't understand consciousness fully worse I mean our visual you know eyes were probably the most you know the highest sort of bandwidth we have going into our minds at this point you know so so we talked about this on the podcast like how it might work and one of the one of the big ideas okay so one of the big ideas is if you can apply if you can get like live data of you know like let's say you're you're you're you're imaging you're using some sort of imaging where you're creating like a tensor field map of the ionic tropic rain you know all the electromagnetic waves flowing through space and you you have AI watching that and it's looking for patterns and it's unsupervised because you can't really label that but then you have another AI like the self-driving car that's as it's doing like you know LiDAR and all these different cameras and it's mapping it's identifying all the objects in the room and then you you need to correlate like you know this is this plate has you know you have all these the AI hat says all these different lines and edges add up to this concept of the plate and at the same time if you have in the other AI is looking at the neural correlates in terms of the ionic tropics sphere in terms of temporal spatial brainway patterns and it's saying this pattern matches that pattern and so if we get that pattern and we have it in the computer and we know the networking protocol we can send that pattern back over the networking protocol into the brain and see if you see a plate where there is no I'm not a neuroscientist but I mean I absolutely am constantly thinking about that being done I mean it's like you know philosophically I'm also not a hardware guy so I don't you know and video better make great GPUs and people better make great displays and as a software you know thinking about it from the software side of things like I can't wait for there to be something that allows us to sort of hack into these sort of patterns and and sensibilities and understand a little bit more about what you're thinking I mean also of course would be dangerous but I do think that there's there is something to be said for AI being a big part of how you can sort of encode because you know it's bandwidth issue right I mean ultimately even our even our visual system and we're not seeing everything at once we're building like that 32k by 32k image well I mean I don't know if it I mean a lot of the neuroscientists that I talked to say it's a bandwidth issue but I'm not sure that it is because you know what when you like let's say when you when you're trying to figure out whether something is is red or blue they you're sort of like your it's your brain is learning how it's different how it's different relative to what's around it and in quantum physics something is defined by everything else around it and so time slicing so if you basically want to encode information like when you think that you're seeing a 32k by 32k image you're actually seeing it it's almost like a raster line your eyes are quickly moving around and building that

up in your brain and your brain may not even see it again but it keeps that

memory of it so information encoding in that ways is fascinating if there are

ways for your brain to learn how to get shortcuts around what the real world is

and there's like light are being fed and there's a shortcut that sort of builds

that point on your mind that would be amazing and that's where this kind of

stuff could be fascinating when it's applied right but in terms of you know

getting around the bandwidth issue I mean I know what bandwidth when with this

gonna be required in the first place but I'm saying all we're gonna do is figure

out what the pattern is and we're not gonna send the exact same pattern back

in we're gonna send the difference between the pattern here and the

pattern that's already in place location or something you can kind of figure out

what things are it could be it could be interesting to sort of play around with

interference patterns and I don't know there's a lot to be done with with these

things but again I'm not really a neurobiologist but I love the space and

decided to see what comes in there.

the neural lace podcast 7

The Neural Lace Podcast #7 Guest Android Jones (The Vision Agency)
https://soundcloud.com/user-899513447/the-neural-lace-podcast-7-guest-android-jones

see note a0249z.md or this article
https://medium.com/silicon-valley-global-news/gti-2017-gpu-technology-conference-the-neural-lace-podcast-5-with-guest-jules-urbach-the-ceo-of-17c4067a648e

Audio Transcription by OpenAI's Whisper

I'm Andrew Jones. I'm from Colorado. I work for a company called Vision Agency and we produce an experience that we're calling microdose VR. And today here here at AWE and you're playing with the Muse. What was the idea behind that?

I met Chris, the inventor of the Muse at the the MAPS conference last month. He came out to a workshop that I gave and we kind of hit it off and started talking about the different visions that we had for BCI and VR and what the possibilities were and then he showed me a photo of this new prototype that had seven sensors built into the foam padding of the Vive and it just happened to be that we were really for the past six or seven months we've been going to the different conferences trying to find what would be kind of like the you know the Cinderella slipper of like graceful way of starting to integrate EEG feedback and biofeedback into microdose so we could procedurally generate different visual parameters and it just worked out really gracefully that we had a call a couple weeks ago and he says hey there's this thing called AWE and we're like that's in two weeks that's totally unreasonable how could we ever make a build and incorporated that we'll do it you know and so we're here wires all these cords make it happen amazing you have this like awesome hacker workstation over here with like that's that that's that's totally hackening right now

welcome to the Neuralace podcast number seven guest Android Jones co-hosted by Michael Bloomberg and Pfeiffer Garbissi this audio was recorded at the 8th augmented world expo AWE 2017 the largest AR VR event in the world so Android Jones was at AWE 2017 to showcase the latest product from the vision agency that integrates microdose VR with the new EEG headband from Muse that has been integrated into the headband of the HSC5 the Muse headset is one of many

examples of how biometric sensors are going to be integrated into basically

all AR and VR AR and VR glasses will have built-in EEG into the headsets

themselves in addition to eye tracking and cuba dilation tracking heart

monitoring all sorts of biometric sensors in this podcast we also talk

about Nvidia's new GPU cloud or consumer level for the consumer version of

Neuralace will need a ton of computing power for each and every person the

reason is that even after we have created a language for computers to talk to the

human brain introducing visual auditory and other sensory concepts that are not

actually there we can't send those patterns directly into the brain we have

to first listen to the patterns that are there at present from the environment

that each person is in so that we can send only the difference between the

pattern that is there and someone's brain in the pattern that we want to be

there so they're basically three ways to use EEG with AR and VR first way is to

use EEG with artificial intelligence so you can predict someone's emotions and

intentions at the interface level the second way is to use EEG to gamify the

virtual or augmented reality environment third way to use EEG with AR and VR is to just let the EEG drive the raw changes in the light sound and tactile effects so that you're providing a mirror for someone's brain wave signals so they begin to form concepts of how their thoughts and emotions are brain wave signals how their thoughts and emotions are changing the light and sound effect so

Neuralace research in general regards the human brain as a special kind of hard drive and in

this episode we talk about the the NVIDIA GPU cloud and how the future of AR, VR

devices integrate biometric sensors and artificial intelligence but if you're still skeptical about how advanced neuroscience research is getting I have three great examples if you can find on my medium page about this podcast and those examples you can also find in my Facebook group called self-aware networks you can find these links at VRMA.io and VRMA.org so three great examples of how advanced neuroscience research is getting is one is that we're rapidly gaining new understanding of how the community brain networks function at large scale and an example is in Nature magazine Nature.com human brain network it's an article it's called human brain networks function and connect them specific harmonic waves check that out. The second example of how we're rapidly gaining new understanding how our brains are assembling information is in a cell.com article called the code for facial identity in the primate brain the third and final example of how advanced neuroscience research is getting and how we are rapidly understanding new ways to stimulate our brains with wireless targeted transcranial magnetic stimulation for example that will eventually allow for next-generation computer to brain interfaces is another article in cell magazine cell.com called non-invasive deep brain stimulation via temporally interfering electric field so I hope you check that out. Now the podcast begins first you're going to hear Android and he's responding to a question you need some type of outer reflection like you can't be like oh it's never like oh man I feel super alpha right now or oh man my EEGs are this like we're totally disconnected with those so that the information that your body and your mind is producing that you're not that you don't have like a visual connection with we're using environmental elements to create that visual connection and it's something that it may not feel apparent but we're hoping that over time you'd be able to kind of recognize you know if you put someone that had a really clear piece of state of mind you put him in here they would get an environment that would be drastically different than someone that was totally like distracted or you know so you'll be able to procedurally reflect states of minds from anybody just getting into microdose and then this could be used as a tool to for somebody who is having a difficult time being calm and centered to achieve that state as well I mean I I definitely think it was I mean I started using Muse a few years ago and you know I'm a good case study for this because I definitely value the benefits I totally understand what meditation can do that like stillness of the mind but I have a really difficult time being bored and feeling you know it's very hard for me to like settle my mind like I've my path of meditation is through a creative flow spate where I just I get to a place of kind of the devotion towards the art and kind of losing myself where thoughts change like the frequency of my thoughts change and kind of go away so I think I get my I'm able to kind of scratch that meditation aspect like through my art but when I sit down and meditate it's very challenging but when I started using the Muse a couple years ago like it gives you that that gamification of the feedback of like oh cool now all of the birds are coming okay cool there there's the birds and then it'll it gives you a little record objective record of like oh you did it this much longer than last time and like little goals like that's the only way I could and I was doing really well with it till I like broke it but I probably still been using it if I didn't break it I'm hard on technology now we got some more but yeah as I think it's the pulse the poll right now pulses definitely are giving us the most reliable most kind of one-for-one like that's me like there's something just kind of when you see it when you're kind of watching your pulse and they never seen your pulse you kind of you just get it you know like I've done this we've been kind of coding and bashing this together for three days and I can see like right now my heart rate I was just in it I could see that my heart rate is way faster than it was like last night when we were testing it out because I've got all these people and I probably had some coffee and then all these things so that's kind of a neat I mean that opens up a whole cool thing of just being able to take your take your just take your data like being able to just see the different aspects you know maybe we could like map your cholesterol level someday so so so EEG like your diagnostics entertainment that's our niche so with EEG you can like you have different points on the brain and you get a number from each of those points so it could be just like a pulse where you can assign a different graphical change to each number and that's another way to you know change the graphics with what the numbers you're getting from question for you what would you if you could if you had a sensor that was that have a similar resolution of the muse what would you want to and you could have any of these things change and manipulate and modulate the environment around you what would you want to attach say like some of your EEGs to like what would feel like an appropriate environmental response to the conscious manipulation of your own EEG waves so I so I did do a project similar to this in 2012 and I attached I use EEG to drive different changes in light and sound effects so I attached like different sound effects like reverb and pitch and just you know different bass effects anything you can use to modify the sound it also the light so the brightness the the the colors all those so your brain waves would drive changes in the light and sound effects and I also incorporated I encoded the sound with binaural beats it worked really good because we'll see binaural beats are really the really the brain is really interested in binaural beats so it causes you to focus more so if you really want to focus with meditation if you're listening to binaural beats you they can put you in a deep meditative transfer easily but the idea was to let the to encode to encode the sounds with the binaural beats but to let the signals from the EEG cap the numbers drive the visuals the colors changes and stuff and also to drive the the sound effects so say of a be played like with alpha like getting into an alpha state like what do you think alpha would like right now we're using alpha I think we do a combination between we're actually experimenting whether we can make the clouds part and dissipate we can make it like overcast or clear dynamically and we're kind of playing between using like the clear function or the alpha to make that happen EEG we've had a hard time really narrowing down what makes sense with EEG because so far it seems a little erratic and unpredictable you know like I can't I don't know I can't I don't know enough about it to hold a state of mind and go oh my even to say like okay low EEG what makes the low EEG or it makes the high EEG it seems like it's all over the place you know it's like I move my eyes back and forth I know that we're trying to find like how can what can I do physically to hack and manipulate my brain waves more consciously so that that's that's completely true in fact so what the companies will say okay I want you to levitate this ball and what they do is is they say okay so if the marker it goes if the EEG sensor goes above 106 then the ball levitates a little bit higher or if the thing is it's like it accumulates the data so it's not like you're holding that we thought about that too that maybe so there's something and every time you you maintain a state for a certain amount of time something happens so the Sun gradually rises not you don't just rise it in one fell like mind thought or mind sweep but you have to hold a state of consciousness for a certain amount of time and it gradually brings it up so the problem with that is so the first time you learn something you have a ton of brain wave activity the first time you learn a car your brain is a spiking incredibly the second time you try it your brain wave levels are cut in half the third time they're cut in half again it's like there's no way to build a consistent sort of tool to monitor your brain in that sense because your brain because your brain will become so it has a program to like reduce the amount of power that it takes to perform a certain task so you're never gonna hit the same levels and on top of that everything in the neocortex I think the neocortex is really the I'm talking about you know on top of your head the need going here so that's the so the forehead is still you know the part of your you'd be measuring the neocortex as well but what the from my hypothesis is everything's still really scattered so you're not in terms of all the you know your senses come into your thalamus that's the integrate there but when they go into your neocortex they go all over the place everything is scattered and messy and it's it's it's gonna be hard not only to get the same signal twice but to get the same level of signal twice then here's a good question for you because you've tried microdose several times and you've seen like a lot of its evolution to most I'd say 90% of the people that try microdose for the first time whether it's not so much the events like this but we were at lib and Coachella and Burning Man we're gonna be like symbiosis week 90% of first timers like never tried VR just you know pop and share pop and digital cherries left and right what would you imagine that someone who's what would the brain waves what would be like the the common denominators of what kind of brain waves we could expect from people their first time in VR with microdose like what you think what are the patterns you think we would see so we can then gauge to anticipate or work around those specifically well whenever someone's learning something new you're gonna see their brains working a lot harder so that's when you'll get the most well defined brain waves but the but that's you know the one-time experience and the next time of course yeah yeah and do they and I guess you need to show that you'd want some type of calibration to like see what their mind looked like before that too right so maybe like you could do a little before they put the headset on it could be like hey this is what your mind is like right now this is your brain this is your brain on microdose that's a good one glad you're recording this yeah so that would be something you could like show a difference right the headset on they would it would go into microdose levels anyway well the real difference would be like in subsequent times using microdose you'd see that their overall brain wave activity would decrease as their skill improved with the program oh interesting so we could reward the decrease like new levels because we're kind of thinking of it to be a really cool way to progress through the game where like in like that that and that original Bart Bartow level we had that the different portals would only open up if you got to a certain brain state you know like that would be a neat way to progress and kind of reward people so you're like no points or anything and no badges but like you get to a brain waves like oh great you've achieved this now you have access to these particles in this new realm and it could kind of spawn out from there that's actually a really interesting idea that never occurred to me is to continually modify your program to reward decreasing levels of brain activity as some sort of indicator of your brain becoming more efficient at doing what it's doing it seems like it's also like a natural way to you know in like a lot of games you get in and one of the first questions is like do you want like easy medium or hard like it's a great way to automate that where to keep the person challenged like you give them more stimulus the lower their brain waves get to kind of keep the brain up at a high stimulated level like we could have like a stimulation kind of a quota that we want to reach for people so they get more particles or more worlds if their brain is that work or is that well the paradox is that if you so if you focus in these e.g. games you can push your brain waves up higher but if you're really like you know focus on learning something then your brain should be at the same time making that more efficient so like like people who are really skilled to driving will not are not going to show as much brain wave activity as someone who's brand new to driving so so if you're really like focused on mastering your e.g. then it should actually it should become harder for you and not easier for you a paradoxically if so the thing that the brain reacts most violently to for any e.g. is light right it's why you can induce seizures and so if this inherently has a ton of light so couldn't you stimulate the brain using those like different patterns of light well you'd need I mean so you'd need that's up there's a there's a study there's a field of science called optogenetics but in order to stimulate the brain with night with light you actually have to alter the the genes so that you have light receptive genes because normally our genes are not receptive to light I mean well I mean we do have you know obviously the ganglia neurons are you know impacted by the light if you're if you're if you have epilepsy the flashlights at you to try to get you to see if you have a seizure well what they're doing is they're they're flashing lights at it because they can cause neural activity in your ganglia neurons by bouncing photons off of your retina but that's not the same as like internally like inside your brain like the lights won't do anything unless you have unless your cells are sensitive to light and they're not by default so but there are gene therapies you can use to make your internal cells I don't mean like light that's like you know if you're in the experience he was talking about making you more oh you just mean like in VR like if you wanted to change someone's brain activity by using a VR experience you could use light in that experience you can't light yeah yeah you could that's exactly what they're doing I mean I mean that's why like I think it's hard to say like what's like what's the chicken and the egg like if you have a VR experience it's reacting to like EEG patterns and then making light out of those patterns like you're probably having those patterns also somewhat because of the light that you're seeing yeah so what we're also playing around with is actually using the erraticness of the data to procedurally generate geometry so just kind of imagine like you're just seeing what the data looks like in like a three-dimensional form and you know I think having access to that it's the kind of thing where it's it's it might be lend itself more to like kind of like a skill tree like you kind of learn it's not something like at first you're just like oh wow this is that but if you spent time with it it's something that by actually seeing your brain waves being generated in real time then you could start to like more you know we're kind of we're just looking for opportunity to make this more of like Jedi training then you can kind of find ways of like okay if I think about this how does that change this wave or if I if I'm really just is that possible so the what I would do with EEG is I would use it as a mirror to understand my own brain waves and this goes back to what I was doing in 2012 your EEG can drive the graphical changes and that's like that's what I would do is drive the graphical changes not try to control it and you know if you're like meditating just this allow it to like be an experience of you not try to control it just allow it to be a reflection of you and through that visualization and the audio as well as assuming you're the brain was reflecting the audio you begin to have you begin to create concepts of how your brain waves are causing the changes of light and sound and you begin to create concepts of your brain waves themselves and that has enormous therapeutic value just by itself without don't try to control it just let it be a mirror of you so then the next question is this based off like where the EEGs are on the spectrum you know we basically kind of we corral everything into between like one zero to one you know is where we use that as like a live particle parameter then it's like where what's the appropriate mapping between like high and low on EEG from between like light and sound like is it something is it like a reward base where like one is really low saturated and one is do we make one less favorable and one favorable or like one blue and one orange so I would not I wouldn't I wouldn't so sir your question was EEG patterns I profile them yeah so I would not do that at all like I would just like take the entire sensor data you know from zero to one sorry from from sorry that's sorry the particle data is zero to one but take the sensor data from zero to 160 or whatever it is and just just map like you know particle effects throughout the in that entire sensor data that's what I would do so that you're not that there's not it's not it's not necessarily about different effects occurring at different thresholds and we're trying to like get that effect to happen you just want I want to see the whole spectrum because I know that my brainwave activity will be inconsistent between one session and the next like it will be it'll be less expressive as I become more skilled so that means that I would want to be able to see effects on a gradient curve so if you have I don't know what the music there's like four sensors or whatever if you have what eight-channel EEG it's an 8-channel EEG so if you have eight channels and they're they're all like let's say it's it's a gradient basically all your effects all your particle effects are on a gradient and you just match the gradient to the sensors so you have a sensor gradient and you have a channel gradient from your EEG and just match them so that no matter so that you can still experience all kinds of cool effects no matter what outputs come in from your brainwaves and because we're kind of I mean there's argument that we're digital but we're kind of like analog in a sense that I want to see that sort of analog with what I mean is gradient basically but you know sort of like because my electromagnetism has a topology and if you can you know not chop it up into pieces but instead sort of like highlight the spectrum of it as it's flowing like like like a fluid dynamic and electromagnetic space that would be very interesting yeah that's good you know I think maybe I've kind of approached this because of my experience of the Muse of the like the thunderstorms or birds chirping that I kind of had a binary approach to the sort of like reward system of like negative positive but yeah if you make the whole spectrum just different you know that could be an interesting way of doing it too we were kind of playing originally to where we were making going from like instead of cloudy to clear sky to so that was actually the key inside of today you know like do things like hey the moon's cool hey the Sun and Sunbeams are cool too and just kind of shows you you're going here there like warm and cool maybe like more like elemental changes like water fire like different different polarities that are both favorable you know and believe it or not that was really my goal that I wanted to communicate to you was to not do it so my whole theory in 2012 when I was doing my company was to to get away from like you know EEG for games is bad because we're trying to like use it as a control your brain waves you don't fit until like it's not a button you're not pressing a button when you're sending your brain waves you're sending a there's a gradient right and so that's my whole theory was yeah we should like have the use the machines in a way that are reflecting that gradient back to us and so that's really like I was like yeah don't don't get away from the gaming concept of binary no totally the game or is the is the gradient like these different kind of wave states so instead of trying to hit like a point like lots of activity you you're trying to reflect the fact that there are many different kinds of states so it's not actually a point but it's the state of the wave like alpha theta waves yeah so if you look there's lots of great charts for great brain-wide visualizations where they're showing like waves in a in a chart like they're showing this great four dimensional visualizations of and that would be good to just like if you could put that into a VR experience if you could just or take the graphics from microdose and make them you know just very reflective of all the nuanced four dimensional changes in your brain waves that a that an EEG device like the news can track and generate and sort of integrate that high to level high level dimensionality and if your brain is in any in any respects like a neural network it's going to thrive on that data and you'll find all these sorts of amazing patterns and that's what I found out in my research in 2012 so that's I think that would be great if you guys do that as we just keep coming up with these like new things that are that make it so much more effective than older versions that we just want to get these new things refined but then we find like another new thing so before you were doing you know VR with EEG which is this like frontier technology and stuff you you're doing two-dimensional art with adobe products for example so how do you like how do you think of the VR as an art how do you think of EEG as art and how are you sort of like you know from your perspective where you going with it well sure yeah I think the one really easy way to correlate it is that the two-dimensional art that I've been making for the past 20 years that's really it's the art that people see the two-dimensional that the two-dimensional like kind of transmission that's just the the it's just like it's the residue that happens after the experience of making the art the experience of making the art is what it's all about that's that's the core I in order for me to afford as much experience as I can possibly take I realized that it was effective to find some type of business transaction of transforming the residue of that experience into you know the life-support token so I could just keep buying more of the experience for myself you know it kind of like we're all kind of free-range slaves buying our freedom back bit by bit that's part of the game but the experience that I have making art is very three-dimensional and it's really like I said even beyond whatever dimension or whatever form or the tool from using a waycom or a brush or a pencil or you know a piece of chalk it's where the that experience of being in touch with you know the creative dynamic conscious forces of the universe is what's the most exciting thing and so EEGs are great because EEGs are a measurable way of tracking the experience that you're having and you know I think over the years my art has gotten I've been more and more attracted to tools like Zbrush and Cinema 4D and Max and now the Unreal Engine is kind of represents you know the current pinnacle of the my endless pursuit for the nonstop creative orgasm because it allows so many different dimensions of creative input you know from sound to the VR editor to sequencer to animating to modeling to compositing to the particle cascade engine it's just this full library of little input places where I can express you know the unlimited potential of you know human creativity and so I think that's why VR is like even when I'm making a piece if I'm making a piece in Adobe Photoshop I'm using layers but when I'm able to kind of relax my mind and get in my flow state like I can the computer monitor I've always just seen that not as a flat representation but more of like a window into another world that I'm creating even with the layers like I'm seeing the layers with like inches of space in between them in my mind and they're just being collapsed like on the screen like that's that's what's happening in kind of the inner world when things are happening and so now I guess they don't have to it's much more tangible I can actually put them on different layers and I can kind of share I feel I feel like I'm able to share a much deeper aspect of my creative experience that people now through the art than I ever was before in any kind of two-dimensional incarnation so do you still have those files with all the layers separating your art I mean could you some of them I'm kind of a you know I my process in the past usually just based off the the lack of Moore's law or my ability to do a Ford you know more hard drives like I kind of get to a point where I'll have like a hundred or a hundred and fifty layers and my my the one thing that kind of one thing I miss about being a traditional painter because they still have a whole background of academic art and sculpting and all the prima was the level of like that level of like committing to something like something really powerful you know every time you say yes to one thing you're collapsing all the fractal possibilities everything that wasn't that and that commitment is meaningful there's something really meaningful about like I'm gonna take this painting in this direction and there's no backing up you know there's no net you kind of go for it and awesome things happen and you learn things by failing that way and with digital art you did quickly realize you didn't have that you had like undo and you just save as you could have versions that you save all the time and I just saw from looking at my own process of doing it every day that the more versions that I saved and the more layers that I saved by unconsciously or subconsciously there was this process of just non-committing to what I was doing and that non-committing was a really it wasn't a very powerful way to embrace creativity or be in a flow state when you're always because whenever you're saving you're basically picking yourself out of the moment and imagining this future possible potential of yourself going back to that save point so you're not surrendering to like what is and all the possibilities so my process was usually like get to a point where the meat was as soon as the layers start becoming a hindrance like I have to go back and I don't know which layer I was on or I noticed like a performance or that it crashes my computer or there's I'm suffering some type of performance it because it's having to keep too many too too many things in place in the layering software then I usually just collapse it and be like okay now I'm committing I'll save it before I do that and then I okay boom collapse it and then work from there it somewhat merges the world of no undos and infinite undos into something that I found workable so I do have layered files but you know if you look at a finished image there isn't a file that has every single one of those layers all the way back to a white canvas to the disappointment of many after-effects artists

I'm wondering what you're going to create when you have when you have the ability to change reality itself through neural lace I'm looking forward to that too very much so I've been wondering like I've been thinking about you know I have this great plan for how you know this we're going to achieve neural lace and there's a number of different directions people can go to you know apply artificial intelligence to brain waves and to figure out what those patterns are correlate them with the you know AI figuring out what the real world patterns are and but then the question is like well how now when we send stuff back into the brain there's we could you know potentially we could have a sensor the CBI stuff and so instead of a BCI instead of brain computer interface like a CBI so a computer brain interface right so it's writing to the brain you're exciting about you're excited about that I am but but you're gonna break the blood barrier no no planning to do this wirelessly huh planning to do it wirelessly so you're a non blood barrier breaker well the interesting thing is that much of the old brain is below the blood-brain barrier like that out like you can reach the thalamus is below the blood-brain barrier you're the guy was talking about like entering the thalamus like through the nasal cavity that's right pretty intrusive well I'm thinking we may not I think blood-brain barrier somewhere in there so through I guess I want to say blood-brain barrier I mean just like breaking the skin or some type of right the nasal cow the nasal cavity is a very sketchy territory it does all these it's very lumpy it's not a smooth channel it would be very easy I was talking to a nurse who stuck a had to take a tube up the nasal canal and that was very sketchy and the sensors that I'm currently looking to use to do this research are a little bit too big they're the chances that they nick something and break something inside the nasal cavity are pretty big so what I'm thinking instead is you know to I the naval cavity is still important but I really strongly believe that wireless technologies can determine the sensor that I'm planning to use has the ability to determine where a brainwave is coming from so we can still kind of target the thalamus but from outside and it won't go through it won't go through the top it won't be on your forehand but I mean these are lots of these are lots of research questions and engineering questions but I my hypothesis is that we could the other thing is okay so look David Eagleman I talk about way too much my podcast but he has he talks about these tongue strips and back strips where you have a camera on someone's forehead and you attach the the camera to the tongue strip so

so I was going to do my nearest research on a nvidia supercomputer and I asked nvidia for one of their supercomputers and they didn't say no but they but they they wanted me to produce a prototype first like with on a lower-end hardware like nvidia like I have a 1080 but they just I went to the DTI conference and they sent me an invitation to join their beta for their cloud GPU

that's right so it's basically like it's just like Amazon AWS except it's all

GPUs in the cloud instead yeah we're like invidiates we are our microdose team

you like bow down to the altar we have a green altar at our house and yeah well

that I mean they're like I don't know if you saw the keynote Jensen's keynote

they're building another universe Jensen said we need to build another universe

and I don't think his employees really heard him when he said that because I

asked them about it and they did and he really said we need to nvidia is building

another universe and that's they really mean like a universe on top of this

universe or or just you know like so that that that's segwayed into he was

talking about Isaac and Isaac is the simulation for robots to learn faster

robots to learn you know how to do stuff in the real world faster and so you

can you can massively speed up how long it takes a robot to for example kick a

hockey stick into use to flip a hockey stick to hit a ball into a goal that is

actually a lot of work for a robot to do and with by creating a virtual universe

for Isaac they're able to multiply that robot the robots experience times you

know a huge number so you have like 100,000 robots sorry so I asked that's

no it's an important point so they they asked I asked nvidia I said you know

what about yourself driving car can't you can you put that inside this Isaac

program and apparently none of them had thought about that and I asked multiple

levels the top people the middle people they and but they all thought it was a

great idea the thing is is that in order to create this for self-driving car which is basically a robot you have to basically create another universe which is what Jensen was talking about in the first place you have to create a planet basically in order to accelerate the development of self-driving cars so getting back to maybe I'd rather stay it up so getting back to so so for neural-based research I think a lot about applying how to apply artificial intelligence to to medical imaging to EEG but also to VR to end into AR so I say because we have this nvidia cloud coming and we're able to render the very best computer graphics light fields of photorealistic computer graphics in the cloud on the GPU and stream it over networks that could be over a Wi-Fi or over 5g to a pair of glasses that's going to enable VR experiences that have that have a rendering quality that vastly exceeds the what you can do with a single desktop GPU because you have a cloud of GPUs right so it just multiplies the graphics and there's a pipeline that can just send you the basically the pipeline it's just sending you what you need to see to your mobile device so they figured it out so they can do this amazing render but only send what they need to send you and so that way you can have a needed rendering that's part that's one of the turns out foveated rendering was part of the initial design but it's not actually necessary they figured the pipeline that will and they foveated render will enable further optimizations but for what they're talking about it's not even necessary so that the great news is that web AR is going so basically it's the future of the web where you're just walking down the street and you want to you want to access something that's normally you look at your phone you look at your laptop or your desktop but now it's just like the world itself is your web browser Wow yeah as long as the bandwidth is strong enough it could totally be rendered somewhere else because all it needs to do is just send to screens or you know to a phone right that's not that's not a lot of pixels ultimately it's making those pixels accurately in space and depth you know corresponding to like where you are and how you're interacting with it that is most of like the processing power that's I didn't know that actually but so yeah so so that is so what I think about for Neurlase though is so there was a project called deep dream by Google where they used of course you've seen it because it's they they had AI doing art basically where you train they trained the neural network on images of snails and dogs and cats and then they showed it clouds and what they said was every time we run this through the network we want the network to draw the what it thinks it's saying AI Paridolia yeah so my my my thinking is that you know we can apply this sort of deep dream deep dream which I believe the program is free and open source you could apply deep dream to EEG so the AI draws what it thinks it's seeing in your EEG waves and that appears inside microdust VR yeah I think was what's more interesting even than that though and this is where I you know it was easy to kind of look at a dystopian future and imagine robots like taking over a factory jobs it was always like oh but we're artists you know like never gonna it's never gonna have you know the intro the perspective that we have on life and art was gonna be like art was gonna be this one little place where like robots couldn't take over your job but then once I started seeing the deep dream stuff and just realizing like all the data is being collected like it will be because we'd like to think that we're really complicated like our tastes and like our our sensibilities are like incredibly these like sophisticated things but we have a range between one and 60 or one and 160 as opposed to between zero and one six you know yeah so but what it makes me realize is like oh man dude the computer I mean the AI is gonna be not all it's gonna be one of the reasons it's gonna be the the ultimate artist in the future is it's like not what's gonna separate us I think it's gonna be interesting one of things that's gonna make human art still novel and interesting is going to be the subjectivity of it is that it doesn't totally make sense is that it pulls like just strange like non sequiturs that don't have any correlation together like that will be interesting it's like that surreal like how did you why would you combine those two things like the absurd data will maybe be more compelling because what it's not very we're probably not very far along from like some type of like a deep learning neural net to basically be looking it could just I mean if you just like had any I just hang out on reddit and just being able to take the track the data especially once we get into the point of if there is a you know say we have classes or whatever that are monitoring like our pupil dilation once we can have some sort of like a measurable input of like awe or like when something when a human thinks something is beautiful and like how their retinas dilate or how their pulse changes I mean you could you could you could you could fake it just by like like number of likes or upvotes or we retweets but it's not going to be very long before a sophisticated AI can figure out exactly what kind of images people like or don't like and combine those things very quickly into like the most liked like popular type of images ever because it doesn't have the judgments that an artist has like I have boundaries you know like there's some places I just don't go because I'm too good for that or I don't like that or I had a bad experience with that the AI isn't going to care about that it's just going to go right for like the bottom of the brainstem and just like the jugular of like this image has all the different aspects and subject matters and colors and compositions and pixel density it's going to be like the number one ultimate type of art that someone's going to want like in their house and that's going to be crazy to see that you know I really think so now I'm not just studying Neuralace but also how to build artificial cortex and eventually artificial brains and I really think it's possible to build an AI that's sort of stacked in a way in a structure that it can become a sort of curator of the you know a decision maker of the kind of patterns that it's choosing to create like it can have boundaries as well as the point I was getting to but so I really think that you know that so there's the sensors that I'm planning to use for Neuralace and I'm planning to apply artificial intelligence to them and I'd love to see you know some AI and inside the micro dust VR and I don't know if you're sure yeah yeah we definitely like that's kind of part of a roadmap is we're looking for you know we're looking for that special brilliant weirdo out there it just doesn't fit in anywhere else and we've just created this spot for them in microdose like we've got that we've got the desk we've got the chair ready for our like lead AI micronaut so you're out there let us know oh me me I that's me okay great that was easy that was fast no so no of course I would I'd be glad to help out with microdose but so where I'm going with with with the with the Neuralace is that I mean not with Neuralace but with artificial intelligence is is not just it's not just about graphics but you as an artist as you sat there you said there's all these things like when you painted multiple layers or something you're imagining in some instances like there's there could be a millimeter or centimeter or an inch of distance between the layers that you didn't really have the ability to add into at the time so you had this this sort of like what I'm thinking is that if you're creating art and maybe you'll go back and do some 2D art while you have this really advanced EEG cap on it and these new sensors that I was you're gonna use for Neuralace where they can pin they they just have improved sensitivity and graphical fidelity in in terms of I mean not a sensor fidelity but what I'm what I'm saying is they can pinpoint like they're kind of like light field sensors but they can pinpoint the origin point of what's coming to them like light field cameras can pinpoint the origin of where lights coming from and so if we create a cap of these while you're doing art then I'm thinking that you know at some point the computer could you and the computer could collaborate on artwork where you're drawing and it's and it's creating stuff also I'm wondering how that would work I mean there's lots of different ways that could potentially work and or you could just like I'm I'm thinking at some point the computer could start to pull out stuff that's kind of from your imagination but then like you were saying without a curation thing it would make something different than you would make but well I think the part of it I think where artists are gonna have a little bit of like real estate like shrinking real estate in the future is going to be creating the parameters of like the sandbox like we're gonna be able to curate like the images that something draws from or we're gonna be able to kind of create like the parameters of like the brushes and like here's a bunch of landscapes and here's some portraits and here's this and here's that and it's gonna be there's gonna be a field of artists that just understand the right ingredients and the right way to introduce these things into the like the deep they're they're they're they're they're they're they're custom like deep dream algorithm you know that that's gonna be kind of a signature style might but maybe just like there be image libraries you know like the curation of the image libraries might be the aspect you know definitely what AI is producing now is very much depending on its training data so you could train it on your artwork for example and then give it clouds and it would produce variations of your artwork in the clouds so going so going back to what what part of the brain should we so so date so I was talking so there is this so there's a tongue strip that's connected to a camera for people who are blind and you turn the pixels from the video feed into electrical signals on the tongue strip this can also be done with a back strip basically the back strip or the tongue strip is like if you imagine it's just a grid and if a pixel gets dark then you have an electrical signal that that stimulates your your that part of your body and what happens over time is your brain figures out visual information from the camera so you learn people who are blind can see through this camera that's connected to it to their tongue or to their to their skin on their back it turns out if you stay in experiments with rats if you take an eyeball and you plug it into the rats audio cortex the rats audio cortex so you have you have an audio cortex you have a visual cortex so like the visual cortex is like in the back of your head you know we had an audio cortex yeah so your brain I imagine it's gonna be a future product that's like I'm definitely gonna make a particle called audio cortex that's definitely whatever happens it's definitely gonna be a particle name I'll send you more names of neuroscience items and yeah I just I think the visual cortex just gets so much attention I don't watch sports at all I almost kind of look down on people who watch sports but I thought to myself if they named the sports teams after parts of the brain I'd probably watch sports so the point is you can plug in an eyeball into the audio cortex and your brain will figure out how to process it process it visual that visual information so your brain is like a generic learning algorithm any sensor that you plug into it from any place it can figure out that data so we don't really need to in terms of in terms of neural in terms of neural lace in terms of sending input back in a computer-to-brain interface like you were saying earlier we don't really need to go to the thalamus what I call the sensory integration center we you can just plug in something anywhere but I'm thinking that your eyes might be the fastest way to get information into your brain and so why mess with something that already works VR might be the input for the audio and video VR might be the best the fastest input for for neural lace that's a great I mean it's a much less obtrusive way of getting data inside and in order for neural lace to become a mass commercial product we have to think about you know getting the brain signals wirelessly you know with with you know Facebook is working on all this really advanced medical imaging that's non-invasive it doesn't involve surgery and so you could use non non-invasive sensors to get at your brain data and deep and figure out what those patterns are and then we can send data back in through the eyes and the ears without being super invasive but my research does involve figuring out like not only what the what what a brainwave pattern of of your controller is but also figuring out you know how we send how the brain sends patterns from clumps of neurons to other clumps of neurons and what the communication protocols are so we could in addition to you know what if we figure out what the communication protocols are but we decide to use a non-invasive device we could use the knowledge of the communication protocols of the brain to design the optimal

exterior device for let's say you want haptic feedback right it's just like it's
just a could be a glove or something or a ring I said I like the idea of
information coming in and out between your optical nerves versus like your
spinal cord or having something go through your nose to your thalamus you
know a lot seems like a lot less points of air there for sure it makes sense
why mess with with evolution when you can work with evolution we've all
received data that way I'm a big fan of that for sure
this one is music this one is not music this one has audio reactive music this
is this is as reacted on music this is reacted on you
don't have both audio reactive and music reactive at the same time we might do
that for tomorrow but now we wanted to focus on one version that just really
focusing on the data from the muse because if we use audio reactivity to
this is too many things so you might not notice your brain wave I don't think
you wouldn't yeah it would be distracting from trying to focus on the
brain waves but our engine supports them both simultaneously they're not so are
the so the brainwaves are only driving some of the light and sound effects
they're not driving all of it no not all of it I mean there are some things where
your controllers driving some of it yeah still there's your controllers we
still have some pressure sensitivity because the idea is really just trying
to you know create as intimate experience as possible so we still want
to make sure that like there's some type of reaction happening from their hands
and pressure sensitivity and velocity like that still physical movement drives

a lot of it but behavior wise when you're looking in a particle and you're seeing something some state change like whether it grows in size or it turns or rotates or pulsates or the clouds moving that's all so what what I would think to do is you know for the purposes of making your brain waves more noticeable is it draw to dramatize the reactions from your brain waves to so you have really profound visual effects and really profound and I don't know how like what what you have in terms of what you can play with and how you can dramatize like in terms of like if you if you put everything instead of because we were saying you know instead of having everything like you know the cloud the sky is either dark or light instead of that you have a spectrum of sky and but if yeah if you can make the whole sky like sort of like into a gradient that that dynamically adjust to every tiny change in the sensor activity from the interacts on use then that's just that would be a more dramatic and you might notice your brain waves more and they stick out more maybe I think partly the challenges for the purposes of this demonstration is that I agree that like the subtlety things are definitely kind of like where it's at in the long run for someone that's using this like you know it's dosing on a regular basis and then but the challenge we're doing here like what are the things that someone's going to see a visible measurable difference in like two to three minutes of a demo while there's like drones flying above their head and all these other things happening too you know so it's like quick payoff and obviously I think the the long-term being able to recognize it over time for people that are going to be you know we definitely want to create the kind of experience of people like you know come back to it over and over which I think it's so going back to Google's deep dream the Google's deep dream it looked like the program was sort of hallucinating like in the clouds it would see snails and dogs and cats right and they said that they achieved this by you know basically creating these feedback loops and they make in making the feedback loops work harder and so I kind of my hypothesis is that when people are when people consume certain kinds of psychedelic chemicals what's happening in the brain and this is there's research around this is that their brains are working harder that there's a lot more brain activity like if you had EEG going and you know when someone's you know first working on learning a new task like programming gonna have a lot of intense brain activity you know but as as Fong you're he's the chief programmer is that his role as so as he becomes a master of Unreal Engine like his brain activity chief engineer yeah yeah so as he gets really good at coding and doing audio reactive stuff and eventually maybe EEG is driving the audio reactive stuff or whatever you're gonna do it's you know I actually lost my place so so we we were saying like one step before that oh yeah okay so the idea is that when people are dosing with these psychedelic chemicals it's forcing the brain to communicate a lot more and the brain is organized in a way it's like there's a lot of little feedback loops there's a lot of big feedback loops like the stuff that comes into the thalamus goes through the whole neocortex you know like your light like bounces off your retina it causes the ganglia to to send signals along the optic nerve to the center of your brain and then it goes back to the visual cortex which is the occipital lobes and the pride of lobes in the back of your head and the same thing with your ears you have data comes from your ears it goes to the thalamus and you know I can't wait for you that's an awesome roadmap so the visual cortex is like a sensory I'm sorry the thalamus is like a sensory integration center where all those stuff all that stuff collides on the way into the brain but then it goes through the neocortex and the neocortex is like a sort of like a deep learning hierarchy but the type of like a pyramid but the top of that pyramid is the thalamus so it's like the entry point is the thalamus goes through the neocortex and it goes back to the thalamus it's a big feedback loop the entire brain the entire brain is a fractal of feedback loops and even our perception of reality is in some sense a feedback loop in terms of like when we observe something like the observer effect we are actually affecting our what we're observing we're affecting it there's some sort of messaging between what we're observing and the observed you know yeah I mean a lot of times you know another more kind of kind of layman's way of kind of putting that too is I think that our what our brains also kind of represent is you know the highest pinnacle of you know at least a few hundred thousand years of evolution of the best technology of like the meaning making machine you know what our brains are really good at is making meaning out of chaos what what the reason that we're here is that we were we evolved to be a look at the planes of the serengeti and recognize the shape of a lion over the shape of a gazelle and we saw that abstract shape and we could be like that's a threat or that's gonna be food and the ones that figure that out are the genes that kind of went down and so that's we still have those processes and on different types of psychedelics I think that especially like they will talk about just they all do different they're all very different and I don't like when they get all grouped into one word you know but say for LSD I think LSD is like steroids for your your meaning-making machine technology definitely you know it takes you're so uncomfortable with chaos it'll just make anything up and it'll grab and it'll it seems like the processor gets kind of it gets overclocked in trying to make connections that are there or are not there and that pareidolia just goes to the extreme and that's definitely and that I guess yeah the machinery of a feedback loop does make sense on how those are kind of like the gears of that that kind of turn the pareidolia that it's so desperate to find something that it's willing to fill in more of the gaps and it does usually and believe more in its results than it does in normal situations and you've seen people that get caught in those loops where to physically the day there's a guy that got caught on a loop over and over and over again so so neurofeedback it literally is a feedback loop of so so so what you're doing like if you look in a mirror that's a form of neurofeedback if you are meditating and you're humming that's a form of neurofeedback why it's because what you're seeing or what you're hearing so okay let me just stick to one at a time and not to try to describe the whole thing so what you're seeing in a mirror is your reflection and that that image goes to your eyes and your eyes it's it's what comes into your eyes is connecting to the how you move and how you move changes how you're like how your reflection moves so that's the feedback loop so then that goes back into your eyes changes your movements it goes back into you know you see it in the mirror again and when you're humming to yourself like if you're meditating and you're chanting to a home or something that's a feedback loop because your what you're hearing is causing subtle changes to your movements in terms of your vocals because that's movement as well say that your vocals are the same thing as moving your hand right and those subtle movements are picked up by your brain which further gets incorporated into the next movement that you make so that's a feedback loop EEG is a feedback loop your entire brain is a fractal feedback loop it's inside a universe it's a feedback loop that in now what you're doing with microdose VR is you're creating a feedback loop from your brain directly into the computer directly into someone's eyes and as that impacts a person in their internal neural network in their brain it's going to cause more changes to their movements including to their hands which is going to further change their brain ways which will further change the light and sound effects which will go back into that person through their eyes and their ears and on and on and so this is a vehicle for it for increasing someone's awareness if someone's overclocked with psychedelics or something they're just going to pick it up that much faster that's that that is not a false

statement we have we have the video now for sure and that's what we're kind of

and within that context I think what's exciting about you know this is our

first entry point into using EEG and it's obviously like a really amazing long

fractal road of potential branches to follow in all of our futures but I

think one of things one of the places on that infinite roadmap we're looking

forward to is really getting to that sort of what they call this the closed

loop of the fractal loop where that feedback if we can start to identify the

feedback of the flow state and that's what we're really after that's kind of

the you know the feedback of the flow thing for yeah because once we can get

that and you can get some sort of feedback and to then to encourage as

much of that state because whatever happens during the flow state you know

I'm not a chemist but I'm sure that the the type of neurochemistry that the mind

is able to create within a flow state it's got to be just amazingly okay so I

heard of I got really deep into you know you know Ken Wilbur and I've studied

Ken Wilbur I've got really deep into this stuff and and one of the the things

that I read or watched in a video was was how there's two you can someone

categorize there's two paths of enlightenment one is like the Buddhist

path where you meditate and learn to calm your mind and the other one is the

avatar's path where you are creating the universe and those are two valid paths

there's no reason why an avatar should try to calm their mind and follow the

Buddha's path those are both legitimate past so when you're talking about a flow state if someone's playing basketball and they get into a flow state and that's their enlightenment fine but it's there's no reason why they should also try to become like a meditating monk those are both valid past yeah yeah no I'm I favor more the avatar path but we're you know we've designed this around actually trying to accommodate at least as far as in the world of like the creative imagination your creativity or the audio or intelligence is like your audio intelligence your spatial intelligence which is responsible for like painting sculpture most of the create visual creativity create creative exploits and then your movement intelligence of like dancing and flow you know our goal following like the Ken Wilbur superhuman model about raising your levels he like a lot of times we specialize when you specialize in one thing you become less of an expert in everything else and so we're really excited about developing microdose into this kind of a platform to inspire and you know give permission and opportunities to like the next you know generation of these young minds like my little daughters you know it's like I want to build a whole I want to build a new art movement for my daughter for when she comes at age and she chooses if she wants to be an artist or not I just wanted to be an entire new movement that she can select form and the pantheon she might be an accountant but I just want to make that option for her she might be a Buddhist instead of an avatar yes her chart her chart does have some spiritual teacher stuff in it you know but it's got a lot of organization too yeah but I think that that's where it's going like we're making this we want to make a tool and make an experience that allows you to increase your intelligence is on I think the things you're I think you're gonna learn in kind of a and so much faster when you have access to the three of those things developing in a in a complimentary and simultaneous matter than you were like you're gonna take music lessons you're gonna go into a keto you know it's like we like to box things box our possibilities so we're really trying to open as many possibility creative possibilities and give people just another and give you know giving people access to a new type of creativity and giving you know the this universal infinite force of creativity more access to humanity too you know it's a two we're just trying to like just just open up the like the bottleneck in the bandwidth between the doors of perceptions yeah that's my that's my I'm hoping that you know within the next year or so as soon as I start start working on this as soon as I get the sensors be I hope I'm hoping it's with the next month as soon as I get this new sensor from this company in San Diego that I'm consulting for as soon as I get it in the next month I'm gonna start you know I'm I'm actually you know my my my chart is to learn how to do has learned how to use JavaScripts due to do to command 10th the TensorFlow libraries and I'm gonna take advantage of the NVIDIA GPU beta so that I don't have to have you know someone donate a super computer to my cause to get on for sure yeah so here we are at AWE 2017 and for perhaps the first time in public people are experiencing their brainwaves inside this product microdose VR thank you very much thanks Micah

The NerveGear Show

Nov 2, 2017

original audio/video here https://youtu.be/p9yTPBrrES4

Audio Transcription by OpenAI's Whisper

Hi everyone. This is Micah here and I'm here with Sarah who's with Virtual Bites.

Hey! Virtual Bites!

Yeah, let us know if the audio is better this time because we're going to try to re-record the nerve gear show that we did yesterday.

So I hope the audio is better this time.

So Sarah here is a neuroscientist. Yes.

Where did you study neuroscience?

I was studying at the Andersen Institute in the Netherlands. I was studying research into psychedelics.

And then I took it because it's really hard to actually give people psychedelics.

Getting their approval takes years and years. And I opened an immersive VR lab in my department.

And I was researching how virtual reality can affect our brain, can affect our perception of our body and our movement.

And now I'm still doing this with Virtual Bites. We're an education and research and art collective.

And we really want to push forward these ideas about what this technology can do for our brains.

The good sides and also the possible dangers that we should be considering.

And we come out with two demos every month of just these wacky ideas that we have of what this technology can do.

And you can see them on our Patreon page under the Virtual Bites.

Great.

So yeah, so Virtual Bites, they're doing research by building actual VR apps now, tying it into their neuroscience research.

And so Virtual Bites was actually at the first SFVR 360 in September.

And again, in October, we had, because we're doing monthly events.

And so you're actually going to be able to see Sarah speak, by the way, at the SFVR November event, which is going to be at the Microsoft Reactor.

This is the SFVR logo, one of them. We have many different versions of this logo.

I'll show you another one real quick. Let me grab the camera.

So this is our other logo.

And so, gosh, I really hope people can hear us. Okay.

I don't see that like a feed, but okay, so I wanted to like, we got, we talked a lot of neuroscience last time.

So the Nerve Gear podcast was sort of like created about like, you know, like I really wanted to say, how could we accelerate the point in time in which we could do AR and VR without a headset and with just by sending signals directly into the brain.

And so we had, this time we got a bunch of brain images here. So it's a really complex problem.

But in general, I'm really interested in building next generation brain computer interfaces and I have been studying neuroscience for 12 years.

And I have a, had a neurofeedback business. So we were combining in 2012, we were combining EEG, taking EEG signals, which as you noted are very noisy, consumer grade EEG is very noisy, it's very bad, but we're enlightened sound effects to the biometric signals it was picking up.

And that would include signals that are mistakenly muscle signals, like if you move your eye and stuff like that.

EEG sensors, the job is to eliminate as much of that noise outside the spectrum of EEG as possible. So you're not picking up ECG or EMG or...

Maybe we should just remind people that at least from our perspective, one of the biggest problems of EEG is it doesn't begin with pick up all of the brain waves, right?

It just picks up brain waves coming from pyramid cells that are synchronized in your cortex. So we're losing a bunch of data even just to begin with.

That's right. Yeah. For example, EEG sensors are usually measuring something in between zero and 200 Hertz, but brain waves go up much higher than that.

So there's a neuroscientist who, I got his picture this time. Let me grab this real quick and show you this.

This book is The Neurobasis of Free Will by Peter C. Criterial Causation is a subtitle. And that book is really great because it's sort of like...

And we also got the Unintelligence book here. You lost me. We also got this. This is Unintelligence by Jeff Hawkins.

Let's see. We also got Networks of the Brain by Orloff Swarnes. Let's see that one right there.

So what I was going to say was... So go into Jeff Hawkins' book real quick, and then we'll go back to Peter C's book.

So Jeff Hawkins' book, and you've read his book, he talks about how grids of cells are complex enough to measure...

Like a 3D grid of cells is complex enough to measure a really complex sequence of inputs from any sensory apparatus.

It's going to be a very general learning algorithm that stores...

So you can have incoming inputs from eyes or ears, from your nose, and it can store unique patterns with amazing complexity.

And the patterns that it stores are based on patterns that came in, and those become predictions for what...

Predictions, yes.

Predictions. So if you get a partial pattern that comes in, it triggers that same network that responded to a larger pattern to re-trigger the...

This is really the unique person, and I guess this whole predictive coding framework that is starting to gain a lot of access in neuroscience.

I consider Jeff Hawkins to be the father of it, because he's the one who started to look at his brain as a prediction machine.

And that's really the first time where people have started to realize that these top-down predictions are really, really important for the brain.

It's not just what's coming into the sentences at any given time, and it's also what's coming down from higher parts of the brain,

that the brain has already been alert to these predictions, and they combine with the bottom-up sensory input in a statistical way to create this world model that we have.

And we can hack this in many ways, and one of the ways that I'm trying to hack this is through VR, because in VR, I can really control the incoming inputs for the brain

and decide whether these inputs fit the known predictions that people already have, or whether they don't.

So I'm looking at you right now, and yeah, you have a sort of avatar that is more or less predictable, but then you have this weird whisperer thing that creates novelty for my brain.

The novelty is the currency for the brain. You really can, and I like to think of it as that's the economy that the brain works on.

Novelty is passed on throughout the different parts of the brain, and the brain has to sort of use that and explain that the novelty is this world model that we have.

Right, so Hawkins' book really drives how our brains might formulate models of the world based on sensory inputs.

But then what was really great about Peter Say's book, The Neural Basis of Free Will, criteria causation, is he then says, well, in the brain, he says, well, maybe every neuron is a coincidence detector,

and maybe the basis of a bit of information in the brain is a coincidence detection.

And what that means is that if you have a hierarchy of cells, like this is, I believe this is a Jeff Hawkins' work, so let's say you have a hierarchy, let me make this bigger.

So if you have a hierarchy of cells, so let's say that you're the lower, the inputs, let's say your eyes, when the senses come to your brain, they're going through the bottom of the hierarchy first.

So let's say your eyes are over here, and do I have a better one?

So they go up through the hierarchy.

So what happens is at the lowest level of the hierarchy, your brain, just like an artificial neural network, could be recognizing lines and edges and curves and colors, is this blue light or red light.

And then at the second level of the hierarchy, or the next level of the hierarchy, it's going to combine these lines and edges go together.

This color goes with this edge.

And at another level, these lines and edges could be like an eye or something.

And at a higher level.

This slowly starts forming distractions and combining or sort of with the rest of our senses.

And the higher you go up in the hierarchy.

Yeah.

And the higher you go up in the hierarchy or the deeper you go into the brain, the larger the chunks get.

So then at one level you're looking at eyes and another level you're looking at, is this a dog or a cat or a car?

And this is how the self-driving cars are designed to work, where you see if I have the self-driving car one.

I don't know if I brought it.

So the idea is that the self-driving car is basically using deep learning neural networks to representations of the world.

And its concepts are how all the lines and edges connect at a higher level in the hierarchy of the network.

And so basically you can see the basis of the concept for an artificial neural network is the map of associations between all the lower level bits that come in through the base of the network or the sensors.

Exactly.

And so maybe some people don't think of their, you think of your eyes like one thing, but it's actually like lots of different sensors and lots of different, you know, edge detectors and color detectors.

Yeah, lots of different layers of computation.

And what's interesting, I think we said we tried to talk about the sense of self, right?

How does our brain abstract a sense of self that all, I guess, meanings have?

Yeah, so and I think that, you know, if you look at like, so look at, I was going to get the book for Douglas Hofstadter.

Douglas Hofstadter says that the self is a strange loop of, so it's like a learning feedback loop.

So you have all these concepts of the world.

This is a dog.

This is a cat.

This is a mouse.

And then if you had a self-driving car or a person observing the world long enough, they begin to notice features about like the self-driving car should begin to notice features of itself.

If it could see itself or its relationship to other things.

And if you had that in a feedback loop, it would begin to formulate a model of a self.

In some sense, it has like, it's not a self-aware self, but it's like a self like, can I move forward?

And to get a self-aware self, you'd have to have not only a model of the self, but you'd have to have it in a feedback loop with all the other data.

So I started this.

The way predictive coding looks at this, do you know the rubber hand experiment?

Maybe we can even try to show the rubber hand experiment here.

If you want to.

That could be fun on you.

So your brain is really, like we said, it just correlates different statistical input.

And sometimes the best explanation it can come up with for these statistical correlations is these statistical correlations are coming from one VA.

So if I take a rubber hand and put it on top of your hand, and all you're looking at is this rubber hand.

Now we're in VR.

So let me put my hand on top of yours.

And let's say I touch you at the same time, and then I'm touching this rubber hand.

I need another assistant to actually do this.

But you would start to actually view.

I'd start to think that this was my hand.

This is rubber hand with your hand.

They squash the rubber hand and they really solve heart rate go up.

So it's a very physiological, very real aspect of the brain.

And it points to the reality that what we're seeing as a model of ourselves is in fact data.

And if you substitute your real hand for another hand, your brain just takes the data.

Yeah, so your brain, so it's like your model of yourself is just data that your brain is putting together.

Exactly.

And it's very plastic.

And for instance, the clothes that we wear, the tools that we use, they all become a part of this self model of what we think of ourselves and the basic bodies that we have.

So people think there's this, you know, people call consciousness the hard problem, like how do you explain what that is?

And I think that, you know, there's several components to it.

There's audio component, there's visual component.

But just imagine like an animal in nature.

What I'm saying is that it's basically like, let's say this is a brain and this is the world that the animal is seeing.

And basically what you're seeing right now, like everything you're seeing is video that your brain is taking through the sensors of your eyes and through the hierarchy of the neural network assembling into a coherent picture.

And the reason it's, the reason it's like, you know, an active conscious experience, because it is for the brain a temporally active brain wave pattern.

And in the temporal reality of it is something you can observe when, you know, like every emotion, every modality has, you know, like a sign, is like a sign wave.

It has peaks, it has lows, it has like, when you, if you, I like to say, let's imagine that you take a second of consciousness and divide it up into milliseconds, even a thousand milliseconds of consciousness.

And you looked at it like a movie.

So it's like, you know, if you take a movie and you divide it up into 10 seconds or something and you're looking at each frame, you say, what is happening in each frame of this movie?

And you could say, well, in one frame of the movie, the animal or the person is looking at a laptop and another frame they're looking at the vibe next to the laptop.

And this is your laptop from your work.

And then they're looking at Sarah or I'm looking at Sarah.

And then they're looking at Sarah with a duck face.

Yeah, Sarah with the duck face.

And then I'm looking at this at this table and these pictures and I'm hearing my voice.

And so in 10 seconds of consciousness, I have this sort of like, so let me grab this one right here.

This is a picture.

Personally, I think that the consciousness and I mean, not just personally, I guess I'm in the Dennett school of thought when it comes to this word. It's an illusion.

I think it's a useless word that's not getting us anywhere. I think we should start looking at these new new words that we have, 86 billion of them, right?

Yeah.

And the moment we, enough of them get activated, it's what we call consciousness.

But that's just because, you know, enough of it gets to this area of our brain, which we can convert it into verbs and communicate it to others, right?

Yeah.

So a lot of what we call consciousness is just this reporting idea, the ability that I can report something to another social being or, you know, in writing.

But so this is where, you know, other parts of our brain are being activated and not the majority or this specific network doesn't mean that they themselves are not conscious.

A lot of athletes, people that dance, everybody that's the flow state, you know, we are extremely conscious when we do more.

So what exactly my body was doing? Absolutely not. I have to, in fact, let the go, the brain has to let go of this little, little verbal part to be able to be in the moment and move it to reality in that way.

So this is an illustrator.

So I know I hope the sound is better on the actual thing.

What is that?

Where's that?

I don't know.

You said I get this.

Well, I don't know.

Where's that coming from?

No idea. This is your old mic.

It's my access to the controls.

Oh, gosh, I'm so sorry.

But what I wanted to show was some settings.

Mute.

Wait, I hope that you're catching the air from my perspective.

Because we're all PC staff.

This is an interesting experience.

So how are we going to learn to interact with each other in these worlds where each of us has a totally different amount of control, right?

Yeah.

And maybe let's do another experiment that I really liked was just passing you, you staff.

What book can I pass you? Let's see, is there like a pen?

Oh, here's a dice.

Can I pass you the dice?

Maybe. I think you can roll the dice.

Wait, I don't want to give it to you.

Ah, it fell from your hand.

Here.

Oh, we can hand on shake.

I meant to be.

I guess it fell from my hand.

Interesting.

In this space before we cannot pass dice to each other.

But I can pass you this pen.

You can pass me a pen, which is very cool.

Because we can change our things.

But yeah, this is, again, why I'm so fascinated with VR and hacking our brains.

Because we can really control things and then control the environment in ways that we never had this capability before.

So can you see this?

It's not just about the visual sense.

It's about everything around us.

You can see this.

So this is an illustration of a neuron.

Yeah.

The density of neurons, which you were just talking about.

They're very densely packed in the brain.

And so an example neuron, let's see.

What I wanted to show you was we have this, which is a, I don't know if you can see that there.

This is the, well, actually, let's start with this one first.

So this is an example of different networks that are activated.

More or less specific conditions, I guess.

Yeah.

So the idea is that when you are neurons activate in a circuit, you can see, and there is a video that I got, but I'm not going to show it.

But gosh, I wish I could turn off the sound.

It's driving me nuts.

It is.

It's really driving me nuts.

Like, that's not fair.

It's like a meditation and hum.

Yeah.

But, okay, let's try media.

Save.

Save.

Explore.

Let's try to put this.

Okay.

Yeah.

Okay.

Okay, let's see where this happened.

Okay.

I don't know where that's coming from, but now we're in a different, like, location.

Wow.

Look at this.

It didn't stop.

Unfortunately, that didn't stop the background noise.

Yeah.

What is that coming from?

Anyway.

You guys just sit in your head.

So what I was going to say with this, when you have a neural circuit, you have a sequence of neurons.

It could be five or six.

You know, it could be a lot of neurons that are lighting up in a sequence, and they're not necessarily directly connected.

We're not necessarily aware of all the connections, but.

It does have a statistical correlation.

Yeah.

And so, but you could say that because of that, if you like watch it, watch videos of this activity as it's been mapped, it kind of suggests that our brain's neurons are lighting up.

And it kind of suggests the electromagnetism that our neurons are activated by electromagnetism.

And the point that I like bring up is that, you know, maybe because we have these, we have our dendrite.

Let's see.

This has dendrites.

Yeah.

We have, you know, dendritic.

The idea is that dendrites are computers.

They're, they're like mini computers, and they have all this amazing processing capability.

And the idea here.

Yeah.

So the idea is that they have all these, it's like, they all have these amazing, like it's like, it's like they branch like trees, right?

And they have all these different hairs and they can, they can actually.

Combine the data that they get in very complex ways.

Yeah.

And apparently.

Decide what to pass on and then what not, I guess.

And of course it's very chemical, giving them entermorpho, and entermorpho sizing them is a bit problematic.

Yeah.

They're extremely intelligent in their own way.

One of the ideas from the neuro basis are free.

Well, Peter C was in some, he's like, he's just trying to say that in some cases we make our decisions for what we're going to do in advance.

Like, and there are, our decisions are based on like all these little tiny bits of criteria.

So if we, if we encounter some situation or some person that matches all this criteria, then we have already planned act in a way.

And that sort of gets around the idea that your decisions are, like, you can see your, like, in a, if you're, if you're measuring your brain waves, you can sometimes see your decision before you're personally aware of it.

Exactly.

But it could be possible that, that's because you sort of planned your, your decision of what you would do if certain criteria were met.

And so that's, he's trying to say that maybe it's, it's not that your decisions are being decided without your consciousness,

that your decisions are being decided at a previous time when you decided them.

And then they're sort of maybe perhaps stored in dendrites, which can activate their own action potentials and start causing neural activity.

And so the dendrite is perfectly positioned to, so normally when we see, like, see, let me just grab a picture of a neuron here.

Normally, no, actually not that one. Let's grab this one.

So normally in textbooks, they say, like a neuroscience textbook.

They say that the action potential travels between cells in a chemical synapse.

And it's, but they actually travel in a cell body.

And what travels between neurons in a chemical synapse is the neurotransmitter.

So you can see with medical imaging that are, it looks like there are electrical signals passing between neurons when you look at medical imaging.

But what, what's actually happening is the action potential is just passing along the body of a single cell.

And what travels between is, is our chemical activations that can trigger cells further down the line.

But what you don't see in all these textbooks, neuroscience, is the really complex mappings between all the neurons.

So this is like, this right here represents this right here.

And this is the dendrite. So the dendrite could activate something.

Then as we were noticing in the, in the previous call, there could be between 10,000 and 200,000 connections between all these different cells.

So the question is like, when you have a neural circuit, which I bring this one, if, if each point, like, let's say this point is a cycle of activity.

If each point is connected to 10,000 or 200,000 other possible neurons, how is it possible that this circuit lights up in a consistent way when that signal could be traveling down any possible branch?

And so the hypothesis that I have is that the, the dendrite itself, when you're, which you say you have a future decision you're going to make,

the dendrite itself is going to, when all the criteria are met, it's going to become the lowest possible negative.

And I mean, electromagnetic negative. So like a lightning bolt will strike the, the most negative point on the earth.

And so that would be a way for a dendritic computer to attract a signal to itself.

And thus it would allow for an organized neural circuit where you have a consistent pattern of activity,

and these would be the dendrites that have the lowest point of electro, electromagnetic negativity.

And the, and they are attracting the signals to themselves, creating a consistent neural circuit in the brain that resembles a highly coordinated pattern of action.

And so when you have a neural circuit, like imagine that each one of them, let's, let's say they imagine we have a neural circuit that's very general.

And one of them represents the, let's go back to the hierarchy of, of patterns in your brain.

So you have patterns that represent eyes and some of the dogs and cats.

And you have this guy, I don't know if I brought it this time, but you have this guy, his name is Jack Gallant.

And he mapped out in the neocortex all these semantic relationships between neural correlations and like in different things that people see in movies, like dogs and cats and houses. And so he was saying, like in different parts of the brain, he says, you know, dogs will be here, cats will be here.

Let me get, let me get that pen.

And so he'd say, he would say, like, you know, somewhere over here is dogs, and some over here is cats, and some over here is, is motorbikes,

and some over here is cars, and cars and motorbikes will be closer together, and dogs and cats will be closer together,

and people would be closer to dogs and cats and far away from, from motorbikes and cars.

You build a contextual network of, again, all of this based on just these statistical correlations, right?

Yeah, so all these sensory patterns would be creating like, so this, so this, this would be one part of your neocortex,

and, and maybe from your eyes, and this would be creating like a, or eyes and ears, and this would be creating like visual patterns,

and you have audio patterns, and then your different parts of your brain would represent that.

And then when you have your neural activity, which is where I'm getting dizzy,

when you have your, when you have your neural activity, the idea is that in 10 seconds, in one second of neural activity,

maybe you're, maybe you're, you're seeing someone like I'm seeing Sarah right now, or you're, you're, I'm seeing this, this image,

and in the next millisecond, I'm hearing my voice, and the next millisecond, I'm thinking about myself wearing this headset,

and the next millisecond, I'm looking at the world behind Sarah, and in the next one, I'm looking at the pictures behind Sarah,

and each second is made up of, of all this, all these conceptual models which consist of coincidence patterns in the brain,

and they're lighting up in a sequence, in a neural circuit, and because they are, in anyway, because of the dendritic computation, and so then-

And yes, you're talking about trying to hack this information directly from the Stalinist. It gets all distributed.

That's right.

And I thought it was a pretty interesting and novel idea.

Yeah.

Not to care how it, if it will be possible, but it's a very interesting idea to try to get this, at least at the bottom of the information

over where the feedback is happening, what's happening in this top-down feedback, and everything seems to, almost everything seems to be the Stalinist.

Yeah.

It's definitely an interesting thing to try to get type of reading from there, which apparently isn't really possible.

So if we're trying to, like, imagine how the brain actually, let me grab this one right here.

If we're trying to imagine how the information flows through the brain, you know, with regard to the visual cortex,

let's say the eye, let me grab that pen again.

The tracking is not so good. It was much better yesterday, but-

So imagine your eyes, like, right around here, right?

And so you have, you know, photons are bouncing off your ganglia, and your ganglia are, the proteins are flipping,

and it's causing an ionic displacement of calcium and potassium ions.

And the, so separating of charges, positive and negative charges, and that results in an action potential,

which is triggering chemical synapses.

And so you see signals in metal imaging traveling from the eye to, along the optic nerve to the thalamus,

which is here in the center, which I'm pointing out right now.

And so the signals travel, the optic is the optic nerve, this thalamus,

and then they travel back here to the visual cortex.

This is the obstetal lobes, and these are the parietal lobes right here.

And something similar happens with ears.

So with your, you know, you have your ears would be out here somewhere.

Let me get a different marker for ears.

And I don't know if they can see this.

So your ears would be out here somewhere.

And again, the signals are going to travel to the thalamus,

and then they're going to travel to the audio cortex.

And so the point being that like your, your eyes and your, in your ears,

and most of your senses, except for your nose, are going to travel through to the thalamus first.

Now I was talking to, I went to a meetup and I saw David Eagleman,

who's a, who's a kind of a well-known neuroscience author.

And he was saying that, you know, if you're trying to, you know, if you're trying to like use medical imaging to,

oh, what are you trying to get?

Me!

Yeah, you, oh.

To feedback on myself.

Let me send this to you.

So if you're trying to do medical imaging with EEG from the scalp,

if you consider the work, if you consider the work of Jack Alont,

all the semantic relationships are spread out in a sparsen distributed pattern all over the whole brain,

at the point within the neocortex.

But if you consider the incoming senses go to the thalamus first,

the thalamus could be the optimal place to look for to, to create a new brain-computer interface.

If you could, if you could have a sensor, and so I know of some new sensor technology that's coming,

but if you could have a sensor that, that you could either insert up the nose to target the thalamus reading

or point it from the nose up to the nasal gum to target the thalamus.

And you can, the sensor is like a light field sensor, but for electromagnetism,

and you can configure it for, so you can notice the origin point of the brain,

and you can predict it, like a light field camera for elect, for brain waves.

And then if you can map the signals coming from the, the thalamus,

then you have the signals before they get more broadly distributed across the neocortex,

and be aware, and so what's interesting is about the thalamus is that not only does everything go into your neocortex,

it goes through the thalamus, you're in a neocortex and gets, you know,

all the semantic map is all over the place, but, but that stuff, it's a big feedback loop,

so it all comes back into the thalamus, like the thalamus is like the, the, the bottom and the top of the pyramid,

and your brain is like a big feedback loop.

And so it all goes through the neocortex and back into the thalamus.

So that could be like the integration point for all the different sensors into modality.

So if you're, if you're seeing a dog and a cat and a house and a motorcycle and a car at the same time,

it could be that those things are, are, you know, being grouped or being like,

there's a neural circuit that's running through the neocortex

and passing that information back into the thalamus where it's being integrated.

And I think that, that could be true. I don't know.

So the idea here is that if we could take the self-driving car type of computer to put it in the backpack

and it can formulate a, you know, like, so there's this,

Matterport just releases really cool.

This is a 3D camera company and they just released a really cool, like,

AI that can recognize patterns from pixels and also draw, like, shapes around the recognized patterns.

And so, anyway, the idea is that if you can have an AI look for the patterns of something in the world

like what Sarah's drawing right now and say,

I'm drawing a car right now.

She's drawing a car right now.

I have a self-driving car.

So the idea is all these lines and edges that represent the self-driving car as a conceptual pattern in the computer

could be, oh, thanks. Thank you. Now we've got a car.

We have a car.

So, so the idea is that that concept can be recognized by the computer.

And at the same time, we, the idea is to apply some new brain-computer interfaces and deep learning programs

to studying the brain, looking for narration neural correlation,

neural correlation to the outside world.

So that we're creating, combining the conceptual models of the world that the computer recognizes

with the conceptual models that the computer is making of our brainwaves to say,

well, this car in the world, this pattern of a car matches this brainwave pattern in our head.

And then the next step is like, we look at the work of Olaf Spornes, right?

And that works for the brain.

So if the brain is like a network, what is the communication protocol?

Is it more like TCP or UDP?

Are we throwing packets or is there a firm handshake?

Is there a feedback loop?

That sort of thing.

So that's one of the things we talk about.

If we can figure out the communication protocol of the brain,

which I think could be alternating transmission protocol,

which means alternating TCP and UDP type of connections,

for conscious stuff, it would be, I don't know,

I feel like I'm taking up, I'm just going like a...

But anyway, so...

I'm being fascinated by avatar, at least by itself.

It's messing with my brain seriously.

At least your avatar is not talking when I'm talking.

That's what was happening yesterday.

Well, I hid my mouth partially because of that.

Yeah.

I don't think it's happening.

I think it's because we were in the same room.

I do feel that this is part because I am controlling

some of the movements.

Yeah.

But at the moment, there's like, I didn't come from my body

and my brain goes like, ah, what just happened here, right?

Yeah.

So the reason I have...

These are things that VR does not have to start thinking about.

So I'm part of this group that makes this program

called MicroDOS VR Vision Agency.

And what we're doing with MicroDOS VR,

what we're doing is we're combining VR with EEG.

And...

So it's creating...

Let me show you an image of the graphics of my...

If I have it.

Yeah.

So MicroDOS VR has these amazing graphics.

Okay.

And so you get in there with your controllers

and you're creating these amazing graphics.

Let me show you.

Let's realize this.

And then what we're going to do is we're going to have

your brain waves.

This is already working.

This was in the Neuralace podcast number five.

I talked to Android Jones.

We got this headset from Muse.

And let me pull this Muse down.

Okay.

Grab that.

What'd I do?

Grab my mind and move.

Sorry.

Which is...

So we got this headset from Muse.

Okay.

And the Muse headband.

And it integrates into the Facebook...

I don't know if you can see that.

It integrates into Facebook's...

No, no.

It integrates into the Vive headset.

Here's another one.

This one is Neurable.

This is another EEG for a Vive headset.

And so anyway, we're looking at the...

We're right now working with Muse.

We're looking to get a Neurable.

But the point is that your brain waves

can drive changes to light and sound effects

in microdose VR.

And that enable you to become aware

of how your thoughts and feelings are brain waves

and how those brain waves are causing

changes to light and sound effects.

In fact, it's seeing the changes in light and sound effects

that sort of like expand your awareness of your brain waves

and how your thoughts and feelings are brain waves

or are reflected in brain waves.

That's what I meant to say.

It's a really interesting and fun experience.

Another microdose VR picture.

What?

Go ahead.

Go ahead, your turn.

So I said it's a really fun experience with microdose.

And I love it.

It's one of the best VR VR experiences

that I've ever tried.

And have you tried my Uber?

That's my trippy experience.

Yeah.

Well, you know, it was...

I'll have to bring it.

I'll have to next meet it up.

Yeah.

Well, the thing is, when I'm organized...

You can do that, actually.

Okay.

I'll download it.

Because I was organizing it.

I really want to.

No, actually, I did try it.

Yeah.

I did try it.

But I don't...

So you get to come to the world.

That's right.

When you dance, the world comes alive and changes.

That's right.

About these experiences that they hack the brain.

Again, you're giving different suggestions

on what you're used to your creating.

It's an aesthetic of effects.

And that's a very, very powerful tool of letting go

of normal reality and the normal world model

and updating things and just getting your brain

into a calmer or more relaxed state

or more active state depending on what you know those times.

So I wanted to say...

So this here is the idea is that when you see...

This is a meme that I made.

When you see a part of your neocortex represents it

and you could call that an advanced data structure

in your biology, and that advanced data structure

may consist of a local microcircuit of neurons

that change direction or frequency of your brain.

And I'm referring to the...

Where's that image?

The neural circuits where I'm saying that maybe

the advanced data structure, like what you're seeing right now

could be patterns in that advanced data.

So it could be that microcircuit

that's activating that pattern in your brain.

And so anyway, that's the idea.

And so if that's true, then that makes the case for

why once we have that pattern,

once we know the transmission protocol of the brain,

if we have that pattern in the computer,

then we can create an artificial neurons

or just a device that can then receive electromagnetic signals and send the pattern,

the difference between the pattern that you have

in your thalamus right now

and the pattern of what your thalamus would be

if you had something in your reality like these glasses,

like these glasses right here,

if you had that path,

the idea is that if you had this pattern in the computer,

you could send it back through the transmission protocol,

through electromagnetic signals,

cause your neuron and your brain to fire in a pattern

that is isometric to the pattern

that the computer recognized when you were looking at glasses,

and you would see glasses in your reality

that are not actually there,

so it's virtual reality sent directly to your brain.

Basically any pattern you could create for your brain

if you know that pattern is

and you know the transmission protocol of the brain.

And that's the sort of finding part,

but the really useful and not super fun part

is that if we understand how bunches of neurons communicate to other bunches of neurons,

if we understand that network protocol,

and we understand how those communication signals

are packaged and what the data looks like,

then we could things like reconnect spines,

and we could connect artificial limbs

or transport your sense of self into an artificial body,

and you could have like a mechanical,

I mean a little bit of that now with VR,

and so what we've been talking about in a sense

is the convergence of all these great technologies

like artificial intelligence and virtual reality

and medical imaging like EEG,

and so we're beginning to see the convergence

of like biometric sensors, EEG,

EEG like heart rate sensors,

and eye tracking pupil dilation sensors

into VR headsets coming anyways.

And people are figuring out how to combine

of course blockchain and all these other great technologies

and drones together.

And that is the topic of our meetup in November where we're going to be talking,

the San Francisco VRs.

We're going to be talking about

the conversion of virtual reality

with biosensors and how we pay management

and for our health, for our good things,

and maybe about the dangers and what we should be aware

of the companies that might be doing it without us.

I want to mention that we've been,

Microdose VR has been talking to a bunch of our scientists,

like one of them is Adam Gasly,

and Gasly in Gasly's lab is well known

for a lot of different things,

but what we're going to do now

is getting approval to prescribe VR for pain relief,

and he's actually going to the FDA to get approval,

and as soon as he does that,

Microdose VR is going to be following short on their tails

to get this prescribed for pain relief,

to get this passed for certification

so that doctors can prescribe VR apps like Microdose VR

for pain relief and for, you know,

you can use, you can get the app for, you know,

medicine, you can use it for fitness

because it's a very dancing app.

When I demo this, when I say Android,

demo this at events, people get in it

and we have these videos of people

and they just start dancing because it's so fun,

but that's, you know, it's,

there's enormous potential for healing from VR apps,

and there's also like enormous potential for,

VR developers have to be very responsible

because you can use, there's definitely a potential to,

to do the reverse, to not do the good things to mind.

And I think there's a lot more research

that it has to be this,

and from what we were discussing this yesterday,

why did we change our avatars

to sort of, and this value of yes,

they are all the brains to identify with,

but then I looked like a 10-year-old.

My brains is to start thinking that I'm a 10-year-old.

I don't think that will be healthy for them.

They're my brains start thinking that,

oh, I can be a weird duck creature with hop.

So much better.

That is going to a totally different paradigm

compared with real me and when I go back to VR.

And these are the things we have to start thinking about.

The more people will spend and what it is

that we're all outside of VR,

we have to combine it well

and not create very disturbing effects

that might happen if we don't take care of it.

So let's talk a little bit more about your company.

And who's this gentleman here

that's with you at your company, Matt?

So this is Matt Ho.

Can you grab his photo?

I need...

People can see it.

Okay.

Matt's a co-founder.

And he's a middleman.

He does WebVR because right now

there's all these different platforms.

More and more, there's just coming out.

And a good way to just go through WebVR

and you can just create web sites

that will alert all the platforms.

And that's sort of his expertise.

And the project we're doing is going to be based on that.

A memory palace experiment.

And CCIF, you can learn French better

and it will just be a few words

and then an experimental health condition.

But we're very curious

if being in an immersive place

or experts create memory palaces

using visual imagery to remember

each additional word and create a path.

What if I could literally take you to path

to learn the words?

What did you remember the better?

So that's our work.

So I wish I could grab this, but maybe I can.

Okay.

So one thing that I think might be useful

is explaining why VR can be more powerful

for learning and...

Our hands...

I'm like exploring.

Oh, we did it.

We were just in the same space

and then the hands just decided to shake

which is C.

One hypothesis for why VR

can have such a powerful effect

on your ability to learn

could come down to this concept

of criteria causation.

The idea is if you have...

If your neurons are coincidence detectors

and you're hierarchy of detecting high level coincidence patterns, and with your, you're creating this world around you, this world of information which is creating a lot of different control, right?

42:54:00

That's the design of what is the coincidence. So we're saying it was that you had this volume of spatial information. It takes up here, which space when you're in BR and that could definitely lead to causing your brain to trigger at a high level when it's trying to absorb and learn from all the information question, that that's a very big thing to like the fact that it's early, my individual says correlated to my microphone, it is, that's very important and we can get out to be.

43:25:00

So the more sensors you get into it, the most is reality. The vertical part is to just mean something to the forces of the picture. Okay. So okay we're gonna wrap it up and I'll say that what we call the guys we have for speakers. That's Sarah and Richard Vice must have decentraland.

43:42:00

You mentioned that Matt saw is really into web VR with the central line is gonna be talking about convergence of web with blockchain, which is what I think, maybe not the other city or yeah. All right. So, all right, so we're gonna go ahead and end up. Thank you much, Sarah.

44:01:00

Thanks for. Thanks for watching person as watching. We got some point but we'll see about the sound and yeah. Okay. Truth.

Neural Lace Podcast Season 2 Episode 1 Neurohackers

Thursday August 2nd 2018
On today’s podcast Micah Blumberg, Organizer of NeurotechSF part of NeurotechX
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Presented by NeurotechSF
part of NeurotechX.com

Listen here: https://www.youtube.com/watch?v=aexQwTpOwYc

Audio Transcription by OpenAI's Whisper

Hi, everybody. This is Micah Bloomberg. I'm an organizer for Narotech SF, part of the

Narotech X, and I'm here with Jean... How do you say your last name?

Rintel. Okay, Jean Rintel of Mind's Eye Biomedical. And we're creating a podcast today called

the Naralyze Podcast Season 2, and we might just shorten the name to Narohackers, maybe

just for simplicity. So this is Thursday, August 2nd, 2018, and we decided to just record

our voices while we have slides, so you're going to be able to see on YouTube our slides.

And so this is... That's Jean to the left, and that's me. That's Micah to the right.

So for the Narotech Meetups that I organized, and also San Francisco Virtual Reality Meetups,

I started a project that I'm just calling Narohaxer. You can join... To join this project

online, you can visit narohaxer.com, and then you'll be invited to our Discord. You can

also join our Facebook group, and the link to that is self-awarenetworks.com. The group

is called Self-Aware Networks, Computational Biology, Naralyze, because I guess the sort

of like maybe dream of Narohackers is Naralyze, or the next generation brain-computer interface,

you know, of many Narohackers, and Neuroscientists. Narohaxer is a project that combines tech

and novel ways to create new technologies and new applications, to create new kinds

of biofeedback data visualizations and new kinds of neurofeedback experiences, next generation

nerve correlation for biomedical research, and new user interfaces that predict user

choices, emotions, and life dislikes, and social experiences in AR and VR. So, this

project, Narohaxer, has overarching objectives combined, brain-computer interface or brain-machine

interface devices with WebXR and XR devices. XR means augmented and virtual reality, and

also, you know, heart rate tracking, eye tracking, deep learning, AI, and 3D point-clad neural

networks. A project exists in part because we know that many AR, VR devices are coming

to the market with built-in biosensors, and let's go to the next slide. I believe the

next generation of mainstream brain-computer interface devices could be an XR device,

like AR or VR glasses, that incorporate biosensors, such as EEG, ECG, or EMG, and also eye tracking.

But there's potentially lots of new sensor technologies coming to the market that could be integrated into these wearable BCI XR devices, like open water by Mary Lou Jepsen, open NIRS,

open electrical impedance tomography, open acoustical impedance tomography, few rocks

of microwave imaging, aquaverts, AI wearable, and there's lots of work being done to combine

deep learning neural networks or other neural networking technologies with brain-computer

interfaces. So that's one of the things that our group is focused on. The VR and AR devices

today may be considered a new type of brain-computer interface already because they do collect

data from the user, like the user's head and hand position or orientation, and some of these

headsets include microphones and other sensors. Increasing though, they'll include sensors

traditionally known for biofeedback, such as EEG, EMG, ECG, et cetera, and eye tracking.

Machine learning, which includes deep learning neural networking and computational neuroscience,

can augment BCI data with data visualization, the prediction of emotion intention, and even

image recognition of what the brain sees from a low cost. There's a reference. You can look

up low-cost EEG data from... Just follow this link right here that you see because they

get all the slides. It's kind of cool. The future of XR devices, I already said this,

will integrate biosensors. NERBAL is an example of this. They're integrating EEG with HC5

and their technology is based on a company called wearable sensors. MTEC is a company

that's creating an EMG muscle face tracking faceplate. NEES Interaxon is a company that

is creating a faceplate that tracks brain and heart data. LUXID is a company that tracks

EEG and eye tracking. They're creating a VR headset that does both. Eye fluence combines

eye tracking with AR devices and AI. If you predict these are intention, and now they're a Google company, I'm sorry, they're an alphabet company. MicroDOS VR is a company that I'm

a brand ambassador for and we combine procedurally generated eye candy and virtual reality via

Unreal Engine with the NEES faceplate with its EEG and ECG sensors to create next generation

or feedback, to create a level of presence and immersion in VR. This is a company that

I'm an advisor for. I advise them on machine learning and new technology. They're creating

an all day wearable technology that it uses next generation EEG sensors that have improved

noise cancellation, that they have massively improved noise cancellation. They get a huge

like a billion times improvement in sensitivity and 100% noise cancellation. There's some

huge numbers like that. With machine learning that we send the data up to the cloud and

it returns to the API in real time, a prediction of whether the user likes or dislikes. The

initial product is called the decision maker. It's really cool. People don't have to wait

for these products to arrive. None of these products that I mentioned are currently available,

but they're coming. With 3D models and 3D printed parts, neural hackers can combine

existing VCI sensors with VR headsets. This is a picture of the open VCI and the HSE Vive.

Both of these are easy to acquire. On July 29th, the neural hacks project made significant

progress. We combined Meetup, Neurotech SF and SFVR at Noisebridge. We connected the

Brainduino EEG with WebXR. We produced a video showing actual voltages. You can find the

link inside the Discord, which is at Neurohacker.com. This is the last slide is a picture of the

Brainduino EEG board on the upper left. To the right of that is the Oculus Go. Below

that to the left is the concept picture of WebVR. To the right of that is a picture of

the actual in that last picture on the right. That's WebVR on the left. That's our neural signals coming in on the right. You can find the video over that. Let's go ahead and go to the slides that Gene brought. Gene, I first met Gene. Before I met Gene, I saw this talk from – I was at Noisebridge and people said, you have to watch this talk from the Creative Communications and Chaos Communications Congress on open electrical impedance tomography.

That was a talk that Gene was giving in Germany about this new technology that has enormous promise to democratize research because it's low cost. It's do-it-yourself and it's open source. Let's go ahead and put the slides up and then present on this device. Go ahead, Gene. If you want to advance the slide, just tap the screen.

Just tap the screen?

Yeah, or swipe.

Okay, great.

I'll just –

I'll try to ask a question as soon as I think about it.

Yeah, thanks, Michael. Looting.

Shoot. It should be preloaded. I downloaded it for offline viewing, but come on.

Okay.

There we go.

Oh, yeah.

Whoops.

Hmm.

Hmm.

Yeah. Basically, electrical impedance tomography is an interesting technology. It's sort of – nobody really has heard of it before. It's relatively new. I became interested

in it a while ago when I was looking into biomedical imaging and what techniques we do have, what

we can do, and why we can't easily hack with many of them. For some reason, my slides seem

to be a little bit –

I doubt what it is. Let me see if I can get them. Sorry. I'll keep talking, but –

Yeah, so I'll just start –

They seem to be working like this.

Okay, that'll do.

Okay.

So basically, it was like, wouldn't it be awesome if biomedical imaging was really easily

accessible? It would be great. We could do imaging preemptively. It would be wonderful

for healthcare diagnostics. If it was so easily accessible that a lot of us could add to it

and prove it, basically have democratized imaging, imagine how fast healthcare would

move forward. It would just be great. So that was like a beginning motivation. If you look

at the U.S. on healthcare, the operating theater hasn't actually changed much in 30 years,

which is a funny thing to say because we've had all these other amazing technological advances

like the Internet, but still the operating theater is a little bit slow behind the 8-ball.

So we also spend a lot on healthcare, yet the change, the innovation is really hard

to see. So the question is, how do you create innovation in this really interesting place?

We want to learn more about the body, the nervous system, and how we can interact with

technology. So I'm going to go through an introduction to what we've got now, which is the MRI, the CAT scanner, the ultrasound, and the EEG. They've all got different pros and cons.

There's several more, too.

Oh, absolutely.

Yeah.

All right, keep going.

Yeah. And they've got different kinds of resolution and different kinds of tissues that they've got looking at.

Should we try to look bigger or would you prefer like this?

That's fine.

Okay.

Yeah, they need lots of maintenance CAT scans. You use X-rays to do those. They're actually ionizing radiation, and they cost a few million dollars. Again, you're probably not going to have one on your desk at home and fiddle about with it. An MRI is absolutely beautiful, amazing physics. And there's also functional MRI and diffusion tensor imaging.

And there's all these variants.

Versions of different new improvements on MRI.

There are. And they all get different things. And it's like, wow, that's awesome, but it's $3 million and patient. I saw this article the other day where there's like patients in Wisconsin, and they're getting charged $1,600 per MRI scan.

That's not for the machine. This is just for a single scan. And I was like, oh, it's interesting.

That's suddenly not something that you would just have to fiddle about with, is it?

Yeah. What's the cost of MRI? Is it something like $1,000 per scan?

It depends on the hospital. These guys must go on to my charging $1,600.

Yeah. I thought that was kind of normal, like that price range.

Yeah. So that's a lot. Just for the scan.

Yeah.

And in other countries, it can be much cheaper. So it depends on the medical system. So you've also got ultrasound. It's a bit grainy, but it's pretty awesome. It's definitely cheaper.

And EEG, which is a bit different again, it gets different stuff, which I'll talk about soon, but it's cheap. And there is an open source EEG, which is open BCI. All of these different imaging modalities have different applications that they would be best at, ranging. You could have tuberculosis where you just need a static image, or maybe if you need something that has fast time resolution, like fetal heart rate or deep brain stimulation, that would be a different kind of imaging again.

So a lot of the motivation here is, can we find something that's more useful than EEG?

Yeah.

EEG, I think.

So what's wrong with EEG?

Yeah.

Let's talk about it.

Yeah. So EEG is great. And we should use it for all the information that we can possibly get out of it. But it's limited. It measures info that's mostly just at the cortex. That's like at the edge of the brain.

Yeah. Just on the surface, basically the surface of the brain.

Yeah. That's not the whole, that's not, that's not like, getting...

And it's mostly frequency information. Not very good at spatial.

That's right. That's right. So it has really poor spatial specificity. So that's a problem.

And interestingly, because of what it's measuring, it's actually measuring these things called post-synaptic potentials. That's like the signal between the synapses and it's not actually the signal generated by the cell or the output signal, which is not as an action potential. In neuroscience labs, there are really things like patch clamp electrophysiology where you're all about measuring these action potentials. And they tell you a lot about the actual neuron firing time and timing and the chemical processes.

We can't do that with EEG.

No. You can't do that with EEG. But you do get these post-synaptic potentials, which aren't the same, but it's still something. But it's not the actual biochemical, like, oh, the cell, this output thing, right? And the other weird thing about it is you only get perpendicular signals.

Yeah. It's like if you had a closed football stadium that was closed to the sky and you were on top of the roof of that stadium and you tried to record the audio coming from the roof, which may be just a roar of indecipherable sound. And you tried to predict what was going on inside that stadium from that sort of like bad sound outside the stadium. That's like what you're doing with EEG.

Exactly.

It's really massively limited in terms of its capabilities.

Yeah. And the perpendicular signals is an interesting thing because the potential difference that you're measuring with EEG polarizes the cell. So that means you're only getting this information from cells oriented a certain way, which means that the information you're getting isn't a true representation of the information transfer that's going down below.

Right.

And if we really wanted to create the best BCI, we want to know in depth what is really happening.

Yeah, yeah. That's right.

We need that information.

We need to go, the best BCI has to go way beyond EEG.

Right.

Totally not disputing that. Absolutely.

Yeah, but EEG is great for what it is and we've done, you know, there's great research going on. So anyway, that brings me to this talk, which is about this other little-known imaging modality called EIT or...

Yeah, which has electrical impedance tomography.

That's fine.

Yeah.

Which has massive improvements for do-it-yourself spatial recognition.

Yeah, it's got a few different improvements. It's a different kind of technique than EEG.

Though it still uses electricity, what it does is it sends very small AC currents through at different angles. And based on the material that's in its way, the currents will actually take slightly different paths.

Yeah.

So...

If they're trying to pass through fat or through water, it's going to pass through different speeds.

Yes. Yeah. Or take a different route around the cells.

And so you have like this sort of like sensors around a bowl. So if you look at the left lower picture that we can zoom in here, you have this bowl with all these electrodes around it and these vegetables in there. And one at a time, these clips which have electrodes that can transmit and receive signals will fire and all the rest of them will record when they receive the signal. And then the next one fires and then the rest of them act as receivers. And through the firing and receiving of those signals, you can plot out what's in the dish between the electrodes. Or you can plot out where... You know, you can plot out the... How would you describe that?

The locations of the vegetables.

Yes. I would call it the tomographic reconstruction. Yeah. Of the image.

Of the image. Yeah.

Which is kind of exciting because here you're getting spatial information, not just from the edge where, say, the cortex might be of the brain, you're getting information from the middle as well, you know, maybe the amygdala or emotional centers. But right now, we've got it in a tank. I've actually got it set up here in a tank as well just for the hell of it.

Yeah, you've got the whole thing down.

Okay. So, yeah. So currently, it's been used for things like lung volume, muscle and fat mass, hemorrhage detection. And there's also some research work for depth of anesthesia via action potentials, which is all sort of interesting and why I would do what's good about it, what's bad. I mean, there's a few things that are quite obviously bad. Nobody knows about it. It's bad. Maybe we're trying to do something about that.

Spatial resolution is limited somewhat by the number of electrodes. And there's some assumptions made in the reconstruction algorithm, which would be better if they weren't made.

The advantage is it's super non-invasive, non-ionizing, making it safe. It's compact and expensive. There's better source localization than EEG, good for functional imaging. So, although the spatial resolution might not have wowed you as much as an MRI, this is where I want to just remind people about what the first MRI scan looks like.

Okay.

You see on the top left, that's a thorax or that's like the lung cavity. And you can sort of see it's not as amazing as the scan underneath it, which is what we have today.

So an early EIT scan I've got on the top right with a question mark saying, what is the future? I don't know. But here's an open EIT project. So, yeah, it's open source. You can go to GitHub. It's under the mysterious name of open EIT. And you can sort of see everything just sitting there. And hopefully the readme is pretty easy to install and stuff.

To sort of like go through a little bit how you get an image back from like sending these cards through. So you send signals through from different angles. And they'll be stronger or weaker based on what material they go through. And when you add them all up together, you kind of get a rough image. And that's the most basic way to do a reconstruction.

You can also do 3D reconstructions. There's some people that you're aware of that are combining multiple layers or multiple X, Y, and Z rings.

Yeah. Yeah. So you can do it any which way. I'm just showing like 2D examples because they're actually the easiest. You can absolutely do it as you mentioned in 3D. And you create what you need to do is you need to know where the electrodes are in your 3D space.

Yeah. You need to calibrate their locations. Yeah, exactly. I think that's where the ARVR part. Yeah. One aspect of where... Yeah. One idea that we're hoping to get help with is we want to create an AR application. So right now you can use AR to measure the distance between two points that you select. Like you can measure the length of your iPad or the length of a table. But you could potentially create an application that would recognize with artificial intelligence, recognize your electrodes, and plot their position in space.

So if you have the position of your space, this would be important because if you're putting... Everyone's skull is a different size. So if you're putting an EEG cap of open electrical impedance sensors like a... Could be like a beanie cap of sensors on someone's head, it's going to be... Every sensor is going to be in a different place every time.

So if you could run a phone around their head with augmented reality and machine learning, you could recognize the positions of... You could classify the sensors, recognize the...

Do object segmentation where you recognize all the pixels that belong to those sensors, and then plot their exact XYZ position in space so that you have that in the computer so that you can take the data from sending an electrical signal. When you're doing...

Oh, electrical biggest demography, you're sending the electrical signal and the rest of the sensors are capturing it. So you'd be able to plot which sensor received which signal and its exact position in space, and from that you could derive the contents of someone's head in a spatial way and create a 3D point cloud of the data you're capturing from inside their skull. So we really want to work with people to make this augmented reality application. Keep going. Yeah. Because right now you're putting your sensors around a ball just to solve the problem of knowing the original sensor position so you can calibrate what's in the ball. Yeah. So this is what the devices look like now. There's two. There's one. On the left is an 8 electrode version, little PCB with a little flex electrode array to do a reconstruction. I think most of the images... I've got a few images of that one working and I've got this 32 electrode one working now which can get much higher resolution than the 8 electrode one. If you've got a few questions about safety, you might be worried about injecting small currents through your head because of TDCS and TACS. So TACS is in the upper milliamps. We're putting up our cast, by the way. So it's up at milliamps and then you've got... When you do EEG, you actually send currents through the head as well to measure whether or not the electrodes are making contact and that's in the region of nanoamps. And in between that is microamps and at the lower end of the microamp range is where EIT fits in. And it's actually within the established guidelines for safety, safety on humans which is... So we're not going to cause burns like TDCS is going to cause? No. Not even close. Not even close. No way. That's good news. Yeah. So that's nice. So this is what the opening IT dashboard looks like. So it's sort of configurable. Lots of buttons there. So this is the EIT electrode version and you can see here as you move this cup on the top left around anti-clockwise you can see the reconstructed image is moving around and clockwise too. Just like go from left to right and to the next level. And again that's with the EIT electrode one. This is the 32 electrode one and you can see you can get much higher resolution with that one. There's two cups sort of placed in there and you can see their shapes reconstructed in the bowl which is sort of interesting. I think we actually... I don't know if we can... Yeah you guys can. We won't get sound though. Maybe I have to hit play first. I don't know. Yeah. Let's see. Present on this device. Slow down. Here we go. It got it working earlier. There we go. So this is just a demonstration of the... Is this actually pulling from YouTube? Yes. So it's not actually on this device. So that might be a problem. Well I mean it is connected to the web so let's see. Oh no no no it's fine. Yeah. So this is with that little EIT electrode version. So they can't hear that so just go ahead and talk over it. Yeah. So you can see I'm moving the shut glass around and clockwise in the bowl and it's doing the reconstruction in real time and you can basically see that on the screen. So that's basically what I wanted to show with that one. I don't know how do I... Do you want to go back? Swipe left or swipe right? So obviously the resolution leaves some wanting but we've got this 32 electrode one now which improves that a bit. This is the other super cool thing that it can do actually. So obviously we have different materials and they're changing and I had all the time like blood flow for instance. How do we differentiate those changes? Okay. Yeah. How do you differentiate blood flow? Okay. So every different material has a dielectric spectrum so if you run different frequencies through it you can actually recreate a spectrum and just to sort of show that concretely

I did it with an apple and a sweet potato and then on the bottom right here you can see this oops you see the spectrums. So that's on the right side of the image. You can make sure maybe you can zoom in. Oh cool. Yeah. So you see this sweet potato has a spectrum that's notably different from the apple which is notably different from the water. Why that's cool is if you can differentiate them visually like that you can differentiate them with machine learning even better. Okay. And I did something sort of very basic on the left differentiating the different objects just based on their dielectric properties what's inside them. Yeah. Say you wanted to do things like tumors, lung volume, you were searching for a coin inside your stomach. Are you starting to write your own machine learning programs? Not just yet. Okay. But I think it's ripe for machine learning. Yeah. So yeah. So I think that's like an interesting aspect of the data and also I'll just go back. So this is like it makes it hard to visualize as well because whenever you're doing a visualization you're actually only visualizing a single frequency. Yeah. So if you can just visualize it like put it into machine learning because it's so high dimensional you can kind of get all that information can yield in one human's just like that's a lot of information for a human to pass or see or whatever. Yeah. So it's interesting because you could point a camera at the original data if you're looking at a dish of vegetables and stuff and train it on looking at the sensor output and the original data and train it that way and then just feed it new data. The new data could be like from inside human being or something and see what it can predict using the previous training data on vegetables and stuff. It's one possible way to train it. Yeah. Yeah. Yeah. Or you could sort of train it on sort of tumor samples as well or something like that depending on what you want to look for.

Yeah. Yeah. So in the in papers the maximum spatial and temporal resolution is 200 micrometers

and less than 2 milliseconds. 200 micrometers. So that means you can really focus on a small microbiology. You could identify cancer cells. Yeah. Yeah. So they're easier to identify because they actually attract a lot of blood. So they have a lot of blood around them. Do you know of anyone doing that? I think some there's papers where people have been trying. The skull is a problem in this paper here. Yeah. What they do is they stick it onto the outside of the rat's brain. So they go through the skull. Yeah. And they stick this little flat array and it's called an intracranial surface array. It wraps around the rat's brain. Yeah. Okay. Exactly. And that's what they're doing the reconstruction with. Yeah. So that's the sort of limit of what people have got to with it so far. But I think also just tapping will send you to the next slide. Yeah. So medical imaging. That was something that like I talked just talked about neuroscience option. But if you remember there's actually four billion people that don't have any access to any kind of imaging and that's interesting. So I saw this project a couple of years ago at an NVIDIA conference where a researcher was pointing the camera at someone's eyeball and then using deep learning. It might like a really focused in zoom of their eyeball and then focusing deep learning on locating lesions in their eye which would help diagnose a whole bunch of images. I mean a whole bunch of illnesses. And so there's all sorts of applications that we're seeing where deep learning is helping to create small objects that you can be taking to the poorest places in the world. And so deep learning combined with medical imaging can help really make active medical imaging for medical diagnosis really cheap and really available everywhere in the world. So doctors without borders or especially I don't know if anyone from doctors without borders contacted you. No, not yet. But I'll be interested in talking to them.

But yeah. So just imagine if like do you remember the cell phone towers how I think in the developing

world they kind of leapfrogged all the infrastructure that we've put in place for our phone lines and they just went straight to cell phones. Yeah, they never built out telephone lines. So what if these 4 billion people that don't have an MRI because it's ridiculously awesome but expensive. What if there was like a cool thing that you could do where you have a cheap kind of biomedical imaging and then you use the best machine learning on it and you can do just as well. Yeah, just as well or even better or better MRI and so maybe the developing world never sort of like never roll out these expensive MRI magnets. Maybe not. I just I mean I don't know. It's just like it's a good it's an interesting idea. Yeah, these things happen sometimes. Is the world ripe for that kind of thing. This technology could potentially change the world for the better. Yeah, that's an idea. That would be nice. Yeah. But like so I did this. This is this graph again of like applications. At what point are we even useful? I'm just trying to be like super realistic. Okay. I think in a conservative estimate. And you know, I don't think you need that much resolution. So like here's a easy one. It would be water on the lungs or otherwise known as pulmonary edema. If you look at this diagram you can actually see on the top right a graph that has a blue and a red one from each lung. You can see one lung has a much lower air volume than the other lung. There you go. That's your information right there. Bam. You can get more subtle on it. But that's basically what you need for pulmonary edema. Okay. Here's like something else that it can get if you put it on your chest. So this is like the breathing and expansion and and contraction of the lungs. So you can sort of see this lower frequency signal and then you see it like a like a faster periodic signal, which is the blood flow through the valve, the heart valve. So again, this is different from ECG. What it's measuring is the change in the dielectric materials. So you've got a change in materials going on to give you the heart rate and you've got a change in materials going on to give you breathing because it's like getting filled up with air and then emptying out the air and then blood is pumping through the lung. You've got lots of different materials changing. Oops. Yeah. So, so this is the 32 electrode system, which is just sort of like getting there. I showed you an early picture and obviously GitHub opening IT is a good place to go. Thinking about like next steps and directions and how do we make this thing even better? How do we really make this an MRI but cheaper and portable and ready to go? Okay. So here's an idea. Is it even possible to like equal the imaging of MRI? It would be different. It gets different info. Different info. Yeah. And as you can see on the bottom right is what happens when you get 8, 16 and 32 electrodes. Okay. Looks like like an exponential increase in definition. Yeah. Yeah. So you get this increase in those. Yeah. Exactly definition. You could also combine it with other imaging modalities. So you don't want to, I don't want to eliminate MRI if you've got one hanging around and you should use it. Microwave is up and coming. That's interesting. I hear there's a few different companies working on optical as well. Yeah. Like Infrared. Yeah. Infrared and Infrared is another kind of imaging but it has pros and cons also. And it's one of its cons I believe is the depth with which it can image. Okay. But it might be able to get good information again at the surface and sound. Acoustical. Acoustical. So I guess the point here is why not combine the modalities. We can do math. We can use machine learning on this information and we can get more info out of it. I saw someone, one company was combining TDCS with EEG and I thought that you couldn't do that because I tried to do that and like the TDCS messes with your electrical currents and then so EEG is trying to measure electrical currents and so I thought you, somehow they pulled it off. So I guess it's possible I guess to combine anything if you understand it. If you understand it. Yeah. Yeah. Just as long as it sort of doesn't violate any sort of rules of physics in any way. Yeah. I mean, so electrical and penis tomography, do you take turn between the different sensors? So I guess you could take turn with capturing your EEG signals or whatever other kinds of, you know, if you needed to. Yeah, you could. Yeah. Yeah. You could absolutely, you could absolutely actually, you could definitely do that. People have in fact. Oh, they have come back. Yeah. Yeah. There's no problem doing that at all. Okay. So totally doable. So doable. It's done. Okay. Yeah. So how do you get to a better spatial reconstruction here? Right now, the reconstruction assumes a resistor network. Now the body isn't a perfect resistor network. It has like capacitive elements. Every cell has a capacitive elements. So perhaps we shouldn't make all these assumptions and maybe we should just use like that these test tanks and create some big neural network by gathering data from them and basically recreate the solution from just from information and data instead of making all these assumptions

in the physics. That's one idea. Right now, you can improve the time resolution. You can detect ion activation and nerve signaling. That's what's really cool about it. So at a slower time resolution, you're measuring things like blood flow changes like I showed you with that heart rate plot. Obviously, you can do the blood flow in other parts of the body like the brain as well. But at faster time periods, going back to this EEG question, you can actually measure action potentials. Wow. And that's kind of like the golden, the golden goal in a lot of ways. For nerve care. Yeah. I'll just go back. But obviously, you know, there's a signal to noise problem. Do you know about neural dust? Yeah. The tiny little MEMS implants. Yes. You inject like magnetic dust and then you can control it with electromagnetic waves outside the person's brain. You can stimulate those and they cause nerves to fire. It's just super cool. Yeah. So there's a lot of very cool technologies going. I think I seem to sort of be really interested in these non-invasive ones. Right.

And partly, I think you can make a good consumer product out of that. Yeah. Not a base of nerve

stimulation. Yeah. So that's what sort of attracts me to VR is because, you know, your eyes are like this high man with gateway into your brain. Oh, they are. And so if you put, if you're basically, when you're wearing VR glasses, you're creating massive stimulation of the nervous system by immersing somebody into some alternate world that you can control the shapes, you know, and so that's just, that is, you know, that's one gateway into writing to the brain. So we're talking about mostly reading from the brain, but, you know, keeping, there's so many different ways to stimulate the brain and neural dust is one way that there's, you know, people, what do you, what do you say in terms of like what technologies you're excited about for stimulating the brain? Right functionality. That's your next slide. And point it back. Yeah. Same wave length. Well, same part. So does, so does, I'm just sort of, I'm just like pointing at the image of the wave. Yeah. And yeah, funny you mentioned, right? Functionality. Yeah. Yeah. So there's like, you could do it with neural dust. But that again, that's an implant that requires yeah, injected, injecting dust into your nerves. And very inefficient. And that's fine. I'm happy for other people to test that. However, so many great wireless technologies that why shouldn't we take advantage of those first? And I think the real neural lace nerve gear product is going to have a wireless transmission into our brains. Yeah, which I, like, I'm pretty sure. Yeah. Like, I think you can do it. There's actually been work to prove you can do it. Like, like, just in cell in 2017, this paper came out, which is on this slide. It uses beat frequencies. So it sends through two signals that have slightly different frequencies. Binaural beats. It's sort of like binaural beats, but a little bit different. Is it sending an electrical beat? Yeah. Okay. So it's electrical simulation. Yep, it is. And it creates a large amplitude at one particular location. Okay. And then it was shown in this cell paper written by this guy called Neil Grossman, that that the neurons in that area actually trigger coherently with the the beat frequency. Okay. So they start firing at the same frequency of the beat. Yeah. Which is what we've seen with other kinds of binaural beats stimulation. Or if you like expose someone to audio or visual binaural beats stimulation, eventually their neurons will begin to oscillate at the same frequency of this pattern you're sending into the brain. Entrainment. Brainwave entrainment. Yeah. And so they showed in this paper that it's what you're saying is that they've put, they've used electrical brainwave entrainment to induce a very local response from a neuron to start pulsing at the frequency they were sending it. Yeah. And I mean, that's even better. That's almost better than neural dust, really. Because neural dust allows you to make the neuron fire, but this allows you to make the neural fire with a frequency. So that's, yeah. So it just depends what like what you want to do. Like there's all these cool things like deep brain stimulation for

Parkinson's disease. Yeah. And that's been shown to work, but you have to like stick this sort of thing into, yeah, into your brain, which is great. If you have a tremor and you need that. Yeah. Yeah. If you want to have like, if you want to install something into your brain, yeah, that's one. But this is not invasive. You might want to just try something out for a day. And they use what for this image shows us they use four electrodes for stimulating one neuron. Yes, that's correct. Yeah. I think they've got a common mode rejection scheme going on there. So like it's a way to control the amplitude of the signal more exactly. Let me have to like, yeah, go ahead. Yeah. So I think that the writing field is open. I'm not trying to say that, you know, you have to do with the beat frequency either. There's other these electrodes work for that or would need a different kind of you could use any kind of electrode to, to do this with. So there's other techniques as well, like phased array and beam forming techniques that are often known in reader. Yeah. And I just want to put that out there that, you know, the, you know, the, the, the Air Force has all these great techniques. And they should still work. Okay. And I believe there's a few patterns out on the phased array with current forming through the brain already. Okay. Just to put that one out there. So people have got that working. Okay. So that's very interesting. We can basically use all of these, these techniques and control in a very localized and specific way. And that's really sort of like interesting in terms of bioelectronic medicine, where we're going. And I just want to sort of like, I went to Edinburgh a while ago and I was like looking at this like surgeons hospital. And like surgeons once use saws and knives. And if you got an infection, they cut your arm off. Yeah. And that was, you're saying they once did that. They once did that. And now we have this like micro keyhole surgery thing. Yeah. And that's definitely way better than chopping your arm off. Yeah. If you have an infection on your finger or something. Yeah. Now imagine, I mean, limbs still, still getting abutated, but not for, you know, just infections and stuff. We definitely have seen this progression towards using smaller and smaller, less invasive technologies for surgery. Yeah. Yeah, absolutely. So, yeah, so there's, yeah, so these less invasive technologies, like I think we could just go further. And I'm like, I think, you know, electronics or this current AC stimulation is one way. There should be other microwave methods that you mentioned for access. Yeah. So that's interesting. Are you looking into that now? Not right now. I don't have enough time to do all the methods or anything. So I'm just like trying to get something really nice going for EIT. But I think there's other methods that are good as well. Yeah. And then there's other things as well, like acoustical methods. There's, so you don't want to sort of limit what method you're using. And I think you can even combine the two. So I may have a question. Yes. I studied, I studied a lot of neuroscience and computational biology, but I've no where like, I don't know if I probably understand like a small percentage of it, even after 12 years of studying. So, yeah, I mean, so I want to ask the question. And it's like, so do you know that like the real difference between, so I guess, so MRI is using tomography, but diffusion tensor imaging is using tractography.

And do you know like the essential differences between, and then the open water is using holography. And I think these are all like related concepts. And I'm like, what are like the distinctions between tomography, holography and tractography? I don't know. It's really hard. I don't know. I can try. So tomography is any kind of image reconstruction. And tractography is looking at the trails of the ions. So I think in diffusion tensor imaging, what like let's have a look.

Oh, we can actually put up on this one if you want. Okay. That way people can see. So let me go here. And so we're going to Google diffusion tensor imaging. If you want, you may use this keyboard. Okay. And then which one did you click on? Oh, I don't know. It's okay. Do you want to use this one instead of yours? Okay. Is that way people can see what you're doing?

By the tracking. And so I know what, well, I don't know exactly. Yeah. Yeah. I don't know exactly what open water is doing. But so there's, there's holography, which is taking advantage of diffraction. And I believe phase conjugation, which is like an optics concept where you can sort of do cancellation by sending light at different angles. I'm not a super optics expert. But you can look up phase conjugation, it will go through the theory of how you do this light canceling to recreate the scatter. Right. Basically, it's like, you're creating a scatter. It's deconvolving a scatter with any light technique. I feel like it's a similar concept to tomography. But oh, yeah. Oh, I mean, it's all a type of tomography. It's all a type of tomography. Like MRI is a different kind of tomography than EIT because it's actually using RF. And then diffusion tensor imaging. I don't actually know what the difference is off the top of my head of my tractography. It's like measuring that the myelin sheath paths. Yeah. Yeah. Like I can, I guess somehow I read that the magnet is like when you release, when the magnet gets released, then the water molecules will travel along axons. The water molecules or the blood will travel along axons or something. And then that, so the radio signals that are received from the X camera position, the Y camera position, and the Z camera position will track, will be able to identify the positions of the, of the, the moving, like the ionic. They'll be able to identify the actual fiber tracks in the brain of the glial cells because they're, that's why we have these really beautiful images of like, this is, actually that's too small, but let's see if there's another one in here. A bigger one. So that's MRI. And then we get, we get, so this is the, these are like the glial cells that are inside the core of the brain and the neurons, the most of the gray matter neurons would be on the outside of the brain. And the glial cells would be able, it's able to map the, the different ion tracks that are along the axons of the glial cells because the blood is moving along them when the magnet, when the, when the MRI magnet releases, the radio frequencies blast into the X camera, the Y camera, and Z position camera. And from that you can sort of, when you have, you can combine the different cameras together with the X, Y, and Z positions and recreate the actual position in space of each of those, those axon locations. And so you end up with these really beautiful images.

That diffusion tensor imaging is known for. And to me it's all, like you said, it's all under the umbrella of tomography, but it's just, I guess it's, I guess I was, yeah, I wasn't really clear on that until you said that, but yeah, that makes a lot of sense.

Let's go back to the, let's go back to the Google. I think that might be the last page.

So let's go to here and we'll go to, like, images. And so you can see this is another, so these are, these images are starting to get really, really advanced. And so one thing I wanted to show you was sort of like maybe one of the things that inspired me was this research by Jack Launt that, do you know Jack Launt's work?

Yeah, that's right. So he uses MRI and diffusion tensor imaging. And so what he does is he, let's go to the, the Launt lab. So he uses MRI, it's something that I want to do with Open EIT because what he did was he created like a semantic map of where, so he had people watching a movie. So you sit in his lab, he's sitting in his MRI machine, you're watching a movie. And then he's also monitoring the brainwamps and his machine is making correlations between not brain waves, but blood flow with the MRI. So he's, his machine is making correlations between the images that you're seeing in the computer and your blood flow. And so from that he's able to sort of like create a semantic map of which areas of your brain are lighting up when you're seeing a certain scene in a movie. And so he found out that you could, you could say, well, in, in, you know, one region of, of, of your brain, like maybe the side of your head, you would see, you would see like a dog or a cat, like maybe in this area you would see like a dog or a cat. And then maybe in some other area you would see like a house or a building. And so then if you saw a motorcycle, the motorcycle would be oddly closer and spatially to the house and farther away from the dog. And you would think, oh yeah, I guess a motorcycle would be more likely to be in a garage or in near a house than it would be near a cat or a dog. And so you, you, you not only think of it as being in a different spatial like place and when you imagine it, but actually it is in a different spatial place in your MRI scan and your blood flow, like spatially. So I would like to sort of like, so the whole idea for the Neuralace podcast, because we're in season two, was the idea that we could sort of extend the basic concepts that Jack Gallant was exhibiting with MRI and an AI to sort of like say, what if we took like the self-driving car, all the centers of the self-driving car, are figuring out like the concepts of, of the world around that car, like they're figuring out, this is, you have like, you see, it has to identify, okay, that's a car up ahead, and that's a car door, and the car door is open, and that's a cat, and that's a dog, and the dog is moving at this velocity, and that car is moving at this.

I think they saw some recons, they have a video.

Yeah, do you want to, do you want to look it up?

I don't, um, oops, Gallant video, what do you call it, recreation. And yeah, ah, here we go.

Oh, you want to, yes, play that.

I think it's this one. So this thing is like, just so inspiring for what we, like, will eventually be able to handle it.

No, I sort of skipped ahead, but.

Anyway.

Yeah, so the user was presented with a clip on the left, and on the right, that's the image reconstruction from, from Brain with Activities, as you can see, but that, but the computer was, was trained on both the original images of, um, the, um, of the person's medical imaging, and, uh, so they canceled, I go back. So the, so the individual, so the individual, so the computer was trained on both the movie combined with, um, medical imaging.

Um, and then what happened is you only, on the right, you only, you don't present the computer with the, with the, with the images in the clips, you only presenting the trained computer on the images of the blood flow. And so from the blood flow alone, it's predicting the images that the person is now seeing. Um, and that is really, uh, significant, um, because we played again.

I know.

Yeah. So, so, so what that means is, I mean, that we can recreate what we're seeing from our brain activity, which makes a little sense that we can.

Yeah.

And the question is, so I found out, I found out that, um, and basically a neural network can function as a, um, as a digital signal processor that you can, I've seen this, I've seen this, somebody showed me like some work that's under NDA, but you can basically take a movie and plug it into, um, a neural network and the neural network can reconstruct, um, the movie just the way, but it's just basically signal processing. It's the same sort of signal processing we've been doing since the 80s and cameras, you know, camera, video cameras, they can capture stuff. And so basically neural networks are just, um, sort of, um, encoding the DSP, the filters.

Yeah.

Then there are no neural networks are DSP. So that makes sense that if, if our brains are neural networks and they are, if even our, even our eyes aren't contained neural networks, right? Um, they are naturally going to be able to take the incoming stream of data and recreate that inside and also learn from that stream of data. And that's basically like, so at that point, you know, our eyes are basically video cameras. And this is basically the Jack Claw's work is showing us that we can, we can download images from our minds because we are sort of creating video, a point cloud of volumetric video with our brains that we're then learning from. And so like, I tell people, when you look around in the world, you're not like, like the explanation is that what you're seeing is an actual point cloud of video that your mind is reconstructing. It's, it's not like video, it is video.

Yeah.

So wouldn't that be cool if there was a way that we could, um, for me, I think that the whole speech thing, it's, it's, it's nice, but it's not as high bandwidth as speaking to you and say video. What if I could communicate with you by like, I could just like, like stick this thing on the back of my head where my visual cortex is. And then this nice hologram would appear between us of the thing that I'm imagining.

You're sort of outputting your, what you're seeing. So you can sort of describe what you're saying.

And, and then like what would be even better is like, you can do it too. And then we can both morph the thing in the middle, like the thing that we're both visualizing. It's like a high bandwidth conversation.

Yeah. It's like a, like instead of just this time series data that's coming out through our mouths, you just have like, like thousands, like so many more dimensions if you can sort of like speak in images together.

You know, I can imagine some diplomats would want to use that to figure out the best way to, to not only communicate with the other country, but to find, you know, peace between the two countries, figure out where, you know, figure out how to best, you know, solve the problems between both countries, the sort of thing. Like there's all sorts of different possible applications there.

It's really exciting. Yeah. So that's in, in, in, and I think that combining VR with, I don't know if we should go back to, I want to show you the self-driving car, self-driving car, machine learning video. I want to see a video of that. So let's go to, yeah. So basically you're, I don't know if I can, here we go. Technology behind the self-driving car.

So this was an NVIDIA video from, let's see. I'm pretty sure, I don't know what this is. Yeah. So basically the computer is predicting, I don't know what that music is. Who is doing that music?

It's background music.

It's background music. Okay. So yes, the computer is, is trying to take video of the world and, and recognize objects in the world, recognize houses and, and predict the velocity of the different objects and figure out if the car can move forward. But if you could take the sort of self-driving car that's creating concepts of the world around it, and let me see if I can find a better one. But let's see. Simulating, self-driving. If you can sort of take, this is an advertisement.

What if home security was different?

Anyway. So if you could sort of like take the concept of the self-driving car and you could figure out the, all the line, all the, the object segmentation of an object. You say, well, this is, this is a cat. And this, these are all the pixels that belong to the cat and you're creating a 3D point cloud. And you're doing the same thing to the medical imaging of someone's mind while they're looking at this cat. So you're, you're creating an object segmentation of their brain wave activity with multiple modalities. You're saying this brain wave activity is strongly associated with this cat that the person is seeing. And at some point you're mapping out all the objects in the world around a person and correlating with all of their brain wave activities. You're, you're directly pinpointing which brain wave activity belongs to which object in the world, in every single object in the world, and all of their brain wave activity.

Yeah.

If you could sort of like map that out.

So if you can train that, like in a way, so, so, I mean, part of the problem is I don't want to spend my life lying down in an MRI.

Right.

I don't want to go into it for an hour, but like, to get this kind of volume of data, there's a couple of different directions. There's the noninvasive directions, which are harder in many respects because you have the skull to get through.

Yeah.

And obviously that means the signal is not as big. So you need a more sensitive way to sort of get that information out. But we've been doing all this cool radar stuff for a while now. It's possible, but it's tough. So we might start with low resolution, noninvasively, and move to higher resolution as we refine our techniques.

Yeah.

The other way is like you mentioned, like with the neural dust, um, electrocortical rays.

I want to, I want to try to point sensors up the nut, the nasal canal. See what we can, because you can almost reach the bottom of the thalamus that goes underneath the blood brain barrier.

Yeah.

And capture those signals. And basically that would be very valuable because, you know, most of your incoming senses go through the thalamus first, before they go to the rest of the brain, and then they come back to the thalamus after they pass through the neocortex. It's a big feedback loop, your brain.

Interesting.

Now, I, I agree with you that the nasal cavity is a hot spot.

Yeah. And also your eyes, your eyes are like a massive two way port in and out of your brain.

Yeah.

So there's massive like research that's valuable for eye tracking and maybe like, you know, just really maybe trying to like put electrodes near the eye or on the eye that can measure the, um, electrical activity from the neurons there.

Um, and that might prove to be very valuable at some point, very valuable research to find out what's going on in the brain by studying the eyes, um, with multiple modalities of sensors.

Um, and in addition to every other place, and then at some point we, so if we can predict, you know, what a brain, you know, what, which, what kinds of brain activity represent objects in the world, and we can stimulate the brain to produce those same kinds of patterns.

Will we see, um, the like, well, if you can have it, if you can have the, the, if you can identify perfectly the brain wave pattern of a cat and you can stimulate the brain perfectly to reproduce that pattern, would you be able to make someone see a cat where there is no cat?

And if you could do that,

If you could do that, then you would have like augmented reality and virtual reality without having to wear glasses because you'd be stimulating the brain directly.

I agree.

I agree.

Yeah.

I think it's possible.

And I think it's really exciting and it's amazing, but it brings up all these interesting questions about control because what you experience, um, what was that saying, neurons that fire together, wire together. So if you create this like little feedback loop where you can both read and write, um, you will be changing your brain over time. Um, what will we become? We will just become part of the network.

Um,

Your brain becomes something you can read and write to like a special kind of hard drive.

You can kind of program it.

You could program it. You could download and you could also download information from it.

Yes.

You could download audio and video and maybe even people like courts may use this to download

like proof that you are guilty or not guilty of some crime that you've been accused of.

Yeah.

Um, that's possible.

Yeah. I mean, it's kind of awesome and scary. Like, um, I think the example today is Facebook.

Yeah.

So Facebook, I think is awesome because it does connect us together. Um, like I keep in contact with some friends from Australia via Facebook, but who I would otherwise keep in contact with.

Yeah. Um, and the recording seems to, the screen recording seems to have ended, but this one's still going. I wonder when it stopped. But anyway, yeah, that's okay. This one's still going.

Okay.

Yeah.

Should I start it again? Or we don't need the screen recording.

Oh, yeah. I don't know that we need the screen.

Okay.

Keep talking.

Yeah.

Um, yeah.

So we didn't lose anything.

Oh, yeah.

So there's Facebook, which is great.

Yeah.

I think it's awesome because it connects us, except it's privately owned and, um, to, for it to exist, it gives us advertising, which is kind of taking up our mind space.

I don't want my attention sort of taken up with something that isn't aligned.

Okay.

There's an alignment issue of advertising is not aligned with how I wish to, to use my mental space.

Okay.

And then there's also a control issue with Facebook. Um, is the government tracking all of our social interactions with it? Um, are they going to like hack down in some sort of fascist regime? If you, I don't know, right?

Yeah.

Kind of conversation with, so if there is a fascist over there and you know, you're just friends and stuff.

So, yeah. So if we perfect neural lace, there is the potential that some of the governments in the world, some of the fascist authoritarian regimens will, um, use this to spy on people's minds. Like, um, I wonder if we could just maybe turn that down.

So how do we ensure freedom and have technology move forward?

Yeah.

Cool.

All right.

Yeah.

So, um, what are we saying?

Um, so, so, so, so, so, so, so, so, so, so, so, so, so, so, so, so, so, so, so, so, so, so, overall, I think Facebook is awesome because it connects us.

Yeah.

I don't think we are aligned with advertisers, that's a problem, and I also think, uh, the

government and the various fascist regimes, could potentially abuse it.

Could you abuse it?

Yeah.

And I, that's the same question with PCI.

Well, even with, even with EEG and eye tracking, those two technologies, you, there's, there's

We've already seen really scary machines

that can do lie detecting that with amazing abilities

to detect the nuanced expressions of your lies

that you're giving.

There's some really amazing research.

And these are old technologies, eye tracking and EEG or not

new.

So at the point when we're combining AI and self-driving

cars and open electrical impedance tomography,

and we're predicting the images and maybe also the sounds

that people are seeing, and we're

able to pull those out of someone's mind,

that's way beyond lie detecting, right?

You're peering into somebody's mind, you know?

To me, some people say the word privacy is dead.

And then as technology moves forward,

it seems like we are more and more transparent.

And more of our lives have moved to the computer.

Sometimes Facebook advertising is really untarget.

And it's like they psychically knew

that I was interested in a pair of shoes or something.

I don't know.

And that's both exciting, that it can know you,

and scary, that it can abuse you.

Yeah, could.

So yeah, so there's this, how do we maintain identity

and freedom in this world?

Should we just stop development?

And that's a major concern.

I mean, major technology companies

like Microsoft have recently been

in the news asking for regulation of facial recognition

so that people are not abusing that.

Because the potential for someone to, you know,

in a city like San Francisco to rent an office and a skyscraper

and point a camera at the street

and start doing facial recognition of everyone

on the street is extremely easy.

They pointed out in that article that if your facial recognition

is only verifying, it only has a confidence of 80%.

You're going to make massive mistakes.

But you can still only trust the images

that have a facial recognition of above 98% if you want to.

So it's not like you're stuck with an 80% facial recognition.

And you definitely don't have to use

Amazon's or Microsoft's face recognition.

You can design your own.

And so the potential for not only for international spies,

but also just for corporate spies

to sort of like track individuals everywhere on the planet

is just massive and like you said, easy.

So tracking is also connecting, you know, like a negative way.

So it's also could be beautiful.

Advertisers could be helping you get to the product.

It could help, you know, like imagine

you're wearing augmented reality

and you want to find a store and I don't know.

I'm just saying like, please finish your thought.

How can I help you?

How can it be positive?

Yeah, because it seems like it comes down

to a central question of alignment of goals.

Like I don't necessarily hate an advertiser who's

trying to help me in ways that I truly need.

But I don't really want my attentional resources taken

by advertising I don't want.

I mean, it could be that they intercept someone

who's on a most wanted list and that person

doesn't intercept you.

You wouldn't really know that happened if that happened.

That could be one positive use of facial recognition

in the public space if they're able to locate someone who

could harm you.

But you wouldn't know about it, I guess.

And but I mean, what would be a positive if let's say

that you lost someone and you lost someone

like your kid in a big city, you don't know where they are.

If that person could be located sort of automatically,

that would be valuable to you as a parent if that was the case.

I mean, there's so there's.

Say you're a kid, you're an angsty teenager,

and you want to night out.

Let's say you want to speak from your parents.

And your parents are able to track you down.

And then you would feel very upset about that.

Yeah, it's like two sides of it.

At some point you might start wearing a mask.

Right, so yeah.

The teenagers will be wearing masks.

To escape their parents.

To escape the saying.

That sounds like some sort of, yeah, that could happen.

And then at some point, you know,

they're able to identify people just by the pattern

of your walking.

Yeah, like everyone has a unique pattern of walking,

which is crazy to think about.

Yeah, yeah, gate recognition.

Yeah.

So at some point, maybe teenagers

will be wearing something that interferes with their gate,

like a little bump on their shoe.

Right.

So they force them to knock or gate.

Yeah.

Fooling machine learning is going

to be like this continual, you know, technology

to fool it will be this continual arms race, I guess.

Yeah, yeah.

So I guess we should keep going.

But be mindful of the security arms race

and be responsible about how.

So this technology could also lead

to building robot minds.

Yes.

We understand more fundamentally how the brain is working

and how like our 3D neural network of our brains

are not only doing digital signal processing

and learning from these 3D point clouds of video

and massive feedback loops.

We can also create machines that are doing

the exact same sort of things.

We can understand.

If we can understand our brains.

Then we can create machines that do the same sorts of processes

that our brains do.

And so those machines would be able to all the same sort

of calculations, all the same sort of computational

biology that our brains do.

And they'd be able to see and hear and speak at human level.

And maybe above.

And even have self-concepts.

Yeah.

So that's where I started my group, Self-Waring Networks.

So it's basically from the research into neural ace,

we're going to be able to build self-aware robots

and maybe above human level robots.

And drones that are basically smarter than pigs

or maybe smarter than humans at some point.

And that's a whole another sort of a can of worms.

Absolutely.

Yeah, all these ideas seem very futuristic, Dick.

But Ale and.

Barreling towards us like a speed train.

Like a speed train.

And we have no idea.

We're just challenging.

By the time we finish this podcast, the first sentient.

But by the time we finish this episode of this podcast,

the first sentient artificial intelligence

could be waking up somewhere in the world.

Someone may have already built it.

That being said, if humans in our old school biological selves,

I think if we want to remain relevant or even competitive,

it's an arms race in some respects.

Of who can build the best conscious sentient creature.

And an entity.

That includes supercomputers and everything.

And I would argue that the best way

is that we have to evolve with machines, not without them.

So we can do it a lot with biology

and we'll continue to do more.

But by using machines to understand biology more,

I think we're going to meld.

Well, with the development of nerve gear,

we can begin to expand our minds into external minds.

I call it the extender brains.

And I keep telling people, and this is a product

I'm going to build, the first product is nerve gear

and relays, the second product is artificial cortex

or extender brain, and the third product

is artificial brains or artificial life.

And I don't know, the research for all three is related.

But it means that we can grow with machines

by a person who could decide to connect their mind to an AI.

And there's a number of different sci-fi books

and sci-fi movies that have animations,

like Sword Art Online, that have explored what this concept would

be like and sort of command narrative

and people in these worlds where these technologies exist.

But I think we don't really know how it's going to play out.

We don't.

Some of those books are a little bit dystopian.

And I mean, it could go in all directions.

But I do think that we need to sort of be paying

as much attention to BCI as we do to just AI.

And I feel like AI is currently like gets a lot of the attention

and BCI gets a lot less.

And that's assuming that we want humans to move

into this new world as well.

Yeah.

Yeah.

I think we should maybe cap it off there.

Yeah.

This is everything else you wanted to say or add.

You want to add any, mention any links you want people to visit?

Oh, yeah.

Yeah, it would be awesome if you want to sign up

to the mailing list.

I'm planning on doing a crowdfunding campaign

in a couple of months for the Open EIT project.

You're selling like kids in your crowdfunding campaign?

Yeah.

OK.

You want to be Indiegogo or something?

I'm thinking of CrowdSupply.

OK.

Because CrowdSupply is like an open source

hardware advocate right now.

So where can people go?

So if you go to MindsEyeBioMedical.com,

just sign up to the mailing list.

And you'll get notifications when the campaign goes live.

And yeah, that would be great.

Perfect.

Anything else?

That's it.

That was lovely talking about BCI with you.

Likewise.

Thank you very much, everybody.

And we're going to end it there.

Neural Lace Podcast S2 E2: Jules Urbach on RTX & VR, Capture & XR, AI & Rendering, and Self Aware AI.

original: https://youtu.be/wgMKMn7srHM

Audio Transcription by OpenAI's Whisper

Hello, hello, everyone. This is Micah with Silicon Valley Global News and also with the

Neuro Lace Podcast. And I'm here talking to Jules Erbach. He is the CEO of Otoy.

The inspiration for the call was we recently had some epic news from Siggraph and even

following Siggraph on, you know, NVIDIA's RTX and also Otoy. So now Octane is integrated into

the two top game engines, Unreal Engine 4 and Unity. One of the talks that Jules was interviewed by

NVIDIA at Siggraph, and he was really sort of startled and surprised by the fact that we now

have real-time ray tracing on a single GPU. Is that correct? Was that they interpret that correctly?

Yeah, it was a great interview and it was one of those cases where, you know, I've been championing the cause of ray tracing hardware for a while. I mean, I was first exposed to that possibility

10 years ago at SeaGraph when I was on a panel with a company called Caustic Labs, which was

later acquired by Imagination Technologies. And they had really early ray tracing hardware and

it looked promising, but it wasn't powerful enough to really move the needle or do anything.

And when they got acquired by Imagination Technologies, which was the company that ended

up powering the iPhones GPUs really up until last year, and unfortunately they went out of,

well, they got bought basically, but Apple basically stopped using their GPUs and that

cratered the company. I was concerned that ray tracing hardware was like the electric car or the

car that runs on water, you know, it was just wither on the vine. But we had tested the Imagination

ray tracing hardware two years ago and the SeaGraph announced that, hey, we're going to shift octane

on this thing because it's a game changer. It's 10 times faster than the compute cores for ray

tracing and therefore path tracing, which is what we use in high-quality visual effects for rendering.

And I think that a video who was keeping this really quiet, they'd been working on this thing

for almost a decade. And we got lighted onto that, under the secret of that once the hardware was

almost to the point where it was about a year away from shipping. And we got good development

hardware. We rebuilt as much as we could of octane as everyone on the experimental RTX hardware.

And we had basically one implementation, the stuff that we built on Vulkan, which is an API

for computer graphics that was able to fully leverage those ray tracing cores. And we were seeing eight times the performance of exactly the same generation card from the Pascal

NVIDIA generation. And that's, it's very rare to see a 10 times improvement in speed and overnight

in one, you know, in one instance. And there's still work to be done. I mean, it's so new and

talk that even with your advanced work that we did, we still have probably another six months

before we can start shipping products that absolutely tap into the full power of this ray

tracing cores. But, you know, the other part of that energy that I gave to NVIDIA was that,

you know, there's no doubt in my mind that the next decade of computer graphics, if not the next

20 years, is going to be defined by ray tracing hardware at the foundational layer, the same way

that GPUs have just basically made 3D graphics, you know, commodity, even on our phones. And we

can play Fortnite on our phones. So there's been a lot of people, like, you know, I've shared a

couple articles on this topic. And I really wanted to point out the fact that ray tracing is going

to make a huge difference in how we experience virtual reality. And it's coming with this generation

of cards, the 20 series RTX cards. It's going to change virtual reality. We're going to have,

people are going to be able to figure out, and this is what I'm telling people, but we're,

you know, people, I'm telling people, we're going to be able to understand a scene. We're going to

be more immersed in a scene because the things like the reflections and, you know, the shadows,

they will give you a sense of realism and a sense of immersion that we haven't had in VR before.

But I tell people this, and I get this skepticism back, and they say, well, there's, you know,

there's no way that we can, you know, VR has to run at 90 frames per second. And you have to render the entire scene in real-time ray tracing. You can't, like, maybe, I'm trying to argue you can

use it as an effect. So I wanted to, you know, doll back from the hype a little bit and get a

sense of the realism from you of what is, how is this real-time ray tracing going to actually

affect our VR experiences? And do you expect to see new headsets coming this year or next year?

What do you think the reality is in terms of the industry for VR and AR?

So I think, yeah, I mean, I'm a game-believer. I don't, you know, I just answered a core

post, like, yesterday, about this very question is, you know, is ray tracing,

real-time ray tracing, or even our cancer gimmick? And it's not. I mean, it's so, there's two parts

of the rendering platform that are fundamentally transformed by having this kind of hardware and

consumer cards, you know, shipping pretty much everywhere. I mean, the low end, the high end,

everything's going to have ray tracing async that's, you know, even on the lower end, 20 series

and video cards. First thing that you could do with that in VR is you can trace primary rays.

And we were showing at the cigarette booth, we could do 4K 120. So I mean, you know, that's,

that's already, you know, and, you know, and that's easily doing 4K 120 with path tracing,

with shading and everything. We were just doing primary rays. And we just wanted to

essentially do coagulated rendering, do all these tricks, you know, you don't have to use,

you don't have to work and render the things twice. So we can do all that stuff with,

without using traditional rasterization on these RTX cards. And even on one of those things,

you could drive any existing VR headset and just switch from rasterization to path, you know,

to ray tracing. I think that that's, it's a big week for a lot of game engines. I mean, one of the reasons why we've integrated an octane, integrated octane inside of Unreal

Immunity is that, you know, those engines have been built for a very long time by rasterization.

And we have a great relationship with both companies. I was talking to Tim Sweeney about,

you know, Unreal and Brigade and octane, all these things. Like, well, you know, the first step

is clearly for us, like hybrid, where we use traditional rasterization the way it is now,

nothing changes, but the reflections in the shading are improved by ray tracing harder,

because that's low hanging fruit. So all of the RTX demos that Jensen was showing

for games typically, you know, have that improvement in quality, you know, from that. But

that's really, that's almost nothing. That's really known as missing the true value of this,

which is that if you go one step further, which I think we'll be able to deliver to Unity and

Unreal Engine users right off the bat, is you can switch to complete ray tracing of the scene.

So, you know, immediately seen complexity, like forest to be rendered and everything,

anything that octane can render, even without the shading, for any film, like feature films,

like we did for Ant-Man and Lost and the like, can be dropped into VR and one or two of these

RTX cards can power that. And even headsets that have, you know, frankly, even 4K, by 4K per

eye, if you ever were to go that further, you can imagine things sort of progressing to that

level, you know, the RTX hardware can keep up with that. And you can start to skip a lot of the hacks

and a lot of the problems that one held back scenes and complexity and visual fidelity, which

because, you know, you have to render everything with triangles, not, you know, can, you know,

raises of ray tracing, you know, light and also things like anti-aliasing are solved,

that's the field gets solved. A lot of effects ray tracing just solves correctly without having

to hack it. And that's double the case in VR, where you can just render those rays, you know, instead of doing two renders and doing a low res one and using phobia to render to mix those, you just use ray tracing to basically do a heat map and just send more rays to the parts of the viewport that are looked at by the eye. And that's something you can't do in traditional rasterization and it would be very expensive to do with that RTX. The second thing, sorry, I'll let you finish. Yeah, the second sort of boost from this whole RTX GPU ecosystem is not just the ray tracing harder, but also the tensor cores and the FK16 floating point operations on there. So we have our own AI denoiser, but frankly, the stuff that they're showing us for real-time is really good. And so being able to do real-time denoisers that are AI based or machine learning based that can clean up, you know, shading noise that we have when you're doing really high quality ray tracing or path tracing, that also becomes a lot cheaper and a lot faster on this generation of GPUs. You combine those together, you end up really getting very close to solving, you know, basically the rendering equation. In other words, all the laws of light and physics you need to drive VR in real-time. And I think that it's going to take, you know, it's going to take new content to drive that. I mean, just converting your Unreal Engine raster game with better reflections with RTX is easy and it can look great. I mean, look at that Star Wars demo that they did, but there's a deeper and more, you know, frankly, much higher quality option that is just going to probably take six months to, you know, maybe nine months to really, you know, get in the hands of game developers. And we're trying to do our part in that by providing, I mean, Unity and Optane are free together and we're going to make Optane and Brigade inside of Unreal also very inexpensive. So we want people to develop content and we're working on a real-time ray tracing system that, you know, while it obviously will be able to go to the distance with RTX hardware, it also,

you know, if you go under a cigarette, cigarette, if you see it's running on an iPhone and we can

do real-time ray tracing on that device and on intelligent graphics. So we've decided we were

going to solve this problem for everyone and everywhere we can, but there's no denying that,

like, when you're going beyond just doing it at 1080p, if you want to go to 4k or you want to do this

for VR headset or even, you know, AR, that ray tracing hardware is a game changer. And so the

idea is that we will bring, you know, through just the two integrations we have in these game

engines, we'll bring the entire cinematic pipeline that the film studios use for rendering movies

and we'll bring that to real-time and we'll bring that to VR. And then it's up to the VR

headsets then to come up with higher resolution, higher frame rates. So that's actually something

that a lot of people are really astonished by, that the real-time ray tracing is revolutionizing

the movie industry in addition to the game industry and you're promising that we're going to be able

to hit 90 frames per second at 4k resolution with some of the, with titles that look as good as

existing VR titles today. Yeah, I mean, hopefully better. I mean, that's the point. Hopefully when

ray tracing you do something better, and there's, I mean, just like ray tracing, you can do it the

hard way. You can brute force unbiased rendering, which is what Octane does, but there's also the

same tricks that you have in games. If you want a pre-compute part of the scene that's told to

ray tracing, it'll still look really, really good. And in fact, many movies use that very same technique.

Not all movies are done in Octane, which Octane is like, is the laws of physics, you know, computed.

It's like you can still do, you know, shader tricks and stuff like caustics and stuff and

renders like Arnold, which are used in many films. You know, Arnold also is moving through the GP,

which is great. And I think that the quality will definitely go up. And the things that you can do

in, with ray tracing hardware, not necessarily super obvious right at day one with, with a

launch of these cards, I mean, that's why I think maybe people aren't getting how big of the deal

this is. But, you know, I think it'll be pretty clear for both on the cinematic, you know, film

side of things where you can really do the real time and have that film quality and also, of

course, remerces, you know, a chance to use in life. So will developers have to, you know, shift

away from using polygons and maybe start to, in order to really maximize the use of these,

of these new cards, will they need to start, you know, modeling in Voxels or Lightfields or

what does the developer have to do? No, no, no. No, it's on the constant side. On the art side,

nothing really changes. I mean, you know, the only thing that we, in Optane, there's really

almost two paths. And the, and RTX only accelerates, by the way, one of those, which is,

which is polygons. Like it's still, the only thing that the ray tracing hardware really does

accelerate is the rendering of triangle meshes. And the thing that we can do in Optane for films

is you can take something that is like a hair primitive, things that aren't necessarily easily

turned into trimesh, and you can still turn them into trimeshes. And that's what you can do in

any game engine. You can turn everything into a triangle soup, and you can send that to the

ray tracing hardware, and it'll, it'll be much faster. From the art pipeline, if anything, it's,

it's simpler because artists have to go, sometimes they start in the much higher quality version of

what they would do for a cut scene or film. And then they, and then they have to figure out how to reduce that quality to get it into a, you know, a game engine. And our work, I mean, really, half

of the work we're doing with, with integrations into these game engines is not just the render,

but also the art pipeline. You can take something that you created in Cinema 4D or Maya, or right

at, right for a Marvel movie, which is, they use Cinema 4D and Optane, like, and, you know, for

Elastic, which is a company that did the, the titles for Ant and the Lost. And you can just drop

that into an Orbex package, which is the interchange format we, we open sourced for Optane. And you

can drop it into Unity and Unreal. And you can then, with RTX hardware, you can now render that

quality and basically in real time. And, you know, that's not making it easier. You don't have to

basically come up with two platforms and stick to one and start with the highest quality version.

So I went back and I watched a talk that you did at Seagraph in 2015, part of a

light field talk with a bunch of other light field talks. It was a really great series of talks.

And I'll link them with the article that's going to accompany this. But I, I really wanted to

sort of like go back to light field capture, which is how I, you know, first heard of, of your

work. And it looks like, you know, at Seagraph, that Google has basically reinvented the wheel

with their, with their light field capture. They basically redid what you did back in 2014.

I mean, I should, I, yeah, I should, I should point out that the, you know, employee that worked,

you know, Paul Kavevic, who's now doing that project at Google, you know, worked with Otoane,

who was one of the co-creators of Lightstage and worked with us for eight years. So he was a friend

of the company and he actually was part of that project that we did in our office. So he basically rebuilt that, you're right. He basically rebuilt that at Google and they've, they've been experimented

with it. And it's super cool. But that is basically, you know, that, that's the exact

treatment. It's the same thing that we would have been doing in, with the spinning camera. They,

you know, the improvements with having 16 GoPros in an office is probably makes it faster,

which is great. But that's, it is exactly the same thing.

Well, the astonishing thing was they went from 16 GoPros back down to the spinning camera rig

that you had. So they actually, they went up to the 16 GoPros and then they reduced it back down to

the, the, the two camera sort of thing, except, except your, you only had one camera that was

active and they had two cameras that were active. So, but it was interesting to see that sort of

big circle, but talking about life field then, you know, so that, so from trying to fill in the

gaps, you know, in the life field is where, where, is that where the concept of AID noising came from

that then became the concept that came the technology that enabled real-time ray tracing?

So they're all sort of separate pieces. For me, light fields, I mean, you know,

when you look at, at, at really where light fields end up, it's not even so much the capture,

because for me, the real value of, and even the work that Paul did, and we did together,

when we were building light stage, I mean, all this came out of our light stage work. And light

stage is more than a light field capturing. This is what we do for high-end films. Like when we

scan in, you know, all the actors for an Avengers movie or, you know, one of these big

temporal films, and we do this every week, every day, like we just, all the DCP shows or

light stage captures, we don't just capture a mesh and we don't capture lights and we capture something more than that called a reflective field, which gives you all of the ways that light

bounces off that surface. So you essentially don't have to, you know, artist and write shaders for

skin. You have the poor level details. You have the way light bounces, and that's really important

for mixed reality as well as for films. So one of the reasons why we didn't go deeper into light

field capture and, and push further even on that experimental thing that Paul ended up doing at

Google was because really we want to get into, we want to be able to capture what we capture on a

light stage in, you know, basically in real time and make that something that is consumable inside

of Octane or inside of the R pipeline. Because that's, if you're just capturing a light field,

you're actually, well, it is better than RGB in depth or maybe stereo or pano. It's really still

bringing, you know, a very small subset of the data that you want. What you want is you want a CG

recreation that can be dropped into a renderer and treated like a CG object that matches the real

world. And for that, you need to capture materials. And there is a lot of work that we're doing where

we're looking at, you know, we have a light stage to capture ground truth. Our AID noise can work

all the eyes that we're doing is mostly speed up rendering to make it so that, you know, the

rendering that you would get out of a ray tracer, path tracer can be done in the 10th of time. The

AI can just finish the work. You don't need to finish the simulation. The AI can figure out the

pieces heuristically. And capture is very similar to that. So our work at light stages, we have the

absolutely, and we have 800 lights, we can capture perfect holographic representations of people, but you have to bring them into a big stage. What we've been trying to work out of what we've shown

almost every year, not to suggest that GDC and others, is we can take 120 frames per second

stereo camera, which is going into phones these days, and we can pretty much use a little bit

of machine learning, plus, you know, some simple lighting patterns that are much less than what

we do on a light stage, we can start to get this absolute perfect live, you know, captured reality.

And that's really our goal. And AI will play a role in that. There's no doubt that capturing AI is

super important. And we have to get that to work in real time, because otherwise,

AR and mixed reality will never look right. And that's something that I discovered, frankly,

when I was looking at the Magically device, you know, which I got a test, what struck me was

that nothing was really being relit, you know, because I think your app on the Magically platform

has to request being able to capture the world around you. But things like that are really

important. So what we're showing at SIGGRAPH on the phone, basically, is able to reconstruct the

scene from the phone camera. And then we're doing, like, we have a little mini version of octane,

called octane light, that is designed to basically do the minimum amount of ray tracing so you can

have objects that are mixed in reality live on your phone, and, you know, cast shadows and have

reflections and just look great. And in order to do that, not only do you have to render and denoise,

you add denoising to get that to be the highest possible quality, but you also have to do some

sort of scenery construction and do that live and do it, frankly, without depth sensors, which is

what the, you know, Magically has that and some other devices like Tango have that. But, you know, the iPhones just have two cameras, and they use basically pretty good computer vision algorithm,

including after mission learning tricks to get, you know, to get that sort of information into

AR kit. But all these pieces, I mean, I can't even imagine VR, frankly, you know, existing in the

future without pass-through cameras that allow you to switch to AR mode trivially, in which case,

you're back to the same problem, which is whether you're seeing the real world to your eyes and

there's an overlay like Magically, or, you know, it's something like, I think, what, you know,

what Akos was talking about in the problem, who knows when it'll be, when it'll be out. But things

that basically have camera pass-through where you actually are recording from two cameras, you know,

what's in the field of view, and you could do AR, you could blend that with VR. That kind of stuff is

super interesting, and I feel like that's, that requires everything to just be, you know, up in

terms of this quality and its setting. So AI is important for scenery construction, it's important

for object signification, it's important for physics, it's important for making high-quality

rendering work in real time. Ray-tracing hardware is a big boost, and I think that, you know, the other

the other crazy technology that I'm seeing where RTX is like really important is kind of where,

you know, as we're referring to light fields, it's like being sort of a, it's more of a visual,

like, description of light. Like, it's basically saying all the rays of light that make up both

your left and right view for depth, but also things like depth of field that you see in cameras,

all that stuff is essentially something you could emit from a holographic display if you had

something like 4000 DPI, and, you know, and you have like a, you know, some sort of filter on top of it to guide the rays of light, and even Paul, and even us, as like, you know, everyone

wants to build a structure, call it, and get to that point, and it's possible. Like, we basically

probably, displays are kind of getting there, you know, 4000 DPI displays are not impossible,

there's companies that, you know, they're working on it, and from our perspective, like, we actually

are looking ahead of VR and AR, because I think that, you know, if you can have a glasses-free

experience emitted from a table or a wall, and that becomes sort of the fabric of buildings and

surfaces and furniture and offices and homes, you know, and sidewalks going forward, I mean, that,

that is, that is going to be a lot easier to consume than wearing, putting on a pair of glasses,

and I've tried some of the smallest and lightest with glasses, and I think that that's, that's,

that's the thing where ray tracing at Harvard is, like, absolutely critical to make the holographic

display panel at that resolution run in real time, like, there would be, it'd be very difficult to

do that without, without ray tracing at Harvard making that 10 times faster, and because it's 10 times

faster, we can now drive holographic displays probably in the next six months with this kind of,

this kind of speed in real time. So I want, I want to just sort of jump off the deep end

in terms of science. I was, I was at this, at a talk last night about, they were talking about,

you know, so Mary Lou Jepsen has this company, she's creating a new device, it does, I guess

that, it's called Functional Near Infrared Spectroscopy. One of the technologies behind it

is photoacoustic microscopy and photoacoustic tomography, and these are basically, and there's,

there's some other technologies like ultrasound and coated optical tomography, but basically these,

these are new kinds of medical imaging technologies that, that can be combined with things like electrical impedance tomography, and what, what that means is we're combining light and electricity

and sound to image the brain in new ways, and we're basically creating a light field of,

you know, what used to be an X, well, you know, we still use X-rays, but we'll create,

this is new, there's X-rays, new X-ray tomography technologies too, but basically all these

technologies can be combined to create, you know, a light field of, of a person's brain, we can do

a whole amount of brain, we don't know the full depth of what we can get, so I'm kind of like

interested in like, you know, there's all these people having these conversations and I go to

these really great conferences, but there's not, there's not a huge amount of talk about using,

using the sort of AI denoising or really using deep learning at all. It's, it's almost like

there's, there's a huge opportunity to, to figure out if, you know, real-time ray tracing,

we're predicting what should be there, can be medically accurate, you know, in terms of,

you know, helping to model the brain, helping to model brain activity, ionic, you know,

ionic flows of, of activity, you know, the flow of ions and the, the electromagnetic field of

the brain. That would be very interesting if we could begin to, to, to accelerate that research

in medical imaging by, you know, basically, you know, combining the, the light field that we're

trying to render with some of this AI denoising technology or real-time ray tracing AI and I

wonder what are the key differences between the AI that's involved in real-time ray tracing and the

AI that's involved in denoising and if it would be useful and, and maybe you can speculate as to

whether, you know, this kind of AI, how accurate this AI can be, whether it could be medically useful.

Yeah, so I should, I should probably provide almost like a breakdown of how AI is used, even in octane and because there's different AI libraries, just like you have different filters

in Photoshop and not all of them could be used. AI assisted rendering, I mean, there's, you know,

we went through all the different things that are slow in rendering, we applied AI to fix them.

So the first thing is when you do rendering correctly, it's noisy, it's just like when you

take low exposure, there's a lot of noise, you need light to gather and you need to finish

rendering to get a properly clean image if you're doing really high quality

photorealistic rendering. So AI denoising just finishes the render and you're

essentially trading compute for guesswork but the AI is so good that it's, it's looked at

enough finished renders to know how to finish any arbitrary view and we built that ourselves and

Vinny's built that in optics and that's absolutely fundamental to rendering, like it's an AI layer

you add to rendering. We also added something called, well, it's pretty straightforward,

it's just AI upscaling, which takes a lower rise of invention, scales it up in a way that you

can't do with a normal like bi-cubic filter or anything like that, it does recreate the edges

and you have spatial resolution or even temporal resolution added, which is why you can easily

go to 120 or 240 from 30 frames a second, and Vinny actually showed a great version of that

working. And then there's other stuff where it's like you can start to figure out like what is the,

if you have a piece of an object or a scene, can you finish the actual scene layout? Can you

figure out from a photo what the actual geometry of the forest is and actually create the scattering

of leaves and trees and all that stuff. And that's deeper, that's further out, but it's still

something that is really interesting. And I think that that is kind of where AI and rendering really

do have a lot of vocation. And then there's stuff that's really more for humans to be creative of.

I mean, having AI that essentially takes a simple stroke of your hand and then creates

all this stuff that's augmented based on your history of how you paint or how you do stuff like

coil or medium or tilt brush or something like that, those things are really key tools

for the future for sure. And I also wanted to talk a little bit about light fields rendering

and baking. So three light fields are a shortcut. We don't have all the time in the world to use

AIV Noising and rendering with ray tracing. Light fields were a way to render something

into a light field as you're just basically generating a digital hologram. And then the

hologram could be looked at from any angle and you're done. And it's so cheap and inexpensive

that you basically, at least you can run this on low end hardware like a phone. You can also use

the compute cost and ray tracing power you do save on other things. So that's where I see light

fields rendering and being super useful for games in real time without oversaturating the

even the hardware that we do have, even a 10x of speed up in ray tracing hardware is

something you can easily use up if you're doing really complex light transport. What you're

describing though with sort of this imaging of the brain is light field or volumetric asset is

super interesting. And I think I was reading one of your posts where I think somebody was maybe

it was you that was looking at the rendering of that in the VR headset and that feedback

move where you're seeing what your brain is doing is probably some sort of kernel of an

interface of the future that I've been thinking about for a long time. So I think this area of

research and that committee is super interesting. I mean, there's a lot of thoughts about having

thought powered, you know, experiences or input and the like. And of course, you know, if you can

see what your brain is doing, you know, there's there's a lot of there's a lot of research being done about biofeedback moves to have it to be open up an online office or things. But

I think that the fact that you can actually visualize that in VR and AR and frankly, yes,

ray traces, which is way better than, you know, you can take volumetric data sets and you can

ray trace those. That's what ray tracing is really, you know, great at versus doing it in

triangles. That is your earlier question. That's the one thing that you can bring in fire and

volumetrics perfectly into ray tracing. And that'll, that'll look great. Unfortunately,

RTX hardware doesn't do volumetrics. I mean, you can still add it in there. It'll be fast,

but you still use the compute course to render that. But when you're seeing your own brain and

you're, you're thinking stuff and you're seeing your brain do things, there's, I spent years

thinking about what that can mean. And I've been waiting for the foundational pieces of what we're

building on the rendering side, on the ecosystem and platform side. And what's fascinating is that,

you know, there's, there's a lot of work that you can imagine being done with AI, looking at what

that, you know, even at that feedback loop and filling in some holes and details to create things,

they practically probably don't have great, you know, vernacular words to describe how they

work. I mean, we know that they're important tools for potentially for input or for content

creation or who knows more stuff. But I think that's your strategy of the key of something,

you know, surface is something really, really, really fundamentally important for the future.

I know it. And I think that's why you're on that too. That's great.

So, so, so, so one thing, so I'm, I'm leading a meetup every week. It's called Neurotech SF.

And we have successfully connected an ED device to a WebVR to an Oculus Go. So that was kind of cool. Yeah. You know, but so now, and so because, I think perhaps because of that, I'm, I'm, one of

my friends or connections is going to enable me to have access to an electrical impedance

tomography machine. So the second phase of the goal is to we, I'm also acquiring some,

another friend is donating some or sponsoring me to give me some, some depth cameras. We're

going to get a few elusive cameras. And these cameras are going to enable us to create a

volumetric video. And we're going to be collecting volumetric data of a person's mind with our

electrical impedance tomography, tomography machine. And I want to do, I'm going to use this,

I'm looking at this, I wrote about this crosshair convolutional 3d crosshair convolutional neural

networks so that I could, I want to try to do object segmentation on the volumes of data that

we're getting from our electrical impedance tomography and on the volume of data that we're

collecting with the 3d cameras. So I can begin to correlate

so that we can have the AI begin to look for correlations between persons, the brain activity,

the volume changes and the volumes that they're seeing in the world around them. And this is,

you know, just a big experiment we don't have like, you know, we have, we have four Titan 5

graphics cards in the cloud, but we have to somehow stream that data up into those,

into that cloud and then back in real time. And so person's going to, and then we're also

going to be running this through VR so people can see their medical imaging so we can correlate that.

So with VR is very useful as you can correlate whatever the user is looking at,

or whatever their head is pointed at with their EEG. Actually that's probably our next step is

we're going to correlate what they're looking at with EEG, but eventually we're going to be

correlating the EIT with what they're looking at with the volumes of data that we're going to be representing in VR. And then VR also allows us to isolate, basically isolate other, you know,

random signals that from the environment. So we're isolating a person from, you know,

so that we can begin to look for how a person's brain changes in response to that specific content.

And the other idea is you can also look at how two people have different, how their brains

are responding differently to the same piece of content that they're immersed in. So the point,

where the point where I was going to was getting at was going back to doing object segmentation on

3D volumes of data. It seems like, you know, because we're talking about light fields and

we're talking about volumetric capture and we're talking about, like, so I haven't really seen,

I think another area where this technology that you've been working on could be really useful

comes to self-driving cars. All the self-driving car companies that I know of are to my knowledge

and I don't know, obviously I don't know what's going on inside these companies. But on the outside,

it looks like they're all using, you know, basically two-dimensional slices of data streams,

you know, you get a LiDAR stream, you get these two-dimensional camera streams and you're running

two-dimensional convolutional neural networks on them. And I wonder at some point if it would be

useful to start actually creating, you know, a volume of data first and doing semantic segmentation

on this volume and doing, you know, upscaling this, you know, so you could, I'm just like, I'm

trying to think of, you know, how, you know, because I'm trying to think of how rendering

can really help solve the problem of self-driving cars. Because one of the issues I guess is,

so I said, you know, self-driving cars, you know, do they need to become self-war networks? Do they need to become aware, does the car need to become aware of itself?

Does it need to have, the reason, the reason, the thinking here is that there's this book by Peter C. where he talks about how the, that his theory of what the consciousness is for, it's a higher level information pipeline that is, that exists to help us solve problems that are too big for the unconscious mind to solve. And so that's really, he sees it as sort of like, as an additional point, like when you get a computer that's powerful enough to solve those logistical problems, it would be a conscious computer. So that's why I'm like, I'm like, well, well, is that where we have to go with self-driving cars to really get to like the level five car? And do we need to have a light field render that we can, because I asked the, I asked the CEO of NVIDIA if we are going to need a self-driving, self-aware self-driving car, and he said that he didn't want to build a black box. He wanted to have every component basically, you know, understood separately so they could understand what was going on in the car if something wasn't working. But I think you could visualize, you could render what a neural network is doing. And so that's my thinking. I don't know if you have any thoughts on that topic, but. Well, I definitely would defer to Jensen on self-driving cars. And he's obviously, NVIDIA is doing some crazy stuff in that field. And Tesla, until recently, was using NVIDIA GPUs all over the place in Tesla's. But I don't know if the car needs to be conscious. I mean, I think, frankly, people can drive and almost be unconscious and still, almost by road, do the right thing, have sort of like, no, seriously, it's sad to say, but I mean, you know, you have almost like the reflexes and everything can almost be trained, like muscles, even for things like driving. And it doesn't necessarily require you to have, you know, you know, the same consciousness that we do. So I don't know if you need consciousness for the,

or so. I mean, if you have existential philosophical decisions, you know, which sometimes you have

with cars, do I run over the, you know, the school children, or do I save the driver? I mean,

even there, you know, it's clear that you can program what you want the outcome to be in those

scenarios into this, into the system and get that. I mean, that, that is basically predecided.

But, you know, the, the, the issue with rendering is that it's not really everything,

even for OATWA, like we're not just a rendering company, we have capture, and we have dreaming,

and we have some other higher level things, which is basically the, you know, the entire feedback

between those things is basically what you really do need to solve for any system to become,

I'd probably want it to be. I mean, if we're going to, let's say, recreate a, you know,

purpurization reality, or if we're talking about, you know, bring machine interfaces, I mean,

it's like, you have to capture the world, you have to render it, or edit it, or understand it,

and then feed that back into a way that, that the, you know, the interface, probably with a human

in the middle of it, hopefully, to do something with. And, and that's why the company is divided

into these three parts. Sometimes the parts are hidden, and people look at just the rendering,

but the capture and the rendering, and even the streaming, whether it's, you know, as you're

pointing out, if you have, I can use in the cloud, you've got a VR headset that's, you know,

not on the cloud, you have to, you know, combine those two. And a lot of the technology that we

built this just does that, it solves that problem for you. And that's kind of where, you know,

we see ourselves fitting into this ecosystem, is we build these tools that, you know, solve some of the harder problems. But in terms of, you know, what's interesting,

the rather important point, which is just rendering, what does rendering really do for AI? And there's,

you know, if you look at some of these things where they simulate like the evolution of like,

you know, jellyfish, or multi-solid organisms, and they, you can see them basically be pushed

on the land, and then they grow limbs, and all this stuff. I mean, take that to launch

a revolution, which is right all the way up to the simulation theory, which is if you basically

simulate everything in the physical world to the point where, well, you know, we don't know,

it's so granular, the entities in it are covered, you can imagine basically creating life that,

that evolves and grows and learns in an environment that's basically the same as ours,

but can be accelerated and you can have shortcuts, you know, all sorts of things. And so that's why,

you know, this, the simulation theory, I guess, you know, I guess Geelong was one of the people

who made it popular where, you know, if you just imagine a video game where we are getting the

point where, even if it's slow or goggles, but it just looks absolutely real and your eyes are

fooled, you know, then you figure out touch and other stuff. I mean, you come up to the

scenario of are we AI running in a simulation, and how do we prove that we're not? Or how do we,

you know, figure out what that even is and isn't? And it's, it's a fascinating problem. But

we're probably going to, you know, we still have work to do before we actually can get to the point

where reality itself is digitized so convincingly that one, you know, cars can, can understand it

the way we do, you know, naturally versus, you know, with rough approximations. But yeah,

I like something you could render in a simulation. The data itself is actually less, you know, less interesting without the, you know, the source that generated it or how it was captured.

Going back to 2015, at that, at Seagraph, the first of the four talks on Lightfield,

one of them was, I believe, the gentleman you mentioned earlier, who is now at Google,

and he was saying that basically, you know, our eyes are capturing a Lightfield. We have two

points or two, I mean, your eyes have lots of different, you know, cells, you know, lots of

different that are responding to light. That's right. So the idea is, you know,

what I've seen is that it is, so that going back, research going back into the 1980s on,

you know, neural networks that can be used as signal processors, it seems very plausible that,

you know, and looking at Jack Lawn's work, that he, you know, he basically created a movie that

was with MRI. He had someone watching the movie, and he had the machine watching their blood flow

and the movie, and they trained it like that, and the machine just watched the blood flow,

and then it pulled the movie. It recreated a movie from just the blood flow. And so that,

so the idea is, you know, that basically what we're seeing is video. What we're seeing is a

Lightfield that our brains are constructing. And this was an idea that I saw. And so if we're

creating a video, but then we're, it seems like we're, it seems like we're creating a video,

but we have that, you know, the ability to learn from this video, but we're also

rendering it. And I'm thinking about Google's Deep Dream and the, you know, that there's new,

there was a huge story, I see graph about the deep fakes or deep, you know, they're created,

they're able to like recreate an actor or recreate a person, and you can make that person.

And so the idea is that, so for me, like, what does AI bring to, what does rendering bring

to AI? It seems like those are, you know, if we're going to talk about creating an artificial, you know, sentient mind, you know, it seems like that, you know, our minds have their own

networks, but we're rendering. And the rendering is then being processed, like it's in a feedback

loop with the AI, where it's rendering, it's crunching what was rendered, and it's rendering

on top of that again. And those are the feedback loops of the mind, I think. And so at some point,

I think that your technology leads towards, you know, you're already combining AI and rendering,

and that seems to be like you put that in a feedback loop, and you eventually have a mind.

Yeah, and it's funny because I mean, yeah, and AI is, I mean, you know, it's one of these things

where as a product, I mean, you have to be, you know, I want to release AI that's useful, like

right now, this year, but it's the stuff you were talking about, where you could recreate a movie,

or you can, I mean, you know, I was reading, you know, about another, I think it was in Japan,

or something like that, maybe, I'm not sure it's the same researcher, where you could basically

figure out the letters that you're thinking about, by again, sort of scanning the back of your head,

and then you can almost get like a 16 by 16 black and white pixel representation of what your brain

is seeing, or visualizing, I mean, you take that to its logical conclusion, that is going to be,

essentially, I mean, the stuff with neural arrays, you know, on top of that, I mean, the bandwidth

back and forth to the brain is not going to necessarily be through goggles on the eyes,

there's some deeper stuff going on, and I think that you're right, also, that's, you know,

consciousness, and how we experience things, and how an AI might experience things,

we don't render the same way that a computer does, I mean, we don't even see the world the

same way a camera does, I mean, we'd be, our eyes like move around, and we basically build an image by, you know, our eyeballs scanning very quickly, and then coming up with a, you know,

sort of a complete picture in our brains, and what our brains see, even with,

even if we see a light field, like, even if a light field is being, like, you know,

which is how you see convergence, and depth of field, and all that stuff in your eyeballs,

even if that goes into these receptors, and where our brains are trained to figure out what that means,

it's still, when we're seeing it inside our mind, it's still something that is, you know,

we have no idea if people see this blue the same way, you know, there's even tests where,

you know, they, you know, people didn't have a word for the color blue, and like certain continents,

you know, ever hundreds of years ago, and they don't see that color the same way we do,

don't see the sky and plants as being different shades of, different colors, they see it as

different shades of green, like, your brain gets trained, and because of that training,

it's to absolutely process the same physical cues very differently, and so what we're rendering in

our brains, even, even as visually, it may not be, you know, it may have identical sources from

the role, but it may, it may just feel different to different people, and maybe, you know,

segment, you know, should talk about object limitation, how we process it and analyze it,

kind of becomes different. What's interesting with an AI is that you don't have necessarily

those limitations, and you can, you can basically just keep rebuilding AI's, but think and look at

the world in different ways, and even a modicum, even if it's not, even if it's a philosophical

zombie and it's not true AI, the ability for it to process and do stuff and kind of act the way

that humans would with that information and just more with it is fascinating, and I think we're

going to get to the point where, you know, and Google stuff this year with, you know, those digital assistants that were on the phone that sounded real, like you're going to, you're going

to get to a simulated person in AI, but even one that they can make decisions that look human,

long before you get to the true, like, consciousness of the machine, which is still

something like we don't even fully understand our own consciousness perfectly, I think, you know,

and so it's just, you know, we're for some fascinating years ahead, but AI and rendering

are inextricably linked together because truly AI needs to render. If it's going to simulate

anything the way we do, it's still, the ability for it to do that is really powerful, and we can,

we can do it in a way that the human brain almost can't, like the human brain can't render

perfectly like a photograph does or a CGI render does, you know, with the precision that we have,

and therefore details and things that an AI could do visually or pick up on and stuff queues

that are there, which is what AI is already good at. It could be augmented in ways we can't even

begin to imagine, and that's why the next 10 or 15 years is so, it's just, it's just exciting,

you know, from an, you know, artist and creative perspective and philosophical perspective as well.

Awesome. This is going to be a lot of great food for thought for folks when we,

when they listen, they have a listen, so thank you very much.

Thank you so much. Always a pleasure.

Neural Lace Podcast Season 2 Episode 3

Optical imaging with Kyle E. Mathewson ~ The Neural Lace Podcast. Corona virus COVID-19 Special!

May 12, 2020

https://youtu.be/xEUrcnUu498

Audio Transcription by OpenAI's Whisper

All right. So here we are. This is a new way to do the Neuralase podcast. I'm here with Kyle Elliott Matheson and we're going to talk about a little bit about FNIRs, just a little bit, but the topic is about optical imaging. And so let's just dive right in. Kyle, do you want to share your computer? Well, usually I like to start with maybe a short introduction about yourself, just the example. Go ahead. Anything you want to talk about?

Yeah. Well, I'm doing it. Maybe you can enable screen sharing because I'm...

Oh, yeah, yeah. Hi, yeah. I'm an associate professor at the University of Alberta, up in Northern Canada. I got my PhD and did a postdoc at the University of Illinois.

In Champaign, Illinois, at the Beckman Institute for Advanced Science, where I learned how to record from human brains in a number of ways, including electrically, but also by shining light into the brain and measuring the resulting light coming out the other side. And I run a lab here at the University of Alberta called the Attention, Perception, and Performance Lab. And we study humans out in their natural habitat and how their brains give rise to the behaviors that we do every day.

And I guess I could probably share my screen now. Yeah, there we go. Awesome.

Okay. So, Annie, you'd imagine it's still recording this, too, probably, right?

I hope so. We can test this, but... Yeah, I think it would. Okay.

Okay, but you can see this that I'm sharing. Yes, I can see what you're sharing.

Okay. Do you have any other questions before I start?

No, go ahead and start, but would it be all right if I do talk?

Yeah, please. Let's have more of a conversation if we can.

Okay, go ahead. Oh, well, yeah. So there's many ways to try to measure the activity of the brain.

And one of the oldest, of course, is electricity. So you can measure the changes in electrical

potential that neurons create as they depolarize and hyperpolarize, either adjacent to them or

on them or in them or nearby. But it happens to be... And you can also measure changes in blood

flow in different ways, maybe with magnetic resonance imaging or with ultrasound.

And because it turns out that as neurons are active, they recruit blood to an area. So even

though it happens a couple of seconds after a neural activity, you can use localized blood

flow in the brain to estimate which areas were active in a given situation.

And how detailed can you get? Can you get down to the single neuron in terms of...

Right. So with fMRI, which is sticking someone in a big three and a half Tesla magnet

and measuring the... And adding a little bit of electrical energy to shake the protons out

of alignment and measuring how long it takes them to be realigned, you can kind of get down to the

millimeter or a couple millimeter level, which still has probably an each square or a cubic

millimeter of the brain is 10,000 or more neurons. So you're measuring the human brain at quite a

coarse scale using these techniques. Right. So is that the same for FNIRs? You're talking about fMRI.

Yeah. So with FNIRs, you'll see today, I guess, that at the limit, as we get more and more light

sources and detectors, you can approach that kind of resolution in noninvasively in a human.

Okay. That's interesting. So we're talking about like when a single neuron fires, it expands and...

Oh, sorry. Yeah. I don't mean you can't get down to the resolution of a neuron. You can get down to the resolution of about a square or cubic millimeter. So a group of 10,000 neurons.

Okay. So we're not yet at the single neuron stage with FNIRs.

Right. At least noninvasively. So you could try by exposing the cortex of an animal or a human in a

surgery. You could use some other techniques to do a little better. But the noninvasively or

something that could be imagined in the consumer realm were kind of at this level of groups of

neurons. So that being said, 10,000 neurons is a very small subset of like the 10 billion neurons

that there are. So these are localized groups that generally are doing the same thing.

Well, you're deep into this niche of optical imaging. And so I'm sure you've heard of all

the other optical imaging projects out there, the big names and stuff that brought the promise

to do a billion times improvement resolution and actually capture. Do you have like innate

skepticism about some of the promises of some of these more plot or headline grabbing?

Say that there's likely some physicists that understand the limits of some of these technologies.

And I wouldn't be surprised if they can be improved on further and especially with new

technologies and expanding on the current technologies. And so I'll talk a little bit about

like different types of light that you can shine into the head and what this new time of flight,

it's not new, but what the time of flight optical imaging that kernel is using,

how that differs from the techniques that I use in my lab or the F nears techniques that are more

common and consumer devices right now. Let's do that now. So yeah, like the,

well, let's at least go one slide further. So as I said, when neurons receive messages from

other neurons nearby, they receive those messages by neurotransmitter chemicals binding to the

synapses and channels or gates opening up and ions rushing into the post synaptic cell. And when those ions rush in, two things happen that we can measure with light. One we've already

mentioned is that the neuron uses energy to create some of those gradients over which those ions

flow. And so to recuperate from that use of energy, it needs to recruit more ingredients from the

blood glucose and oxygen to make more ATP to power the pumps and gates that let things in and out.

And so there's signaling cascades that happen when a local area is active that ultimately

lead astrocytes to open up blood vessels in an area and attract through kind of plumbing forces,

more blood to that part of the brain. And that blood absorbs light. And so at the very

course of scale, you could think of it like a little localized shadow. And so parts of your

brain that are more active are absorbing more light even from the lights in the room and the

sun around you. And then a little bit less light is coming back out your head. And then it turns

out something else interesting happens when those ions rush into the cell. Water flows in with them

because of osmosis and the membrane of the cell expands and gets stretched out. And it becomes

less wrinkly and it apparently becomes more transparent and therefore it interacts with

light differently. And so then in theory, you can use light to measure both of these things,

how much light is traveling through tissue and how fast the light travels through tissue.

So the basic idea, well, the first couple studies that were actually done were done

in exposed cortex of an animal. So you could actually just open up an image of the brain,

a little window into the brain and take images of that exposed cortex. And you could see it change

in color as people use that part of the brain more or less. And I believe there's even reports

from Wilder Penfield in Montreal in the 30s of observing change in redness of exposed cortex in the same way. So I wanted, I was interested to, there's this doctor who's been talking about

you've heard of the Medcram doctor, the guy on YouTube? No. He's been talking about, well,

so he's a surgeon and he's been treating patients with the coronavirus and he's been talking about

the end, how the coronavirus attacks the, it's sort of, it's sort of, it targets the ACE2

inhibitors, which are, there's a lot of them on the endothelium. And that is, that's causing

basically the damage to the endothelium and the von Neumann's factor is cause, is coming out and

that's creating blood clots and it's, it's causing vascular constriction because usually the ACE2

protectors through the angiotensin 2 and angiotensin 1,7 pathway would be inhibiting the vasoconstriction

actually doing vasodilation if you have, if you have more ACE2 compared to ACE. And so he's been

exploring this and one of the things I've been doing for coronavirus patients is saying, well,

hey, we are sending out the, we're actually recommending that people have an oxygen detector.

And so I was thinking, well, if someone was like a pioneering, you know,

neurohacker that they could build an oxygen detector from F-nears.

Um, yeah, let me grab mine right now.

Yeah, so this is a common technology at the hospital, a pulse oximeter.

And it uses the same technique in that maybe we can't even see it, it's hidden in here so well.

It has little light sources inside this cavity that shine through your finger and then it has

light detectors on the other end of here. So this is actually called transmission optical imaging.

So the light's transmitting through my tissue as opposed to going in and coming out,

which is diffusive optical imaging. But yes, so you can, if you have two wavelengths of light and you're shining them into anywhere into a human body and they are the right wavelengths

by knowing how much light you're shining in and measuring the amount of result light coming out,

you can estimate the oxygenation of the blood because hemoglobin has four spots for oxygen to

bind to it. And oxygen coming from your lungs is all four spots are taken and then your,

your body uses one or two of the oxygen. So you end up with three or two left on the hemoglobin.

And the oxygenated versus deoxygenated hemoglobin absorbs light differentially.

Let's see if I have that chart here. Yeah. So tissue with the all four oxygens in the hemoglobin

versus with just two or three has a different absorption spectra. So here's wavelength of

light and absorption. And if you zoom in right around 800 nanometer light near infrared light,

you see that there's this crossing over of the two absorption spectra. And so the basic technique

of near infrared or sorry of pulse oximetry or oximetry of human tissue is to use one wavelength

of light over here and one wavelength of light over here. I don't know if you can see my mouse.

Yeah, I can see your mouse. And to estimate how much of the light that you put in is absorbed

of those two wavelengths. And then you use an equation like this, which is called the

beer Lambert equation. Okay. And you have to,

you have to know these absorption coefficients. So there are some of the parameters of this

equation is the points of your light on this graph. And then what you get out is the change

in the oxygenated and deoxygenated blood. Okay. And really cool. So yeah, now there's work.

So in theory, then you can measure that over the whole head so that yes, as we get the coronavirus,

for instance, we might have more trouble getting oxygen into our bodies, but localized across the head, some regions of the brain are using more oxygen than others. And you can estimate those

changes over time. So would you be able to detect blood clots? Because that's one of the things with

the good. Um, no, no, keep asking. So one of the things they were saying with the, the Medcram

folks. So if you look, if you go on YouTube and just type in MED, C-R-A-M, the MD who presents

it, his name is Roger Schult. And his lectures are really worth watching for, like, what is the

best research I can find on the coronavirus right now. But he's, so one of the things he's saying is

that the, let's see if I can fast forward, maybe I can get the chart up for myself real quick.

But one of the, one of the things he's saying is that the, if I, well, let me just go by memory,

then, is, is that, um, the, oops, I lost my monitor. What happened? Oh, wow. Uh-oh. All the

monitors are resetting. There was a power, I guess there was a power outage in the building.

Nope, it's back. It's the power, as we call it, a brownout or something real quick. Let me see if

I can go and just say, okay, so what happened was he was saying that the, um, the, there's, there's, there's,

so going back to the, the ACE2 receptors are basically, um, you know, they have, they have.

Hey, now I can hear you. So apparently, like my whole electricity over here got reset, but

yeah, so. That was a great thing to happen in the middle of a podcast.

We're still recording somehow. Yeah, I think it's pretty, it's, um,

um, that was kind of the goal of Zoom was to make it robust. Yeah. Um, so, um, I don't, I don't

know how long was I gone for? I can just continue from, um, the last thing I heard you say was the

doctors, the leading doctor, and he had this proposal that. Oh yeah. So the, so, um, his name is Dr. Schult, um, Medcram, and he's saying that basically, um, what it comes down to is, um,

that if you do not have enough ACE2 receptors, then your body is going to produce too much, uh,

oxidation or superoxide. Um, and, and, um, I mean, another, another, uh, that's coupled with,

you know, you know, inflammation or hyper inflammation. Um, and, um, so one of the,

so one of the ideas was, well, I've looked, there, there are certain things you can get

which, um, claim to help reduce inflammation, like on the consumer side of things. You know,

there's, there's, there's a supplement called D ribose. Um, a lot of people try to say that,

um, you know, what is, what is this, these, uh, magnesium salts, uh, that, that you soak your

feet in that reduces your inflammation and reduces your, um, so if you could take, you know, people

say, well take your vitamin C and your vitamin D and your vitamin E and that will help your body

to reduce its inflammation. And some people, you know, there's, there's obviously, um, there's ARBs

or, um, you know, there's statins, there's, there's different drugs that are meant for people who

have heart attacks or strokes that reduce inflammation and reduce, um, they actually, um, increase the

amount of, of, uh, of ACE2 receptor action. This is outlined in the, in the recent MedCram talks

that he does it, he does a better outline, much better outline than I'm, than I'm doing. But the

idea was, is if, um, if somehow, you know, D ribose as a fundamental building block of cells is

actually, you know, it helps, it, it helps your cells to reduce more ATP. If you have this, this,

there, the same, the same idea was with the, um, you know, taking the vitamin B12, uh, supplement,

which help your body make more D ribose, which would help your body make more ATP. And so there was this whole energy drink sort of, uh, craze where people were taking high doses of vitamin B12.

And, um, so the idea is that if any of these supplements are causing a, um, an effect where

they're reducing your inflammation, uh, there's, I mean, there's a point that you could measure,

or I'm going, I'm coming back to, you know, AFNIR is an optical imaging. Uh, there's a point where

you could measure, um, I guess you were saying that if someone is having a blood clot that is going to

create a different sort of signal that you're going to pick up on. Um, but if someone is receiving

a treatment of say D ribose and it's reducing their oxidation and it's allowing their, um,

whatever their blood is able to transport in terms of, because your blood, the purpose of your blood

bringing oxygen is so that you can make ATP, correct? And if, if you're not able to get oxygen

because your, um, you know, because your ACE2 receptors have been whacked out, but you're

receiving D ribose, uh, and you're able to make ATP through other pathways than the dependence on

oxygen. But what I'm curious is that, is that at some point in this chain, would we be able to

measure someone getting their, their ATP from, uh, an injection of D ribose or it's not a, you know.

Yeah. So there's two, two cool things. One is, um, that you could measure, well, you could imagine

that we're like in the hospital, they're measuring these effects systemically throughout the whole

body, but then some of the effects might be more localized to one brain region or another.

And so having kind of like distributed sensors around the body might change things. Um,

I like your idea though about measuring kind of effects of treatment. There's one cool thing you can do, um, recently shown with optical imaging is you can measure, you can estimate the pulse wave

velocity. So how fast the pulses of blood are moving through the body. And that is an estimate of

your vascular elasticity or how kind of hardened your arteries are. And it turns out you can measure

that across the head. So you can measure in localized regions of someone's head as some of their

vasculature, um, more healthy than others. And so that's one maybe kind of thing that could change

with some of these treatments is that your vascular system is working more effectively.

But there's a really cool, um, kind of rabbit hole that you reminded me of. And that's that, um,

have you ever seen some of these therapies? Maybe if you hurt your knee, were they shining near

infrared light into your knee? Um, no. Well, it's, um, maybe I can just use the internet instead

of my slides. Yeah, totally. Let's try like a near infrared therapy because there's pretty funny

helmets and stuff. Yeah. So this, um, you could get like a belt or something to wear around your

waist or put on your knee. And the one idea would be that the heat helps your body. But it turns

out that there is, um, in the pathway that creates ATP, there is the, um, there's the CREB cycle.

And then there's another four stage process that's name is escaping me right now.

Um, the electron transport chain. And one of the steps of that electron transport chain is,

um, uses a molecule cytochromoxidase. And it actually absorbs, I think it's,

that it, there, something about that step, the near infrared light can make it work more

effectively. So in theory, near infrared light can boost the production of ATP locally in the

brain area or in a body area. Huh. And so not, I think there's also, um, helmets that you can get

that do this kind of thing. Yeah, this lady. Hey, so you can, you're, this guy is treating

Parkinson's disease with a bucket that's full of near infrared lights, which doesn't look like a real product in Silicon Valley right now. But I'm sure there's some that are being made like that one or this one. Um, and it's the same idea that you could boost the vascular activity, you could boost the production of energy for the same input molecules. And so maybe your idea that maybe if your oxygen input to the body is diminished, maybe you could acutely improve the activity of those people's body so that it's making use of, um, less oxygen to do what it needs to do. That's kind of cool. Um, I know I think I just closed my slides, but yeah, so I think that that, and that's really cool for me. And we've been testing a couple of things with this. So we, we've been testing if you could locally enhance one side of the head and not the other. So you shine near infrared light in one hemisphere and not the other hemisphere. And can you look for changes in cognition that might result from that? All right. Okay, where were we?

Why are we shining this light in and how are we shining it? So this is a gentleman named Britton Chance, who was the first to use near infrared, to use kind of non-invasive optical imaging in humans here on himself, had a single light source and a single detector. And he was measuring the amount of light that goes through this path between the source and the detector. And, um, when you use two wavelengths of light, as I mentioned, you can estimate the oxygenation of the tissue underneath. And then to kind of test the technique, some studies were done to look for known distributions in the brain, what you would expect to happen, say if you illuminate the whole right side of visual space, you'd expect there to be activity in the left visual hemisphere. And so you see that in this kind of test of that technique. So you see this boost of activity in the left visual cortex when you stimulate the right visual field and vice versa. So you can use it as a way to map brain activity, which it's been used for a while.

And this is pretty old. So this is maybe 10 or 12 years old, some miniaturizations of the technology.

And you can tell how recently I put together some of these slides, because in that time,

since there's technologies like this on the horizon that are built into the glasses,

this is a company in Toronto that's just in the up and coming stages and is trying to put some

of these techniques into eyewear. Yeah, I've got one of those devices here in my office.

Yeah, not the glasses, just the near infrared part. I got one of the developer kits.

Right. And? It's cool. It works with my phone, and I'm working on developing a WebXR

biofeedback application with it. Nice. How do you affix it to your head? Or you put it under

your hat? It comes with a headband, and then you put it right on your temple. It's where they

recommend you put it. And yeah, I mean, obviously, you don't want hair in the way, but I mean...

Yeah, hair is an issue. And that's an issue. If you look at the kernel

Hello Humanity post, the kind of the first thing I looked at was the thing I think of the most is

like the interface between the human and the machine. And it looks like this is what they're

imagining. These are little kind of plastic fiber optics at the end of an optode. Looks

like a detector and six sources that are about two, one centimeter away from each other. And I'd

say that, yeah, this is how we'll have an issue getting in and around hair. So maybe they're

imagining it will be on a part of the body with less hair. Or they'll just, you know, ask their

participants to shave their heads or something like that. I'll show you some examples of that too,

if we have time. Yeah, we've got time. While you're doing that, I'm going to look to see if I can

find my F-nails. Cool. So the basic idea of kind of delivering light into a tissue and measuring the light coming out, you could imagine how these miniaturized electronics could do that job. You

have small LED sources and you have kind of miniaturized sensors that you could embed or kind

of attach to circuitry and power quite easily. So this is one of the original developer kits

that actually became those glasses. And so you can see that it just attaches to be a headband.

Yeah. And then you, I guess you put it on backwards like this and then it just sits on your

temple right there. So that's great. And does it give you heart rate as well?

I believe it does. It's been a while since I've plugged it in, but I don't remember

I don't remember seeing heart rate, but it does give you,

it says right there in the dialogue gives you heart rate. Let me have to check the latest

application. Yeah, well maybe the heart rate's a good example of how the technique's working,

because it was something that took me maybe a year to think about when we talk about blood

arriving at the brain, when you use a particular brain area, what we actually mean is pulses

of blood every time the heart beats. And it's in those pulses that a little more blood comes

to an area, but it's not like the tide rising in an area, it's that bigger waves of blood arrive

at that area. And so the inherently in the signal that you get from light over time that goes

through our tissue, there's always a heartbeat embedded in it, because every single time our

heart beats it absorbs a little bit more light, that tissue. What I do like about these devices

is that they talk to your phone, I've got an Android phone here to talk to it, and

it outputs from your phone, it outputs as a, what is it called, a web socket. So that's good.

The VR application that I helped develop in 2018 at Noisebridge, we brought EEG into WebVR,

we used a brain EEG device, and what happened was we created a local server, we used Python, and later we upgraded it to a server that we created in Go that had some extra features,

we added the four-year transform, and what we did was we created a web socket, and we sent the data

out via the web socket, and then we brought it into the web page with a web socket. And at that

point we could just use our JavaScript and our 3JS and our A-frame and our WebXR to take the

incoming stream of numbers divided up into our delta beta, our right channel betas, left channel

betas, the whole EEG spectrum, and we could define what our alpha was exactly, which was nice,

but then we could, at the point that it's in the web page, you can say, well, I want these

objects, these planes, or these spheres, or these squares, or these cubes, to go up and down,

and the height is based upon the incoming number that's being received at one interval of time,

and so the blocks go up and down, and we had them in an array, I have a video of this,

we had them in an array so that they would go up and down in a time series, one for each of the

four year transform channels, and then they would change colors they went up and down too.

So you can add any sort of JavaScript animation at that point, because you're just making the

numbers more reflective, but that's a far cry from making this basically, that's a kind of

biofeedback application, and if you can get the noise out as much as possible and have a real

signal there, then people might find that to be useful, but when you're in VR, you move around

so much, and so I thought, well, the next biofeedback application, maybe we'll get a better

signal to noise ratio with this F-narratives versus the EEG, but then I'm listening to,

I was organizing the Neurotek SF for two years, and I'm so glad that my friend Morgan,

the amazing neuroscientist, Morgan Huff, is not doing that organization because it's a lot of work, but when I saw, you're talking about doing optical imaging, medical imaging with F-narratives,

that's a different kind of computer program, that we get the signal, and instead of just

applying JavaScript variables to each incoming number, how would I create a program that actually

begins to maybe map out an image, and I don't know how to describe that 3D image,

is it like photogrammetry, is it like an object file, is it like a community?

Yeah, because that's what kind of drew me to this optical imaging, that I had already been

recording the electrical activity of the brain, and the skull smears the electrical activity,

so a good analogy, I think that one of your last guests gave maybe was that it's like recording,

or it was you that gave the recording on the outside of a sports stadium trying to figure out

what's going on inside the stadium, and so that's like what EEG is, and so the idea that instead

you could get at least a fuzzy image of what's going on actually inside the brain is appealing,

and especially from like a feedback perspective as well, that it gives people not just like a

state over time, but kind of an object to imagine. One thing you could try, I guess,

with the blueberry as an easy first pass would be to allow people to visualize their heart beating.

Okay. Maybe with the kind of how dark their setting is or something, because that's a

really strong signal as you'll see probably in this slides of from the head when you shine light

into it. I mean there's so there's this with EEG, you probably you know a ton about EEG

because you were doing that first, right? So you know about all about source localization and that's

something that I've heard Morgan talk a lot about. One of my questions to Morgan was why can't we

you know use you use basically you know if you have a cap to 256 electrodes on it and you're

doing source localization so that you know you know basically you can predict where that brainwave may have come from within the 3d volume of the human brain. Then you know what's what's

why can't you at that point build like you know sort of like accurate 3d models of brain activity?

You can do okay, but I think that the problem is ill constrained. There's not enough data

from the outside of the head to differentiate from two or many possible sources of activity inside

but the best people in the area now are making really which is the same thing we do for optical

imaging is they're using the subject specific anatomy from an MRI scan and they're delineating

different structures in that object and how those different structures would transmit electrical

signal and so they're using like really complicated models of the electrical conduction of the head

to try to estimate sources and it takes two different modalities it takes the structural MRI and the EEG.

So have you been have you been because I've also been talking to Morgan a lot about

doing the structural imaging with electrical impedance tomography it's something that he's

excited about he mentioned it is is helping to solve the skull problem or the I guess the

the way I think of that is like the how you know a different different people have different

skull shapes and the way that the ions travel through the different parts of the skull is going

to be you know different from patient to patient it's also going to be different if the patient's

lying down because their brain sits in the skull differently and so go ahead on the topic of EIT

if you want and other options for yeah I haven't looked in too much to this EIT thing that I hear

that Morgan is excited about I had there was one thing I remembered of using kind of light near

infrared light to get a rough estimate of the structure of the brain as well because of different

absorption or scattering properties in different areas um yeah I guess the electrical activity you can measure from the brain the advantage of it is that it's almost instantaneous in time

you're measuring things as they happen because of the speed with which the electricity conducts

so at least for my research we try to design experiments that are answering like a when

question instead of a where question because the that's what the modality is best suited to answer

like how much earlier did it happen in this condition than that condition um and that but

I think that um optical imaging can allow you to kind of merge those questions if you also want

more ideas about where in the brain some signals are coming from because it does have better spatial

resolution all right let's keep going on optical imaging because that was sort of like that oh

yeah whatever we can but the um I guess I was here and we were talking about how simple it is now

and why there's a bunch of companies moving into the space because if all you have to do is shine

a light or a laser into tissue and measure the light coming out then you know I could take my

camera from my phone here the flashlight from my phone and turn it on and I could put it up

to the webcam here and if I just then recorded my webcam over time or your viewers can pull this video

and they can pull my heartbeat from how red my finger is over time interesting and so you could

put that on your ear in your head um and so it's any continuous illumination and any

light detector and so that's why um blueberry is able to do what they're doing here and we were

even thinking of making kind of um epidermal electronics that adhere directly to the skin

because the the technology's advanced that you can make tiny little flexible leds and tiny

little flexible photo detectors uh in these kind of circuits so we are testing out some things like this um and so I think that the I think one of the limitations and I I think that the companies

in the space know is the rigid form of consumer electronics we're moving farther and farther

away from rigid electronics um but nonetheless there's always a circuit board or um plastic

um involved that usually make things um not adhere perfectly to the skin so one of the areas where

I collaborate with people in material sciences and kind of imagining what the next form factors of

these interfaces between our body and electronics are going to look like I wonder if you could if

you could measure specifically vascular dilation or a single vein or map or a map or a map of

blood veins yeah there are so here's an example I've seen some other evidence that was like this

so this is like we put four of these lights on a forehead let me see if I have a picture yeah so

we stuck four of these on a forehead and then using a camera from a phone sorry my slides are kind of

going haywire um using a camera from a phone we just take the frames of that video and pull out

the average value of red or green in the frames and just from the frames of that video you can get

these um heart rate out just as I showed you with that little demonstration on my finger

but usually and you can see in some images online you can see shadows and bright spots from veins

as well in the hospital they have um what is it there's yeah there is this technology that nurses

use to find veins when you said phone you you provoked an interesting thought for me because

one of the the basically I was watching a lot of a lot of videos about the open water

technology that Mary Lou Jepsen is working on and and I came to the conclusion that that she's

that it seems like the major contribution being promised is a new CMOS chip or new a new phone imaging chip where so it's kind of like you brought up well if you just use a phone you

could do some basic you know you know medical imaging but if you had a really good camera chip

like better than the best camera chips available yeah with that yeah let me um we're getting close

to that you're right because it's gonna be we're gonna move past just measuring how much light

and we're gonna start talking about how fast the light moves through the tissue and then better

cameras are gonna be good because you could measure with at a higher frame rate

so yeah let me so yeah we were you're right trying to also see like how high of a resolution of

camera can we use to try to reconstruct underlying tissue we were thinking about um brass tumors

or tumors as well and maybe your idea about blood clots is related to that that if you're now moving

almost to non-contact physiology sensing if you can shine lights in from across a room and have

cameras nearby it's not far off from having kind of like a wireless imaging thing that shines lasers

at your face and measures a couple things about your physiology and I um there's non-contact

temperature sensing already happening all over the world today and there's for sure non-contact

heart rate sensing as well and you've probably seen some demonstrations from Chinese CCTV of

them doing that out on the street I've seen a picture of a policeman with one built into his helmet

because all you would need to do is pull out the color of someone's face over time

and and then pull out the heart rate from that and then estimate the frequency of that rhythm

nice and if you had a good enough camera maybe you could get to the point where you're doing

you know holography uh you know high frame rate cut in different uh of different color changes yes and if you even if the the source of light is non-apparent to the person across the room

maybe you have like an infrared source of light that's coming out of your helmet and just like

my neighbors security cameras have or our security cameras have the um then you don't need to have

anything attached to the participant and you might be able to estimate some local changes in their

blood oxygenation in different parts of their body and and then perhaps you could detect if if

they're suffering from vasoconstriction and estimate their chances of having the coronavirus

remotely yes that yeah that I think the idea of doing heart rate is to do that but you're right

that um yeah maybe you can put this blood oxygenation let's check mine right now um

seems to be something that before negative symptoms are occurring that there's changes

in blood oxygenation so I have a 98 blood oxygenation right now you did that with your

afner's device yeah this little finger finger one oh yeah okay um so I think there's a big promise

and you can see there's people in the space like blueberry of using continuous light to measure

from human physiology whether it's brains or we already have it in our watches

um so on the back of many of your watches there's going to be a little light source

and a detector that shines through your wrist and measures your heart rate not far off from

measuring your um blood oxygenation as well and it should probably also be able soon to

measure your blood pressure that's apparently a holy grail in these wearable wrist devices as

blood pressure monitoring yeah well I mean if you can if you can detect vasoconstriction

or vasodilation that's the same yep exactly so I think that the probably what's stopping apple

right now is just a database of of known blood pressure values that they can use to train some models that sounds like just um some lab work it doesn't sound like it yeah just waiting for enough

people to fill in the survey on their phones or something yeah so um I yeah so even in this we

were able to measure changes in people's cognitive effort or at least what looked like changes in

cognitive effort when they're doing math versus just calm and meditating there's less light coming

through their head to our phone and so you could imagine maybe even being able to estimate that

regionally across the forehead and it's hard to know even what product to develop is if you can

do that without with just a phone from across the room with the laser um but maybe something at

airports or shopping malls um so as I mentioned there's another change in the tissue that happens

when neurons become active and that's that the group of neurons swell up with fluid and become

more transparent to light and so you have a group of neurons that's sitting there and they're not

relatively very active and then they become hyperpolarized and they fire a lot of action

potentials and throughout this time uh water's rushing into their membranes and swelling them

up like grapes and so the photons of light which in this diagram are not oscillating but it could

imagine that they're they're vibrating through the air here go into the tissue and they bounce

randomly off things and scatter through this tissue so our brain is like um the same scattering

coefficient as skim milk so it's like very cloudy that's why I can't see your brain this part this

part in your presentation has really caught caught my eye the the last time I saw it was

was that this is it seems like if you had a CMOS sensor powerful enough to to this is how you

would detect you know that a neuron had fired because with with this type of tech with with light is it's not you're not measuring the action potential you're measuring the the the in in rush

of of water and and what there was a calcium ions yeah so it's um it's you're measuring the change

in the transparency of the membrane that's because of the inrush of water and the filling up of the

interior space of the cell and you're right that as you see an action potential in that cell you can

see a change in the transparency of the the membrane either in a single cell um or this is the axon

of a squid or in like a slice of hippocampus in a dish so these are classic papers you can see from

the the previous millennium um showing changes coincident in time with the electrical activity

uh that you can measure with light and so the basic engineering problem is that you need to

measure how fast it takes are you basically you need to measure how much further on average the

light goes into the tissue or you can measure um how long it takes to get back to a detector because

it travels at the same speed so if it goes a little bit of an extra distance then it's going to take

a little bit of an extra time to get back to that detector so the very simplest thing of course you

could do is like put in a single photon and then measure at the detector for that photon and pick

up the photon and then time it and it's going to take some crazy fast amount of time because it goes

three or four or five centimeters through the tissue and it travels at whatever it is 300,000

kilometers an hour and what you find is in tissue that's active versus inactive there's a delay in

active tissue of like uh three or four trillions of a second in the time it takes light to get

through that tissue so that's the engineering problem is how do you measure changes in the speed of light that are at the order of trillions of a second and the other problem from like a data

perspective is is that signal big enough compared to the noise that you would get in that system that

you build that it's meaningful for your your goals okay fair enough so I've shown one way that people

have done this or I talked about briefly but here's an example of it this is called intrinsic optical

imaging and it's done in animal models where you open up a window into the brain and you measure with

a very high frame rate camera changes in the light that come from an illumination source into the

brain and then kind of bounce off the surface and back to your camera and the the really cool images

that that you come out of this research showing for instance on this top right these are alternating

columns of the cortex that respond to the left and the right eye and so you cover one eye and you

show the animal something cover the other eye and show something and then you just subtract two pictures

of their brain and this is the picture you get in that subtraction so it's a little darker in some

stripes and a little lighter and other straight okay that's from the blood flow but you can also measure

those changes in the time in the time sorry you can measure changes in scattering as well with these

techniques of changes in the transparency of the tissue and there's work also kind of looking at

whisker specific stimulation so you can see really specific changes in transparency of tissue when

you tickle a one whisker versus another whisker versus another whisker mouse that are coincident in time with changes in electrical activity in that same part of the mouse's somatosensory cortex

so if you need to measure um how fast the light's moving through tissue there's two ways you can do it

so we've already talked back here about what we call continuous wave continuous optical imaging so

you have a continuous source of light that isn't going up and down in intensity you shine it in and

you shine it in and just measure how much comes out the other side but if you want to measure how

fast light moves through tissue you can do two things you can use a time of flight device okay

which is what they're talking about at kernel which means that you put in a pulse of photons

and you wait at the detector and you measure at the detector how long but you don't just measure

how long you measure the entire distribution of photons as they arrive at that detector so because

you shine in like 10 or 1000 or a million photons and a little fraction of a second you get a

distribution of activation at the detector and do you think that they're using a lot of a lot of

these distributions of active activations from different detectors to sort of you know combine

all this into a 3d spatial tomography yeah so that's what they're alluding to and and that makes sense

because um let's go back to this picture here I think that's a good one so um their idea the idea

of these time of flight techniques is that instead of just measuring the average time that it takes

a photon so the mean of the distribution of the time of photons okay if you're shining a million

photons from here some of them bounce off and go off into space some of them go deep into the brain

and get absorbed as heat um some of them take the path of least resistance the shortest path right and some end up taking the longest path and so the time that it takes a photon to get the detector

really like a tag of how deep that photon went into the tissue okay and so with the technique that I use

in my lab we don't get that measure we're just measuring the mean of the distribution so we

end up knowing like on average this is how long it took a photon to get from here to here and so

we can only assign the measurements that we get at our detector we can assign them to this whole

space and maybe we might assign them weighted by probability so like we know that they're most

likely to have gone through here and less likely to have gone down here um but what they can do

with a time of flight technique I hope you can start to see now is they can have kind of really

fast channels that go through the surface cortex so maybe the first quarter of the distribution

and they can estimate the median of that time and then they can have these really long

photons and they can assign the signal that they measure maybe that's intensity or the speed at

which those photons got through the tissue they can assign to different sections of the depth of

the brain so they have to they have to improve the kinds of receivers light receivers that they

have in order to do time of flight on each different portion of the receiver is that what's

what's happening or yeah so I forget I know that this is um

it's the it comes down to the receiver camera like what is the resolution

of the camera in your receiver that's going to enable you to do really precise time of flight

and other good yeah so this is what is going to be expensive and this is going to be the hard part

and it's what like so the system that we get in my lab um does a different engineering trick to measure the speed and it's maybe a half a million or a quarter million system um at the scale that

that company would want to produce it um and the current available techniques I think of doing time

of flight measurements are also quite expensive so because you would need to be sampling at a very

high resolution so I think there was some really cool videos high resolution and a high frame rate

I mean that's right that's it's like one of those cameras it's like we're we're it's not just uh

it's not just um an eight megapixel uh camera it does you know like every frame is as good as a

photograph oh yeah so the um no I don't think so because actually these the detectors in these

systems are single pixels so they're they would usually be a single part of the head that transmits

with an optical fiber to a single detector and pulls all the light from that detector so I think

they have zero they have resolution in space of one okay and then they they spend all their

energy trying to record really quickly um but you're right that they're those demonstrations

from MIT which I think we're showing trillions of a second camera um watching light there's

like a video of yeah here it is so this is a video of someone introducing an experiment um

come on show us the real thing yeah here so they're recording frames of this video

at resolutions of the trillions of a second so they're able to slow it down and observe

the photons of light moving through this bottle wow when I showed you um our iPhone experiment

where we record light going into someone's head and record how much comes out if you wanted to

measure the time of flight like the scattering of the tissue you would need a camera like this that can measure at that very very high frame rate okay so that's probably one of the advances

in these time of flight systems is that they have very fancy cameras

nice what else do you have in in your uh in your deck what other things you

are you talking about let me let me show you what we do with what our system does so our system

instead of um shooting a pulse of lasers it is a frequency domain system so it's kind of the middle

ground and in cost and the middle ground and in benefit so what it does is it modulates

the light going into the head at a megahertz frequency so it's going up and down in intensity

as it goes into the head at say 110 megahertz and that same frequency that's modulating the

light is driving a photo detector and the photo detector therefore is kind of expecting light

at that frequency but you also add in a slight different frequency called a heterodyne frequency

which is in the kilohertz range okay and then your photo detector can measure at kind of a

relatively shorter um interval measure the signal and it can pull out this oscillation

caused by the difference between the detectors and the light sources modulation frequency

and if you have multiple um if you have a helmet of ethners then you're going to have to

oscillate between the different transmissions and receivers so you're not

ruining it ruining the image of go ahead right yeah so um

any detector can only know light it doesn't know where the light's coming from or what frequency

it is so you have to kind of like turn each light on like Christmas lights or tag them in a certain

way such that the detector can separate okay and um yeah so oh so just to show you this these

frequency domain and the time of flight domain techniques they can measure slow changes in

blood and tissue but they can also measure these faster changes that happen at fractions of a second in the scattering of tissue okay um let me move ahead a little bit here the

the right so the out the signal that gets measured is um you end up with an oscillation

because you're measuring the the frequency that the light was modulated at and therefore you can

measure the how how big that oscillation is and that's this estimate of intensity or how

much light went through the tissue but you can also measure the shift in phase of the oscillation

and that's what we use to estimate scattering because um the photons went into the tissue

at one phase of the oscillation and when they come out nearby they're at a little bit later phase

and the ones that came through more active tissue will come at a little slightly bit later phase

which translates to these trillions of a second delay in the photons moving through the tissue

so we can then use that to make these kind of maps like this of neural activity over time

and there's a bunch of boring kind of preprocessing that i've been working on this week of

pulling out heartbeats from the signals and filtering them in all sorts of ways

and then also averaging repeated presentations and stimuli to get rid of some of the inherent

noise in these signals the other thing you alluded to was mapping of different spatial areas

yep and this is where the consumer electronics are also going to probably start small and scale up

towards these kind of research grade um techniques where you can record from 30 or 60

light sources that are shined into the brain and maybe 20 or 30 detectors is the biggest

systems out there right now and so you end up with like 800 or 1000 different paths of light

between sources and detectors and if all the sources come on at once then all the detectors

get flooded with light you get a big image of the brain and you have no idea where anything's

coming from so you end up kind of like Christmas lights turning different parts of the head on different times or modulating light at different frequencies that the detectors can separate after

so are they're showing yellow and red to indicate the approximate distance between you know turning

lights on from some sensors transmitters to others because there's a certain range that it's

you know you you put it in and so that means you could turn on you know looks like a good

section of the brain that as long as the sensors are spaced out far enough yeah so the um when

light goes into the brain because of how the brain's like milk right if you shine your flashlight

into a jug of milk um you'll only see like a bright spot maybe three or four centimeters away from

that light source because the scattering just just like a foggy day it makes all these photons

dissipate randomly in all directions and so um any light you shine in only goes about um

I guess it's like six centimeters to detectors about six centimeters away at the furthest

and so you if you shine a light on the left side and you have a detector there and you also have a

detector over here only that one nearby will measure any recognizable photons from that source

so that helps also to measure more areas more quickly is that you can separate out

um but you can have four lights come on at once on different sides of the head

so I one of the things I've been looking for on the side here while listening to you was it was a

question I asked a neuroscientist a while back and she never got back to me with the answer but

what I asked was um regarding chemo dynamism in the brain can you is sodium ion movement in

neurons attracting blood flow that was my question but I think you kind of answered that a little bit

yeah so the they're kind of two two echoes of yeah I wouldn't say so sodium transport is a mechanism

mechanism the brain uses to communicate and the when sodium gets transported it's because usually

a channel opens up through which sodium can pass across an energy gradient that was built up

and once it passes through that gradient now energy needs to be used by the cell to pump it back out

to recreate that gradient because in like 100 milliseconds it needs to do it all over again

and um in order to run those pumps you need ATP and in order to get ATP you need oxygen

yeah delivered from the blood and the other thing was sweat yeah and that one's a really

really weird and it's more recent that they discovered that like um when the neuron starts

to pull glucose and oxygen to replenish its ATP it through astrocytes it signals to the local

capillaries in the blood vessels to like let up a little bit and they they get bigger and they allow

more blood to flow to that area so it's like a pump then it's it expands and that and that sucks

in the blood is that yeah yeah okay yeah so it's not like a vacuum that's like pulling in blood

that the astrocyte makes but it just like your garden hose it lacks a little more area in that

space and that allows more blood to flow to that area okay um yeah no because I was wondering if

there was some sort of if the you know I don't fully understand how the electron electron

transport uh works but I was wondering if there's something else that was moving the blood around

in the brain if it's just you know an area opens up oh I see yeah no it is pretty passive that was

something I remember learning as well that it's not um yeah it's not like an active process

but it's passive change in the plumbing that that allows more blood to flow to one area versus another

okay um oh so here you can see we also would use structural images of the people um or some atlas to try to recreate exactly which brain areas the light traveled through

and well one of that I'm sorry to interrupt you it started going off in a tangent so one of the

ideas that that people a lot of different people are talking about and I like to talk about this

is the idea that that your your your dendrites can uniquely your dendrites are little computers

and they can uniquely store you know uh memory information perhaps in the way they store ions

and the they they they might look it a dendrite might look like a a tree and it's in its branch

like structure and and it might it might have little hairs on these branches that that store

ions and different arrangements and and that might uh that might have enough sophistication to

to store unique memory patterns and and then those would be represented in in how you're

in sort of like the configuration of how your cell is holding uh how your nerve cell is holding um

an electron charge of some some gradient of some of some meaning that's not decoded but

but maybe that's where part of the memory is at and right and that's um it's kind of in between

the way we were thinking about how memory might be stored by like real connections between this

neuron and that neuron it's a little more fragile than that and then it's kind of the arrangement

of the trees of the of the dendrites yeah um yeah that's that it is is interesting the

the one good thing to think about is the the signal I'm just going back to this fun picture

of the swelling up cell um this is showing the cell body swelling up but in theory the around

the cell body is a huge dendritic tree here maybe this is an intern neuron but if this

was a pyramidal so there would be this huge arborization of of membrane that's the dendrites

and there's much more surface area in those dendrites than there is in the cell body

so I show these all as the cell body giving rise to the signal but it's really the dendritic tree that would change its scattering properties and would be measured by this kind of technique

for whatever it's worth interesting yeah um

there must be some more cool stuff here yeah you can see that these contraptions in the lab

are pretty homemade still and they're still kind of honing in on the right form factors

of helmet to hold the sensors against the head they're uncomfortable because they use glass fibers

um to transmit the light effectively um and they're they need to be held against the head

so that the photons going in uh don't bounce across the surface of the skin uh hair is an

important consideration and that's another reason to use glass fibers because they can

kind of go in and around the hair um but you can see that um for this to become kind of a

product one might have in their house there these fibers are going to need to get kind of hidden

behind some contraptions or eliminated altogether um and so some of the head gear development

looks like this that we're using this kind of stuff in the lab now which is a flexible

kind of craft material in two layers that um is strung together with elastics so it's rigid

against the head but still kind of conform to different people's heads right yeah i remember

we saw i believe in and there's there's yeah there's a lot of new technology coming out in terms of

head gear so that's uh that's one of them yeah yeah the and and um there's really cool new stuff

of 3d printing specific shapes for people's heads and building the electronics or the optics into

those and i think that's where we're gonna head in the lab because then you can get really good

estimation of where you are with respect to their head nice um this is a boring story that took me

a year or two of my phd but in order to turn in those lights yeah maybe this is relevant but the

if you have four different lights coming on on different parts of the head and you don't want detectors to confuse them you need to have them come on far apart from one another such that

no detector gets light from two of them yeah and this is a problem that you can get at computers

to solve and um that works okay so you can kind of assign sources and detectors in certain

arrangements so that you don't get crosstalked between them and the final step which is kind

of what you alluded to i guess is uh one of the one of the exciting things about optical imaging

is that you could in theory recreate an image out of it and so instead of just getting a signal over

time from a part of the head you could in theory recreate the depth of different layers of brain

activity or different areas with different sensors nearby one another yeah you can get better and

better spatial resolution because the path of light from each of these source detector pairs

are non-overlapping so every source detector pair has a slightly different part of the brain than

it goes through and the more sources and detectors that you have in an area the smaller and smaller

intersections of them you'll get and you can estimate better and better localized signal

in those tinier and tinier areas

um and so this there's a couple techniques you can use you can kind of estimate on average

what the path that the light takes through the tissue is just assume it's like a banana

between the source and the detector and then assign the data to any brain area in that banana

um but then the more complicated techniques would involve kind of modeling the dynamics of photons

through tissue of estimating the optical properties of the skin and the scalp and the

pia and the cerebral spinal fluid and also um kind of estimating the differential time that

photons that travel deep versus superficially would take and this is where these new techniques

that kernel is proposing to be developing will be really beneficial because instead of just this green medium you could have a gradient in that space and the fast photons would be assigned to the

higher more superficial areas and the slow photons to the deeper areas so do you have to

complete all of this scanning because it sounds like a lot of extra work you got to scan a little

bit here and a little bit here and a little bit here and you have to complete all of this

within a short time window because those your your lymph lymph nodes and your blood vessels

and all your you know your brain is everything moves around right so you have to I would guess

there's a time limit what do you mean you're like uh you mean over the course of an hour the tissue

is going to move around oh I see like when you get the structural scan versus when you try to recreate

what's there yeah yeah that's funny because I have a an MRI of myself from 10 years ago that we were

I was just gonna use that for now but you're right that surely my brain has deteriorated

or grown or grown yeah in some places and and not always the um yeah that's really important

those are different parts of our university they're like totally different buildings

that you go get the structural scan um so there's actually one process where you take like a 3d

representation of where all the sources and detectors were in space on a head and you take a

3d object of a head and you co-register them together on top of one another because you

collected them at different times and so you use fiducial landmarks on the nose and the ears that

you can identify in both 3d models to co-localize them and then you use like the shape of the scalp

to try to fit the shape of those sensors so that you minimize some error so the output of the

sensors so what are you are you getting like a point cloud are you you're estimating the depth of the points is it i'm just trying to picture the 3d data does it look like what we're looking at

in terms of yeah so that both of the two 3d datas are in this plot one of them is the point cloud

of red and orange and yellow dots and the other one is the gray scale 3d surface and so you have

a point cloud with three landmarks which are shown i think they're in green on the ears and you have

a oh yeah and there's a landmark on the nasium on the nose here too and you also have the structural

image and in that structural image you can identify the nasium and those two points here so

so yeah you have a point cloud and a 3d surface and you need to overlay them but the day so the

data you're getting from the sensors is that green data right not even know that there's actually no

data in this image the green is the um the estimated path that the light took when it got to the

dot to the detector and then you kind of go through is there a good example of that sure maybe here so

the data you get is just numbers over time it looks like e g data or or weather or stock market data

because anyone detector just measures how much the phase of light was delayed over the whole

course of the experiment every four milliseconds or 20 milliseconds so at this at this point you've

got depth data but you're not producing a 3d model you just have a bunch of 2d models yeah so for the

most part the the depth reconstruction is the least developed aspect of these technologies okay and

for the most part we would then project our data up to the surface because as you can see

the the techniques can't image that deep into the brain they can only measure in kind of the surface area of the cortex anyway so projecting it up to the surface doesn't isn't that um have you

heard of of the some open water theory where you could use it ultrasound to extend the length of

your imaging is i might be wrong what do you mean well they so what i heard and maybe i maybe i

misunderstood maybe i misunderstood was that they were able to to extend the the the reach of their

imaging by by um shining the light through an ultrasound frequency um cool and they're able

to get twice as much depth there i i'm sure it's a video that that's was public maybe it's a long

now video i'll send it to you sure please yeah that's really cool yeah the the reason that this

depth occurs is because the white matter scatters like our axons and our brain um have fat around

them and they scatter the light the most they're the most like milk and so once the light hits

that white matter it just kind of bounces really randomly and very little of it arrives back at

the detector um so what's really cool about these frequency domain and time of flight optical

imaging techniques is you can actually measure like things that are happening at the speed that

the brain is working so one thing you can do is um that the brain picks up on rhythmic frequencies

out in the world okay and so you can flash uh one frequency on the screen like four or six hertz this

is the way some bci's are are used now that they'll flash different parts of a an interactive display

at different frequencies and you can attend or look to some of them so this is showing how

these time of flight techniques could be used for that kind of bci i guess that it can pick out

the peak frequencies of the things that you're attending to um in the display um and then you can also record multimodal imaging so you can have eeg sensors built in

and around the optical imaging sensors which i think the the kernel white paper was proposing as well

and so you can use for instance like the alpha from the eeg as a regressor on the optical imaging

data which is a little more noisy or you could try to look for um um areas that correlate with like

larger slower changes in eeg activity and and there at the current i was talking about uh

MEG as well yeah so there there are other imaging technique is using these um

opm MEG devices which are really new right now and instead of having this large rigid MEG structure

that sits in a room in a hospital you can have a helmet with kind of uh MEG sensors that come out of

it and a Faraday cage to wrap around yeah and it still needs to be in a magnetically shielded area

so yeah there's they're talking about helmets that are Faraday cage helmets um

that's a way this is a way to combine the eeg and optical um we're working on kind of new

software and thinking about this depth reconstruction and how it maps on to existing

techniques for visualizing fmri activity and um yeah and since this i've just been working with the

emony python crews who are working in the same space trying to make tools for fneers as well

well do they have an emony javascript because i am let me i'll look it up

anyway keep going that was it that was my last slide so i have i can keep talking yeah you can keep

talking um emony javascript uh well we we were able to just um you know export anything going on

in python into a web socket and bring that into into the web page and then apply javascript

yeah so that's what i have this um educational website egedu.com that we made this last um break christmas break and um one of its functionalities is it can take these streams of eeg data

and output them over a socket to other software or people have used it to control a drone um or a

robotic vehicle yeah and the sockets are really cool yeah because you can um we're finding that

you can combine sockets so you can pull in i'll even stop sharing all together here um you can

we can start to pull in multiple sockets from multiple users into one place

yeah well i mean there i mean there was um what was it there was the uh software from

if you can what is what is the guy's name uh his uh tim molan uh he has this entheon

a company called entheon and they make this uh open narrow pipe software um and um i think that

what it does is it it takes all of your any kind of data signal whether that's you know heart rate

signal or you know eeg um and it puts it on a single sheet a single page and it's able to

synchronize your signals with with your um you know it takes your uh what is it your your time

interval um and it uses the time interval to synchronize different kinds of signals so you

could have um basically um you know it's not a relational database it's the um it's the the

kind that that allows you to have you know raw signals that don't match up and synchronize them

by time and then you then you can make correlations between you know weird heartbeat patterns and weird

eeg patterns and weird eye tracking patterns and and and then you then you can you know maybe you

could use at some point you have all this this uh synchronous measuring of incoming sensor data

you know now we're now we're playing with with with optical imaging and maybe three three uh uh 3d modeling with optical imaging and all these really advanced things but if we if then you can

correlate that to uh things that you're looking for maybe we're right now we're looking for our

is this patients it do they have blood oxygen problems do they have uh are they going to

is their vaughn von neumann's factor um you know acting up and causing them to get blood clots

is are they be seeing vasoconstriction where in a healthy patient who who shouldn't be having

vasoconstriction and are these treatments working can are these drugs working what's the impact of

these drugs in the vascular system and these are things that that you know fnears uh could be

part of an answer too but you know you get this you at some point you have uh we're going to see

like the low-cost augmented reality device would be like the oculus quest it'll be four hundred

dollars maybe it'll have eye tracking um maybe you'll be able to just clip on you know uh you know

your your afnears device and it'll do blood oxygen and maybe that's something people will

really want in this new post um coronavirus if you rather know what your stats were or people

that you're looking at um there is definitely room for you know that so there's the the the

doctors who've um have been talking for a long time about the the digital human being the virtual

human being that represents all your vitals that lets you know about a problem before you before

you get to the hospital there's a lot of value in that because that's you know potentially saving

your life um so you know I think that yeah for me to to have a digital double for me to have like

a bevy of sensors um for for my own personal use it's protected by HIPAA it's protected by you know you're you know you're doing data collection but it's behind encryption you know home you know

homomorphic encryption or whatever and you so I've um I collect a lot of data myself and my

heartbeat and steps and exercise and I found that my physicians don't have time to consider all my

data like they there's a there's too much data that I can collect that my physiotherapist or

my family doctor is like that's way too much for me to consider right now I don't want to see your

your heart rate three times a day for the last year right um but when you have too much data I'm

looking to see if I get my hand in the picture when you have too much data I was like where's my hand

where's my hand the the thing to do with a lot of data is to apply neural networks because that's

where neural networks thrive is when you have a lot of data and if you could get the neural network

to basically take a huge amount of data but summarize that the the semantic meaning of that

data to something simple that a doctor can glance at and then make a decision to either

confirm the the prediction or estimate of the of the AI and turn it into a diagnosis because the AI

will present the most relevant facts after pouring through the mass amount of data and that's the

goal that I want to get to is not just having my data collected and presented as a virtual human

but having AI crunch it to its its most salient uh uh a point because right now they've put the

onus on the user to be like here's your heart rate every moment for the last year but what do

you yeah like I've graphed it it changes but I don't know what to do next you don't have a semantic

meaning estimate of what that data means and that's my family doctor and the healthcare system doesn't

yet either like they they haven't learned what they should keep track of and there's so much of medicine I think is based on like you know this context we ask you so many questions to determine

if these numbers are relevant to your context and that's just really messy in terms of you

know how medicine works but we could maybe get better answers if we not only collect this data

but have you know do a lot of hard work to get to figure out how to apply neural networks to

crunch this down into semantic meaning that's relevant to your life and that's a huge like for

me that's that's that's a test somebody could be doing right now and who owns the data like then

it's a shared data sharing agreement and the user gets the data and the companies like who how do

we motivate that middle between the data and the knowledge um you know there are companies that that

are working on answers you know like Verily versus the Google company they're working on well how do

we do data sharing how do we how do we profit somehow um or how do we you know make it so that

like you know I've heard people you know what why does blockchain come up in the in this context

but the idea was well you know we want people to be able to share encrypted data we want that

encrypted data to be validated but still like only people you you own it in a sense that you

choose which doctors can see it it may be out there on the internet on everyone's server

but then only special people have the special glasses that can see what's in that file until

then it's like this really expensive public well you know blockchain data is a lot more

expensive than destroying it so I guess my my concern would be that the way things are going

that the the knowledge from that data isn't shared the value from the knowledge from the data isn't shared with the producers of the data that's the concern that if I if there's some value in my

data um it should be to kind of and I and you want to motivate me to collect it it should be beneficial

for me it should give me feedback about my physiology or when I should see a doctor what I

should be eating or what I should be exercising it shouldn't just be used to make kind of higher

level decisions about the healthcare system um but yeah so how do you you have to sell the user

on the benefit to them and and users are not gonna you know there's there's too many stories of

companies and and just regular people discriminating against people oh this person has a coronavirus

let's let's go mob their house and oh let's like deny them insurance and oh they can't they can't

have insurance now because they have a freaking pre-existing condition and all this stuff you

don't you don't want uh uh your your medical data to to be known uh in in theory because of all the

all the weird irrational ways that people could attempt to discriminate against you and there's

like lots of examples of that so so yeah I don't know I think you really want to be able to control

your data and decide what hospitals get it but also to control it because hospitals go out of

business and then what happens to those records they're lost it's hospitals are going out of

business right now and that's it that's a real problem facing people if their data is not on a

some some uh server that they can transfer to another hospital um so and they gotta do all the

tests again but um I think we should wrap it up there this is a great call thank you we learned

a lot about optical imaging and 3d imaging or the 3d optical imaging but there's a lot more

there's a lot more to learn I sense and so there will be more talks in the future to dive deeper

into into everything that everybody cares about with with uh mathematical imaging there's so much more to discover and talk uh about and thank you very much Kyle yeah thanks for having me

hopefully I'll go ahead and test the video now see if it recorded properly and we didn't just have

a nice chat it was good at least it wasn't I sometimes record lectures for my class and it

doesn't record at all and I've literally just talked to no one for now at least I was talking to you

okay all right talk talk to you later see you Michael

The Neural Lace Podcast Season 2 Episode 4

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https://medium.com/silicon-valley-global-news/fnirs-functional-near-infrared-spectroscopy-the-neural-lace-podcast-season-2-episode-4-8acbacf53af9

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Hi, this is Micah Blumberg with the Neuro Lace Podcast, and I have a special guest here with

me today who's going to talk about functional f-nirs, or Functional Near Infrared Spectroscopy.

His name is Jonathan Toomim, and Jonathan, you have family history with f-nirs.

Did you want to?

I got grandfathered into this project. Back in around 1992, my grandfather got really

excited about f-nirs as a potential tool for biofeedback, so he built a device and

tested it out, and he found that it does actually work, that you can control your brain blood

oxygenation. So f-nirs, just for the people who aren't aware, f-nirs is a tool for measuring

cerebral blood oxygenation using light. It takes advantage of the fact that blood changes

color based on oxygenation, and that the human body is relatively translucent. It doesn't

absorb that much light, it mostly just scatters it around. So by shining light through a person's

forehead, through a person's skull, into the brain, and seeing how much of that light gets absorbed in different wavelengths, we can measure what the oxygenation of the blood

in a person's brain is.

So f-nirs sort of came to my attention because of a talk by Mary Lou Jepsen. She was talking

about combining the near-infrared sensor technology with ultrasound. Have you done any research

into her technique? I'm just curious off the top. This sort of conversation is obviously

not going to be about her, I just was curious.

Yeah, I've done some research into it, and she is not revealing her secret sauce. Consequently,

I have no idea whether or not her secret sauce is real or if it's fiction like there

in us. So it might work, it might not, I can't say.

So what can neuro-attack enthusiasts and neuroscientists do with f-nirs today? What are some of the

things that are being done?

So something that can be done with f-nirs is biofeedback. Another thing that you can

do with it is pure measurement. So f-nirs is sort of like the poor man's fMRI machine.

It gives you the same type of signal, qualitatively the same signal that an fMRI will give you

if you are doing some experiment to try to measure what part of the brain's activate

in some task. But instead of costing $3 million like an MRI machine does, the f-nirs machine

can cost hundreds of dollars or thousands of dollars. So that's one application. That's

not what my device is optimized for. For that application, you want a lot of different voxels.

You want to have like a 2D map of activation and you don't need that much temporal resolution.

You also don't need that much precision or sensitivity to small changes. My device is

optimized for the biofeedback application, which is, biofeedback is where you're measuring something about a person's body and giving them real-time feedback about that measurement and encouraging them to use that information to learn how to control that part of their body. And biofeedback has been shown since the 60s and a little bit earlier than that to be effective for controlling all sorts of weird things like your finger temperature or your heart rate or the amplitude of your heart rate or your skin conductance like how sweaty your hands are. But it can also be used to guide people in order to change their mental state.

Okay, so the question was, what can fMRI be used for? And it can be used for basically two different types of things. One application is just for measurement. You can do science with it. You can identify what parts of the brain are activated for any given task or see how heavily they're activated. Basically, fMRI is a poor man's fMRI machine. So it measures the same type of signal that fMRI does, but it does so with much lower resolution and also much lower cost. Instead of costing a few million dollars, you can make one of these or build one of these or buy them for a few hundred dollars to a few thousand dollars. Although the high-end research ones are usually around a hundred thousand dollars or so. The other application is what I've designed my device for, which is biofeedback. So biofeedback is what happens when you take some measurement of a person's body and give them real-time feedback on that measurement, real-time feedback on that aspect of their body. And using that feedback, you can teach people how to control that aspect of their body. So in the 1960s, people started doing biofeedback with measurements like finger temperature. By getting feedback,

you can learn how to make your finger warmer if you want to or colder, which is kind of weird. And it seems like it wouldn't be very useful, but it turns out it is actually useful because finger temperature is a metric that tells you something about your autonomic nervous system state. It tells you about how much of a fight-or-flight response you're in or how much of a rest-and-relax kind of state. So by learning how to control your finger temperature, you can learn how to control your anxiety levels and learn how to manage your mood and mental state. And this is something that has surprised FNIR's research, which is that you actually can control what your finger temperature is doing or what your blood vessels are reading in terms of scanning something on your forehead.

Yeah, yeah. So you can do this with your finger. You can also do this with blood flow in your cerebral nervous system, sorry, central nervous system. You can control your brain blood flow. And that seems like it might be useful. Like, hey, you know, if I could get more blood flow into my brain, maybe that would make me be able to think better and concentrate better. Something like that. You might think. It's a reasonable hypothesis.

So I have a question. So they did this experiment, which is making the news for the past couple of weeks, where they were measuring the audio cortex and they were having the audio cortex manipulate something in a computer program. And then the neural network was analyzing the computer program that was being manipulated by the audio cortex and decoding words. Do you think that if your brain is manipulating your blood flow that you could somehow communicate with that, that that could be translated? Yes. And that has been done.

Oh, really? Yeah. So it is hard to do that in a useful way. So in the fMRI literature or the FNERS literature, there's this thing called the hemodynamic response function.

So if there's a very short burst of neural activity, neural metabolism in an area, you'll see a response to that in terms of blood oxygenation and blood flow. But that response

lasts for about 15 seconds. And that response is delayed by about two seconds. There's actually

a very small dip in oxygenation followed by a very large increase in oxygenation that

starts between two to 15 seconds afterwards. And so trying to deconvolve that hemodynamic

response function and get the basic neural activity with high resolution is very difficult

and nearly impossible. So to try to read somebody's brain and try to get useful brain-machine

interface type information out of a person's brain and control like a mouse cursor or something

like that, it's possible, but you end up getting a low bit, excuse me, a very low bit rate

with the FNERS approach or with fMRI. But if you do something like implant electrodes

on a person's brain, you can get pretty good signal and then you can actually start to

do something useful. Okay. So also in January out of Sweden and Germany, there was a study

about EEG and you could get good spatial data if you do like 256 electrode cap. What kind

of, how does that, I wonder, I don't know if you've looked into that, but I wonder how

does that compare to the kind of spatial data you could get with FNERS if you had a sort

of cap around the full head? Yeah, I would expect that the FNERS approach would give

you better spatial resolution if there was as much engineering effort that had been invested

in FNERS as has been invested into EEG. The reason for this, there's actually a few reasons

for this. So one reason is that the signal versus, the signal strength versus distance

for an electrical signal falls off more slowly than it does for the light signals. It's basically

a roughly inverse relationship, one over X relationship versus distance for the electrodes,

whereas for the light signals, it's E to the negative X. So you have a much better fundamental ability to get spatial resolution just because of that. With EEG, you end up getting like if you have an electrode on the vertex on like the absolute top of your head and another electrode on your ear. That's going to pick up neurons that are on your forehead, on the back of your head, it's going to pick up neurons from all over and it'll give you a slightly different contribution from each neuron or from each group of neurons, but it's going to not be spatially specific to either of them. And so those 256 electrode arrays have to do a bunch of subtraction and analysis, linear algebra analysis in order to try to tease out the different signal contributions from different locations and it's a hard task to do. It's also very complicated because the orientation of each neuron matters and synchrony of the neurons that are firing together matters and so forth. So yeah, solving that problem is very difficult for EEG and it's taken 30 years of work in order to be able to get to where we are now, but we're making small incremental steps. And with Heffner's, yeah, if you just put enough optos, put enough LEDs or laser diodes and photodiodes, you can get an inherently spatially rich signal instead of trying to extract spatial information from an inherently noisy and messy signal. So I wanted to get your sort of expert opinion on, so okay, so Jean Rintol talks a lot about the electrical impedance demography, but she also talks about combining approaches with, like, Heffner's and EEG. What do you think about the, how daunting is that task of combining maybe the spatial EEG program with the electrical impedance demography with Heffner's? Is that a huge task?

Yeah, I think-

I mean, because we're talking about completely different types of measurements, unstructured data.

Yeah. So it's already very difficult to solve what's called the inverse problem. It's very difficult to figure out what the physical object is producing any given signal if you understand how to go from how to model, like, the effects on a signal from a physical model. So if we had multiple inverse problems that we have to solve simultaneously, like, that's just a mathematically far more complicated thing to do. It does give us a lot of leverage. There's, you know, some new tools that could be developed in order to combine that data, but figuring out how to do that is going to require a lot of math and a lot of public experimentation and deduction.

So for example, the model that I led a team that we brought EEG into WebVR, and I just noticed that we just kept- it seemed like we just kept abstracting away useful or the actual data over and over again in order to make our 3D representation. And it seems like at that point, if you're taking the end model, you've cut away so much of the original data that you might be introducing- you are introducing lots of artifacts.

Yeah. Yeah. So what often is useful in neuroscience and frequently done is co-registration of data.

So you might have a structural MRI image that you take of a person's brain, and then you do your source localization for EEG, and you overlay that on top of the structural MRI. You can also take a structural MRI and use that to enhance your model of how electrical signals would propagate within the brain. And instead of using a generic brain, like- yeah, instead of using a generic atlas model brain that's based on averaging a bunch of different people's brains together, you can use the actual person's brain and model the electrical connectivity inside that. And that can give you a more advanced or more accurate representation. But trying to take multiple noisy and difficult data sources together

and try to create something that's better than all of them, that's difficult. That has

been done. That problem has been solved for time series signals with Kalman filters or

other kinds of one-dimensional signals, where you have a few different one-dimensional measurements

and you're trying to figure out what the true value is given that you have several noisy

measurements. So for example, you might have a drone that's flying and you're getting acceleration

data from an accelerometer. You're getting GPS data, which has absolute accuracy, but

some error. You might also be getting a gyro. You might be getting an optical measurement

from a base station to an LED that's on it. And each one of those measurements has some

error and some uncertainty associated with it. And the Kalman filter is engineered in

order to take all those uncertainties into account and to provide an estimate of the

true position and velocity of the object that is more accurate than any of the one measurements.

And so the idea that I think Jean has is to develop something kind of like a Kalman

filter for brain imaging to take the uncertainties in each of the different measurement methodologies

and to try to reduce them by mixing and matching properties it can observe elsewhere.

I thought that we might take the unstructured data and try to represent it in 3D and maybe

create a time series for each, like a time stamp for each stage of the data being collected

from the sensors and run a neural network and try to look for correlations with the

neural network. Yeah, you can always just run a neural network on it and see what it

comes out with, but then you don't know what it's doing.

See, I would want the neural network to predict reoccurring patterns and to help point out patterns and then you'd need to associate those patterns with. In my mind, I would want to do something that we're associating it with user activity, what someone is doing or you're associating with environmental, like maybe evoked potentials in the environment or maybe if you could look for the evoked potential of a tree if someone is seeing that in VR or something. Yeah, getting the evoked potential of a tree is going to be like trying to distinguish a tree from a person is going to be very difficult just because, well actually maybe a tree from a person might be easy but like tree from, I don't know, a wall or shrub or balustrade or skateboard. It might be really hard. Yeah, because most of those objects are encoded in very nearby areas, basically the same module of the brain but in different subnets of that. So you're talking a millimeter of level resolution in order to be able to get that kind of discrimination ability out of it. But if you're comparing a tool versus an inanimate object, those are actually represented in different parts of the brain. So you might be able to tell if a person is looking at a tool versus an inanimate object versus an animal or human. You see big regional differences in brain. Yeah, that's going to be more like a centimeter resolution that you need for that, which is in the range of what you can get with Hefner's. So do you subscribe to like the semantic map outlined at Jacqueline's labs, like how he's sort of like that research? I don't know how it works exactly across individuals or semantic maps drastically different between people and like in terms of what areas of the brain are. I'm not sure exactly what you're referring to. Jacqueline's lab was like he did the fMRI imaging and he said, okay, well, you have, you may have like a dog and a cat and they may be closely associated spatially and a house and a motorcycle would be closely associated with each other spatially. But the dog and the cat would be far away from the house and the motorcycle because the semantic meaning has a spatial sort of distribution.

Yes, I'm not sure what you mean by the semantic map stuff, but the observation that different types of objects are represented or encoded in different parts of the brain is a fairly old one and it's been replicated a few times. There are, for example, people who have had lesions who have lost their ability to visually parse all tools, but they have other types of objects intact and their ability to visually parse them.

So I looked you up online and you were doing something with trying to make blockchain transactions or Bitcoin cash transactions a lot faster with BitTorrent and BlockTorrent. And use your datagram protocol. That seems like very innovative thinking. You're like, well, how can we break this problem down and make the transactions more efficient? I'd sort of like to hear a little bit about that, but also I'd like to hear like, if the brain is like a network, what is the transmission protocol like between different bunches of neurons? Is it more like use your datagram protocol or more like TCP?

I would say that it's more like a factory with an assembly line. And you've got a bunch of different workers. Each worker is doing one specific task. And so they might be drilling a hole in a component at a certain position in order to make room for a screw. And so each time somebody gives them a part, they look for the right places, drill that hole and they drill it and then they hand it on to the next person. So like the information that is present in an action potential that arrives at a neuron is that the previous neuron observed some feature or thinks that a certain action should be taking place. And then the next neuron will integrate that information with other neurons that are providing other components like for example the screw and assembling it into a new signal. And these signals are all just present or absent or degree of presence. They're very limited signals. But each one does a small step and then passes it on. So yeah, I wouldn't say that it's so much like UDP because UDP gives you 1,500 bytes per packet or per datagram. Actually up to 64K but whatever. Gives you a lot of data per packet whereas neurons are just giving you a simple present or not present or variations of their kind of signal.

Okay. So I mean do you think in the transmission of neural activity, do you think it's just on or off? It's either active or it's not? Or do you think that there's some communication in the amplitude of the signal that's being sent?

So if you're talking about axons, then yes, it's just a digital binary signal. It is a little bit more complicated than that because A, timing matters. B, phase matters. Sorry, by a timing I meant frequency. Like how often the action potentials come. That matters and also the phase matters. There's a really interesting circuit in the auditory processing pathway really early on in the brainstem that has a bunch of different parallel neural fibers each of which is firing at the same time. And you have two sets of these fibers. One is firing based on sounds that came from the left ear. The other one is firing based on sounds that come from the right ear. And these parallel fibers are of slightly different lengths. And by having slightly different lengths of two different sets of fibers from each ear, you get either the signals from the two independent parallel fibers arriving at the same time or at different times. And when they arrive at the same time, because the lengths of those axons is just right, that triggers the next neuron in this circuit to fire. And this serves as a phase detector. You can tell what the phase difference is

in this auditory signal between these two ears by looking at this timing information, by looking at these parallel fiber circuits. And that's a really cool way of doing it. And it just shows you that the brain likes to encode information by increasing the number of parallel signals and having each signal be as specific and unique as possible.
So if a neuron is connected to 10,000 or 200,000 other neurons after it fires, how does the brain sort of guide the signal from the neuron that's firing to the subsequent neuron? Like, what I'm saying is a neural circuit is a pattern of neurons that fire in a cycle. But how do they fire in a consecutive manner? Yeah. So I think that something that has happened a lot recently in humans is that we've gotten really good at filtering out people who disagree with us. Social media has allowed us to form these bubbles that are self-reinforcing. When people are saying things that we agree with, we like them, we subscribe to them, when they're saying things we disagree with, we just prune away those connections from our social network. And this is actually very similar to the way that brains work. Brains have, well, there's this principle called heavy in learning. Neurons that fire together, wire together. So when a pre-synaptic neuron fires an action potential that pushes the post-synaptic neuron over its activation threshold and causes it to fire, that post-synaptic neuron goes through some biochemical changes involving calcium and second messenger pathways, crab, et cetera.
And those cause that post-synaptic neuron to strengthen that synapse. It makes that neuron click like on Facebook and say, I want to listen to you more often. I like what you're saying. So that just increases the odds that it's going to be the neuron that receives a signal from the neuron that fires? So not only does it increase the odds, but it also causes these sort of social media bubbles that you see or the neural equivalent. It

causes local circuits that respond strongly to very specific types of stimuli and that

filter out stimuli that don't match the specific set of criteria. So you might have a set of

neurons that respond very strongly after this heavy in learning. They might respond very strongly

to checkerboard patterns that are composed of red and black. And eventually, this later on in

that pathway might respond to chessboards than it might, yeah. Okay. So I have this hypothesis

that maybe if a neuron has a low enough electrical potential, like a very negative electrical potential,

that it might be the next neuron to receive a signal from a down neuron. So like there's

some sort of electromagnetism happening where the action potential is an electrical event

that's rebalancing the electrical activity of that neuron. And it's sending the signal,

I think, potentially to the neuron downstream that has the lowest negative or the highest

positive or something like that. So just an idea. Yeah. No. What tends to happen is that

neurons will do analog summation in their dendrites. Like when they're receiving the

signals, they allow the excitation to some in a very analog fashion. And then if it gets

above the threshold, it triggers the cell body and the axon to go into an action potential,

which is the digital signal. And once that happens, once the action potential is triggered,

all of the downstream neurons will get the same signal. There's no filtering of signals. It just

delivers it to everything. And then you go through another step of this analog summation.

Not all of the downstream neurons will have enough excitation from other sources to trigger

them to go into action potentials and continue on the process. You usually need around 10 or 50 or

so simultaneous action potentials from different neurons in order to trigger a single neuron

to fire. It's usually around 3 millivolts per EPSP, per excitatory postsynaptic potential, at exactly the location where the synapse is forming. And then that decays spatially,

so you get a much weaker signal by the time they're actually integrating.

Do you buy into the predictive coding theory of the idea that your memories are becoming

your predictions of what's there? I don't know if you know Jeff Hawking's work.

He talks about, recently he's been talking about how neural columns are acting like grid cells,

but they're representing the objects in space and their features and how those features are

correlated. And if you pick up something and move it around in your hand, it's helping to track

the orientation of that object and what your fingers are touching it and putting it together.

And then maybe your workspace of everything, your environment and the orientation of every

object in your environment and every leaf on the tree is being tracked by different

columns in your brain. Would you buy that? Yeah, I think there's a lot of

truth to that. A person who is imagining something activates the same parts of the

brain as a person who is seeing the same thing. There are differences in intensity of activation,

but that visualization or that expectation primes those neurons and makes it more likely that you're

going to see that thing. There's some fun experiments that have been done where people have written down

ambiguous words, like a word that might have a letter that looks something in between an R and

an N, for example. And depending on the context, you can either push people towards interpreting

that as an R or push them towards interpreting it as an N. You can construct a sentence or you can

use a word previously in 15 minutes earlier in a conversation, and that will influence

how people parse that letter. For example, bar versus band, you can have as the question. So, yeah, these expectations of what kinds of stimuli you're going to get affect how your

low-level systems process sensory data. There's actually more feedback in the brain,

in the visual system, than there is feed forward. There's more information coming from your higher

perception areas and your abstract association areas down to your basic visual system than there

is information coming from a visual system to those abstract areas. Is something like 10 times more?

I don't know the exact ratio. I heard it was more like twice or like 60 percent more. I don't

think it's quite 10 times. I don't think it's quite 10 to 1. But yeah, it's large, significant,

and it's how we see, it's how we do everything. And it's also, interestingly, something that's

completely missing from the neural networks that computer scientists are making these days.

Pretty much all of the AI research that's being done right now is completely excluding any feedback

circuits from their networks because feedback is really hard to get right. It tends to make the

system more unstable and instability is a very common problem in AI research these days.

I saw a talk about brain-computer interfaces. I think it was a talk by Valovic at GDC in there.

And they seemed to, like, they were saying that, you know, basically the neuron is the basic unit

of computation. And throughout the explanation, I was like, you know, they're making it seem like

it would be really easy to start reading emotions and reading thoughts. And there's a lot more

complexity to the brain here. The dendrite itself might be, some people will compare it to a computer.

Maybe we could talk about the sort of the scale of the challenge of trying to do what some of these people in brain-computer interface are imagining they can do in terms of reading the mind and

creating, you know, nerve gear. That's a monumental sort of problem to attack with hidden depths of

complexity that they may not even be realizing. Yeah, so I think a lot of people think about neurons

as abstract nodes in a graph, in terms of like graph theory, where they, where you can just represent

a neuron and all of its structural complexity as if it were just a circle. And you're connecting

circles to each other. And that is the connectome, that is all the information you need to know.

And so from that perspective, you can create brains using neural networks where you're just

doing simple matrix math, where each element in a vector might represent one neuron's activation at

one time. And this approach is really powerful and allows you to do some very fast and efficient

calculations in AI, but it has very little bearing with how the brain actually works.

The dendritic tree is very much an analog computer. I mentioned that the neuron as a whole is

digital, but the dendrites are very analog and very sensitive, and they have a lot of different

dynamics to them that are difficult to quantify in that circular neuron model. So one thing that

matters is the diameter of the, of the dendrite. The larger the diameter of the dendrite, the better

it is at conducting signals to distant regions. Short of the diameter, the more quickly that

signal will decay spatially and temporally. And the reason for this is the axial diameter increases

the, the conductivity down the, the dendrite, whereas the surface area increases both the

capacitance and the leakage current. So having a high surface area to volume ratio means that

the signal doesn't obligate very well. And this isn't just like some, you know, coincidental

accidental fact. This is something that neurons actually use when they are choosing connections or when they are evolving their processing systems. They have usually one very large apical dendrite

that serves as like the trunk of the tree. And then they've got branches that are more and more

finely sized in order to integrate information. And if you have two synapses that are making

them, or two synapses on the same part of that dendritic harbor that are nearby in terms of

either being both on the, on the main apical dendrite or if they're on the same part of the,

the small dendrites, those synapses will add together much more strongly than two synapses

that are very distant. And you can also get, this is fairly rare, but it does happen. You can also

get action potentials within dendrites. The voltage-gated sodium channels that are necessary

for action potentials on the axon are also present in smaller concentrations in dendrites. And so

you get positive feedback locally. And you can have back propagation of signals. Yeah, you can,

there is also some back propagation. There's, again, the long-term potentiation stuff that I

alluded to earlier with the heavy learning, which is something that does not happen in AI neural

networks. You also have more than just one type of signal. It's not like you have excitation and

inhibition. You have several different types. You've got, you know, you've got glutamate,

you've got glycine, you've got GABA, you've got serotonin, dopamine, norepinephrine, you've got

a bunch of different types of signals. And they have different representations or different

interpretations of those signals. Even if you're just looking at glutamate, you have three different

classes of glutamate receptors. And two of them are purely, instantly excitatory. But a third one

is only excitatory if the neuron's already excited. And it's not instantly excitatory. It was not

purely instantly excitatory. It's long-term excitatory. It causes that neuron to be more

sensitive for a few hundred milliseconds to a few days after that excitation. And trying to model all of these little things that tweak the function, each of which can be used to enhance memory or

depress memory or to add some specificity or sensitivity. Try to model that. I've heard

some hypothesis, like from Jeff Hawkins in particular, that the dendrite could be used to

store a memory of events, to help the timing of when a neuron fires and help the decision of

when a neuron fires in response to criteria. I've heard a neuroscientist whose book I read

talk about how a neuron could be considered a criteria detector or a coincidence detector.

And I sort of like, I don't know what you think about this, but I sort of like to

describe to the idea that maybe a coincidence in the brain is the basis of a bit of information

that makes up, like if the world that we see when we look around was made up of,

was constructed of bits of information, if it was like, I don't know, I like to imagine that

there's many layers of our brain rendering reality. Maybe at the baseline it's just like

simple frequencies and they're not, I don't know, I'm just imagining, like before we get to this

level of rendering that there's lower levels of rendering. And then like, this is like really far

out obviously, but so I guess when I'm sort of going back to something that's more coherent.

So what do you think in terms of like the dendrite being, the sensitivity of the dendrite being

essential to how the brain processes information and maybe how the brain sort of communicate

this to researchers in the tech world who are thinking about what is the importance of a dendrite

in terms of what it does for the brain. And maybe in terms of what is its output, what is its,

it's affecting the, at some point it's affecting the ionotropic brain, the electrical balance

of a certain region of the brain. And maybe it's affecting like, I think at the neurotech

meetup that we were at, there was someone talking about how what the basis of memory requires some sort of attractor of some sort of signal attractor, some sort of electrical

attractor. I don't know if I'm recalling that correctly what he said, but what do you think is

the sort of like the basis of memory and cognition in terms of, in maybe data, in terms of like,

I mean just maybe speculate about how the brain is detecting information and then moving it around.

Yeah, so I think the coincidence detector is a good starting point. The brain definitely has

systems in it that are built for detecting coincidences and rewiring the neurons in a way

to enhance the detection of these coincidences. By coincidence, what we mean is multiple things

that happen at the same time. And coincidences are, you know, correlations, they don't necessarily

imply some causal relationship, but causal relationships often come at the same time.

So by making a model of the world based on what things coincide, what things happen at the same

time or in the same location, you can often generate neural hypotheses about what's going on,

which can either be strengthened or weakened later on from subsequent data. So yeah, coincidence

detection happens. The third glutamate receptor that I sort of alluded to, the NMDA receptor,

is actually very much a coincidence detector. It only responds when you have multiple action

potentials in a nearby portion of the dendrite that happens in a few milliseconds. Yeah,

a few milliseconds and a few hundred microns. A microns is a distance. Yes, yeah. I mean,

if you have it on completely the opposite ends of the dendritic harbor, then the excitation

isn't going to propagate across. I mean, are there instances where you may have your ears

are on the opposite sides of your head, but is there maybe an NMDA receptor that might fire

because there's a wire linking that your ears together at some point? Right. So this isn't spatial distance in the world. This is spatial distance on the dendrite. Oh, okay. Yeah, right. The action potentials have to be hitting the same neuron in nearby parts of the dendrites at roughly the same time in order to activate that NMDA receptor. And once that happens, that NMDA receptor causes that synapse or that set of synapses to become stronger and to be more sensitive in the future. And yeah, that correlation. I'm just like, so if you built, if we built a robot, right, that was that basically it built a model of the world based upon incoming coincidence patterns, sort of like, ideally, I would think that if the brain builds the world based on coincidence patterns, the image of the world that we perceive, that I perceive, that, you know, we could, you know, put cameras and, you know, for eyes for this robot and microphones for ears and run some sort of program that takes all the coincidence patterns that this robot notices from the world and have it build the model of the world. One that we could make perhaps, you know, render for someone in virtual reality so we could see it here what the robot has constructed. What do you think about that? Yeah, I mean, that kind of thing is possible and it's a large portion of how human brains or animal brains work. Unfortunately, it's not the only thing that's going on in human and animal brains. A lot of the wiring in the brain is actually hard-coded. The visual cortex has the structure it does, independent of sensory stimuli. And sensory stimuli is necessary in order to fine-tune it and to improve some of the networks. But even in the absence of vision, you still get pretty much the same or mostly the same network. And so what we can see in the brain is that we have this algorithm for detecting coincidences and becoming more sensitive to these coincidences and also for making sure that different groups of neurons

don't all encode the same coincidence. There's also what we call lateral inhibition going on.

So to have as many different dimensions of sensitivity to coincidences as possible.

So that's one side of things, but it's not the whole story. There's also

just the nuts and bolts wiring diagrams of which areas receive connections from which other areas

and what the different layers of the cortex are and how the neurons in each layer connect to

other neurons in the same layers. What the balance of excitatory versus inhibitory versus

metabotropic neurotransmission is, a large portion of that is all genetically hard-coded.

And in AI, it's also genetically hard-coded. When people are generating a neural network

to process, I don't know, images to look for faces, they will do some of it as back propagation

learning. And some of it, they will just do as trying different models, trying different

connectivity models and seeing which neural networks learn it best. Do you do again or

do you do a convolutional neural network? What works best for learning this kind of thing?

And that's kind of the genetic information. And you just have to, well, currently,

you just have to make guesses and evolve it. You try something, you try something else,

mutating the concept until you get something that works really well.

Okay. So have you studied the basis of how the brain makes memories? I'm just curious.

How the brain makes what memories? Memories, yeah. How memories work.

Yeah, I mean, I've learned a lot about it. What kind of memory are you talking about, though?

Because there's several different categories. There's, you know, the badly model. There's

episodic memory. There's semantic memory. There's procedural memory. There's implicit memory.

There's explicit memory. There's working memory. There's short-term sensory store memory,

both in visual cortex where you have the visual spatial sketch pad. And then you've also got

the auditory cortex for the phonological loop, which is about two seconds. So you've got each

of those types of memory. And a lot of those types of memory have different mechanisms that

underlie them. Like the phonological loop, that's probably a dedicated neural network that operates

in a loop. And so it has, you know, a bi-stable electrical phenomenon where you can either have

a certain network running or a certain network not running. And you've got the,

like, several of these loops in parallel. So each one would be for a different time delay.

So each loop will activate the next loop over and cause it to output a bit. So you can have

a sequence of sounds that get produced in sequence. And that happens inside your memory.

The visual spatial sketch pad is probably something different. Long-term memories are also

very different. Those mostly go through, like, the heavy in learning to calcium going through

NMDA receptors to gene expression changes, increases in receptor densities and synapse densities.

Those are more of a structural thing. So, yeah. I mean... Yeah, it sounds like we have

centuries of work to go in neuroscience. Lots of study. Hopefully it's longer than 10 years.

Hopefully we don't go extinct in a couple centuries, because that's the only thing that's

going to stop us from studying it. Right. Yeah. I mean, I think that, you know, just...

I think one thing that this conversation maybe points to is how important it is to...

for neuroscientists to study which parts of the brain are firing in correlation with

the sensory stimuli around a person, around a brain, and, you know, and correlate that with

the activity of that individual. And because the spatial information really matters in terms of, like, you know, how your eyes are positioned relative to your brain and

how your incoming senses, you know, from your eyes and your ears go to the thalamus, and then

how that information may flow through the brain and how it's structured genetically and how signals...

the various different ways the signals propagate and the various different ways that memories

are formed. And there's a lot of, like... it's not... I mean, there's a lot of...

a lot of information, a lot of

insights that may only come from just from studying how things move around spatially.

Yeah, I mean, I think that there's a lot that you can learn from just watching and correlating.

And I think ultimately, though, what is the best way to learn is to not watch but to interact.

And one of the reasons why I'm excited about the Nurentford Spectroscopy Biofeedback process

is because it allows you to modify the brain in a way that's spatially specific

and see what happens. And this can be used both for improving cognition and it can also be used

just for discovering how cognition works. So if, for example, I have a hypothesis that the left

hemisphere is happy and the right hemisphere is sad, I could test this hypothesis by training

somebody to increase the activation in their left hemisphere versus their right hemisphere or vice

versa and seeing how that affects their mood. And by the way, I think that left-right thing is

a huge oversimplification and mostly it's about 95% wrong and 5% right. But that kind of model,

I mean, you can also do something more subtle. You can try to identify which parts of the premotor

cortex are involved with gating and activity and deciding whether to enact a memory plan, or sorry, a motor plan, or to keep it as just something that you could do. And so you could

set up an experiment in which people are trying to do some go-no-go task where they have to either

do a task or not depending on environmental cues. And you could try to do biofeedback in order to

modify the activity in one particular area in order to bias them in one direction or the other.

Those kinds of experiments become a lot more feasible when you have a relatively

non-invasive and safe method and cheap method for modifying activity on a local basis or

activateability perhaps would be a better term. So let's talk about, do you have any plans you

want to share, any areas of research, any products you're working on that you want to talk about?

Well, don't tell anybody, don't pass this on because it's a secret now. But I am working on

something soon which will hopefully take over the entire world and put it all under my dominion.

It's going on next Sunday, actually, on the 12th. But what is that?

There's a Dr. Horrible sing-along blog. Oh, nice. You're part of that. Yeah, I'm the doctor. Wow.

Yeah. Nice. So that's, oh wow, you've got a Dr. Horrible lab coat. So what is the,

maybe plug that for a little bit. What is the date and time and how people find tickets? Actually,

I think we're going to be running out of space. So I'm just mostly just teasing at this point.

But you're going to be doing that? No, but so for the near and front,

near and front spectroscopy value feedback stuff. Yeah, I've been working on a lot of other projects

too. I've got like six things going right now. And this is one of the things that I want to

finish up. Are you still making innovations in the Bitcoin world? Yeah, so a lot of my

time nowadays is taken up at the intersection of cryptocurrency and the environment. So I've been doing mining for the last few years. Right now, I'm trying to find scalable energy sources that are carbon neutral or carbon negative for cryptocurrency mining. Specifically, I'm working with a company that's looking at Arctic methane emissions. And methane is much more potent greenhouse gas than carbon dioxide. So if we can find a way of making it profitable to burn methane, that would otherwise be leaked as methane, then we reduce the environmental impact of that methane by about 96%. And we also can make some basically free or cheap energy at the same time. So trying to find a way of using cryptocurrency mining to make that economically viable, I think is interesting and exciting. But yeah, like the biofeedback I think has the potential to help a lot of people. There's some circumstantial anecdotal evidence that indicates that doing biofeedback on prefrontal blood oxygenation may improve concentration and focus, especially in people who have attention deficit type disorders. It may also improve the ability of people to read social cues that might be lacking in, for example, autism. And a lot of other things, a lot of therapists have tried doing biofeedback with people who have very psychiatric disorders and they've had positive results. Of course, they might have had equally positive results from a placebo, I don't know. But it does seem like it's worth investigating a bit more.

There was a company at a blockchain event that I went to that was talking about storing your biofeedback data on the blockchain encrypted. In some cases, they offered a homomorphic encryption service, which is computationally expensive. I don't know if you've seen that sort of thing out there where, I don't know, but did that make you think of combining your two worlds and like, well, for your biometric data, I've heard it described as like a fingerprint. You want to

have it protected, right? You want to have it, it's personally identifiable.

Some is, some is not. The near and front spectroscopy data is not personally identifiable.

Okay. Good to know.

I also think that if you want it to be private and encrypted, why do you put it on a blockchain?

Right, yeah, that's what I was thinking too.

I think that a lot of those, a lot of the blockchain excitement and hubbub is just

metuism and most of it's just saying, oh, people are excited about this technology.

How can I use this technology for this completely unrelated task that doesn't require that technology?

Well, I mean, we've been, some of the groups that I've been talking to are like, well,

how can we send EEG up into the cloud into a multiplayer VR experience so people could

sort of do their meditation practice in VR next to other people doing their meditation

practice in VR? And would we need to protect that information with the, like the blockchain

or something that would allow us to distribute the...

Blockchains don't protect information.

They don't, no, they don't.

They share information.

They share information.

It's the opposite idea.

But you can share, you can share encrypted information.

Yeah.

You can do that either in a blockchain or anywhere, any other way.

Like the only time you need a blockchain is if you have a multiple writers, multiple concurrent writers, who B, don't trust each other, who are C, writing to a shared database. And in this like game scenario, they probably trust each other or you can like use some kind of either game rules or input validation in order to minimize the effect of any untrustworthy activity. You don't really need a shared database.

You just need a central server that like tells them what the game state is.

Right.

Yeah, so...

It's the wrong concept.

Yeah.

It does work for money.

Like that is a scenario where you do need multiple untrusting shared writers to a single shared database.

But for most other applications, you just need a server, so...

Any, anything else on the topic of future plans, future projects, exciting events that are coming up that you want to attend besides that?

Was there that May 16th thing?

May 16th, that's right.

You're going to be speaking at the Neurotech X event in San Francisco.

Do you want to give a preview of what you're going to be talking about?

Well, I don't know what I'm going to be talking about yet.

So like I probably should figure that out.

But there's going to be this, it's a Neurotech event.

So I'm willing to bet that FNIRs is going to be a topic.

Like, maybe the topic will...

It could just be that.

It could just be that.

There might be a little bit about computer interfaces in general.

I know you mentioned MRI and compared it to FNIRs at the top when we've talked about different

technologies.

So I'm looking forward to that.

We could also maybe ask the audience and ask them what they would like to hear.

Great.

All right.

So that you heard there, we're doing a Neurotech event.

And y'all can come down on the 16th.

What's the location?

The location is going to be at the Red Victoria.

And great.

So I'll go ahead and stop this.

And thank you very much, John.

I want some Tumen, everybody.