Brain health basics and podcast intro

Well, okay, what you can do to protect your brain health is a good diet. I mean, that's most of the stuff I eat is from my farm and, you know, organic foods, stay away from glyphosate.

That's poison, and don't go out and spray Roundup because what they replaced it with is even worse. How am I not sued for saying things like that? Stay away from chemicals and clean the air, clean water, stay outdoors, exercise and exercise your brain too.

And then be able to track it and see how you're doing. I think those are the most important things to promote brain health. Welcome to the To Curious MD podcast.

With the wisdom from holistic, alternative and these conventional medicines, we are here to challenge the status quo. We're curious about the connectivity and complexity between diverse fields of knowledge as they relate to consciousness, chronic illness, mental health, resilience and beyond.

Learning more about art and science of healing, or listening to stories of extraordinary healing. You're in the right place. Let's dive in. Welcome to another great episode of the Too Curious, M. D.

podcast where medicine is more than science. It's story, art, connection, and integration. Today, I am honored to have Dr. Mark Tomberdahl and we're going to be talking about BrainGage, a way to optimize brain health.

As you already know, i am a nerd and I love to know about what else we can learn about brainhealth and how we apply these technologies in our healthcare.

Dr. Mark Tommerdahl is a biomedical engineer, a neuroscientist, and researcher and a long-time professor at University of North Carolina. And his work has focused on understanding how population of neurons interact across the cortex.

After earning his BS in biology at Davidson College, he completed his MS and PhD degrees in biomedical engineering and mathematics at the University in North His early research, supported by NIH awards, explored cortical dynamics, sensory processing, plasticity, pain, and interactions within and between brain hemispheres.

Over the course of his career, Dr. Tom Merdahl helped develop high-resolution approaches for studying patterns of corticactivity that laboratory research ultimately contributed to the development of BrainGage, a technology designed to assess aspects of brain function through quantitative sensory testing.

Introducing BrainGage and Dr. Tommerdahl

He has authored over 150 peer-reviewed publications and continues to collaborate with researchers studying neurological issues ranging with traumatic and developmental conditions to neurodegeneration, pain, and pharmacological effects.

So today we're going to be exploring this fascinating question. of how can we measure and how well the brain is functioning without relying solely on what someone tells you or tells us, the physician, about how they feel.

So, after doing decades of research, Dr. Tom, tell us just for somebody for the first time hearing about brain gauge for first-time, what exactly is it and does it tell about the So anyway, my students called me Dr.

T, so I'm good with that if that's easier for you to say. This is the brain gauge, Mr. Dr T. So, anyway this is a brain gage and it's got two, it is not a mouse.

It's a lab in a mouth that lost 100 pounds in 20 years through lots of research and lots effort. But these two little buttons here that you see are not buttons like on a They actually vibrate your fingers at very specific amplitudes and frequencies.

And then we basically ask a series of questions to do the testing. The advantage of the way we've designed this is that we can target just about anything in the brain.

Well, that's sort of a source of, a lot of people's research is how do you read the brains. A lot people do a different types of interventions to try to reach the brain.

They use a wide range of electroceuticals. In some cases, people use psychedelics and what that does is it, you know, breaks the pattern. And then after you make the pattern, then you need to reform new connections.

And a lot of times what happens, well, what happened a long times in areas of chronic pain is that when you have areas, one thing that we found in the animal models, which is very, obviously very difficult to confirm in a human model because we don't have electrodes stuck in people's brains.

But what does happen is that at a place where you have higher than normal activity, super high activity say in chronic pain areas or in an area that's got super-high activity.

Which is what we do see in brain mapping. It doesn't turn off. GABA actually reverses. And so GABE is normally inhibitory. Yeah. it reverses to excitatory, you're done.

And that's one reason I postulate that electroceuticals and things like psychedelics are very effective at rebooting the brain. Because your brain needs some help when it gets in that state and you have these areas of, little pockets where something's just locked in and it can't let go.

How do you flip that off? And so basically it's not just retraining, it is rebooted. Rebooting and letting it rebuild new connections. But people don't realize that.

You can actually activate auditory cortex, a sense of hearing, with the right vibrations on the skin. And you cannot activate visual cortex by stimulating the scan.

People don' realize how far reaching the different things are. We can vibrate and ask specific questions. The questions are always easy. When we're doing the testing, it's a little bit like reading an eye chart.

It starts out very easy and gets harder and harder as you go along. So as you go down the eye chart, it gets a little bit harder. And that's how we can objectively find what you're, you know, how can we objectively target different aspects of brain function and get numbers for different things.

But you, know the sense of touch is something that is overlooked. Everybody wants to use a phone app. They want to do something with vision or they don't want do do with hearing.

My mentor, the person who became my mentor back in the 1980s, 1990s. You know I was hooked when I was looking for a lab and on the first interview, what he told me, he said, look, everybody wants to study the brain and they want to studied with vision, they wanna study with auditory systems because they can use a flashlight or they're gonna use the speaker.

How tactile testing maps brain connectivity

But the sense of touch is really the best way to understand the I don't want to go into all the really details of why, but it targets parietal lobe, which is right in the middle of the brain.

You have access to, you know, like cerebellum. Like you have to access the cerebella pariotal pathways. And so you can focus and lock in and the parietal lobe have all kinds of activity there.

But the way that that part of the cortex is organized is it's organized everywhere else in the brain the same way. And when you target just two places on two fingertips, you activate two place in brain that are side by side and you could modulate a little.

You can make things happen in between those two. Now what happens in-between those clumps of cells, they're called columns or mini-columns, is predicts what's going on everywhere else.

And it's not just that one spot in the brain because you have, you basically, the whole network is connected. So I can back up, I guess I should back and just say, here's a little bit more history.

I'm kind of a nerd on history, so apologies. Yes, tell us how this actually came about. This is amazing. You mentioned I was a biology major at Davidson College and I working on a paper and back then I I started to get pretty interested in how the brain works, but I was also interested exercise physiology because I as a competitive athlete and I have decades of experience in competitive athletics.

That's a whole other story, But it had an impact on how we designed exercises later on for the brains. But when I came across the paper and basically, you know, it was fascinating to me because it said, Oh, everyone knows that if you put your right arm in a cast, The muscles will atrophy.

What they don't know is if you're one arms in a cast and you exercise the other arm, well, it doesn't atrophy as much. That's because of connectivity in the brain.

You have connections from both one side to the. Now let's fast forward a little farther into when in my, during my graduate and post-doc years, I said, Oh, you know, we want to write a paper.

We were studying interactions between the two hands in. And we were looking at it and the results of that were, We wrote a paper talking about how stimulating one hand basically activated the same part of the cerebral cortex on the other side.

Now everybody grows up through high school and college and everything and med school. They say right hand, left brain. It's not completely true. You're connect.

Everything's connected. And so the paper I wanted to write. I wrote the paper about this and the title I wanted to give it was that the left hand knows what the right hand's doing.

My mentor said, no, and it's got to be ipsilateral, contralateral, bilateral, blah, so total nerd speak, but you think I'm a nerd, he was a total. But anyway, so, and then fast forward a few more years when we started using, that was all done in the animal where we stuck electrodes in a brain and we did very high resolution imaging.

When I say high-resolution imaging, I mean at the micron level. So, most people say, well, it doesn't mean anything. Well, if you go and get do a medical imaging, the best you're going to do is in millimeters, not microns.

Okay, a micron is one one thousandth of a millimeter. So we were studying this at extremely good resolution. And that's what we're publishing. Now, how to explain that in terms of sensory persa or how do you explain interactions between the hands and stuff like that.

We actually developed, after we developed the brain gauge technology, we actually studied those two hands and we noted that the only way to explain the type interactions that you get between your hands were those same findings we found in the lab.

Fast forward a little farther. Recently, this was a few months ago, stroke patient, or I didn't have a stroke, patient one of the clinicians I work with has a stoke patient.

He didn, his hand had been, he had a stroked three years prior. His right hand was clenched in a fist, couldn't use it for several years. It was spastic in one hand, but So, and I get these calls all the time.

Clinicians call and they say, well, I have a stroke patient. He no longer has used of his right hand. What should I do? Use the left hand, but he started using left-hand and you know, 45 days later, he has full use of this right- hand and he can actually do the brain gauge with both hands now.

So that's the kind of thing, that kind connectivity, and it's all about connectivity by the way. It's about that. That's what we study. The brain gauge study makes measures of connectivity.

Different types of conductivity. And it also has exercises in the brain gage gym where we do things like we try to target that same connectivity and exercise the connectivity Well, you mentioned that this is a touch response that provides cortical information, cortico-functioning.

How does it actually work? Because what is actually happening at that somatosensory cortex during these tests? You brought up the association of one cortex to the next.

Okay, so see if you can visualize this. So I have lots and lots of slides showing stuff from the brain, but we won't go into that detail. But if you can visualize vibrating two fingers and activating two places in the brain, we're going to talk about something called lateral inhibition.

Lateral inhibitions is this phenomenon that was proposed back in 1950s and 60s by a guy named George Wanbekashi. He was the ultimate biomedical engineering nerd, first one to do a lot of neuroscience and got the Nobel Prize eventually.

But his idea was, and all the testing he did was through sensory perception, he delivered Vibrations and noted that wherever you, what he proposed was wherever, you have a place that's active in the brain, the surrounding areas are become, are turned off.

And so the, brain turns out to be a pretty, normally a, pretty efficient mechanism because when there's something active, it tries to turn off everything else.

And so when you activate two fingers or that are basically side by side and you active a two place or you vibrate two figures, you're activating two places in the brain that were side-by-side and they're competing because they are both trying to turn the other one off.

From research history to stroke recovery

Actually, they were really turning off the area in between to make a clean signal. And the way to think about this is really. So think about you're vibrating two fingers and you want, it doesn't feel distinct or does it feel fuzzy?

Correct. With people with brain fog, it feels fuzzy. They can't distinguish between those two areas in the brain. And because lateral inhibition isn't working well, and as brainfog lifts and gets better, It's just like headlights in fog get more and more clear.

As you get, more more clearer and it gets sharper, then and lateral and inhibitions starts working, brain fog dissipates and so we have a measure for measuring how distinctly you can tell the difference between one vibration on one finger and one on the other and it's that simple.

Yeah, but what can this sensory discrimination tell us about how the brain is working? Okay, so if it's inefficiently doing that discrimination, go on.

What we're doing is what I just described to you is we use sensory discrimination. We deliver two vibrations to the fingers and we ask somebody, for example, we'll ask, which one's larger?

And if you can tell the difference. between those two, then what we do is we modify the next test and we say, okay, now which one's larger this time? What we measure each time we're doing a sensory discrimination test, we find out what is your discrimination capacity for determining between these two things.

It turns out that That gets localized with a particular cortex. Yeah, it's localized to that. Is that discrimination and localized? Well, we're doing that locally, but think of that, you know, as more like a non-invasive biopsy.

Because when we correlate, and some of the studies we've done, that measure correlates extremely well with GABA levels as measured with MRS. So using MRs, or magnetic spectrum spectroscopy, can measure GAB levels.

That can tell you something about that if you've got too little GABA, then you tend to be hyperactive. So like somebody, you know, who has a lot of hyperactivity is seizure prone.

Now the thing with MRS is MRs is good at detecting GABO levels, but it can't differentiate between GABAA and GABB. We actually have tests that can differentiate the impact of higher than normal GABE versus GABI.

B. so that's like if somebody is like, well, They have hyperactivity of the brain and then you give them GABA-A or GABAB and you can do a particular test and determine that.

So anyway, I'm going… So when we measure, when you measure the sensory discrimination on this cortical cortex, wherever that localizes, how is it measuring cognition or how it is measuring connectivity?

Okay. So that lateral inhibition tasks that I just described, that's just one of the tasks, but it's dependent on connectivity. And so what we've done in all our studies, the studies include things like developmental studies develop people into developmental disorders, say with autism, ADHD, Tourette's, OCD.

What we do is we measure and then we see which aspects of cognition do these particular metrics correlate to. And so if you're, you know, if lateral inhibition is not working, even though you keep saying, it's not really just that local space that you are testing, It's all connected.

If it is working there, then it isn't working anywhere. And it does impact. What we target are what we call building blocks of information processing.

So if like in the developmental world, You see changes at the cognitive level that are very different, Then you see the cognitive changes in, say, brain trauma.

Somebody's brain gets impacted by say a TBI or a stroke, and they're impacted very differently than somebody with a developmental disorder at the Cognitive level.

But there's cognition, executive planning, language and learning, but at that base are the building blocks. things like lateral inhibition, plasticity, different types of timing, all those different features contribute.

For example, lateral prohibition and plasticities are the building blocks of memory. We don't test memory, we don' exercise memory what we do is we target lateral, inhibitions and plasticsity.

Those are features and those are basic functions that that are necessary. They're basic fundamental building blocks that're necessary and that's really all we can measure.

We don't want to try to measure cognition or language because those things get messy, you know, because changes that you get, it's like error propagation and everybody that went to high school or college and experienced, went high-school physics or you know, some type of chemistry question or whatever, you experience where you might've moved a decimal place somewhere at the very beginning of the problem.

You're going to have a huge error at end. Well, that's the kind of error you get with error propagation when you have something go wrong with one of building blocks.

Something goes wrong the building block. then at the very highest level, things go off in a different direction. So it's very hard to compare a language deficit in one person versus the language deficits in somebody else, when it

could basically be a fundamental building block that's really the problem.

You mentioned traumatic brain injury, and what have you learned about using brain gauge testing in patients who've had concussion or traumatic injury?

Well, we basically, back in 2000, We started getting concussion data many, many years ago, around 2010. And we started doing studies in sports concussions back then.

and that's where we got our original data. And after we got some data that showed, which shows it very favorably, it tracks very well, the kind of data we get from the brain gauge tracks, very for tracking response and recovery.

And then we were asked to, after, we started getting that kind positive data.

Concussion, TBI, and timing measures

we were asked to join the Office of Naval Research's BLAST program. BLAS is an acronym for what it sounds like. And what we did was we brought in and they sponsored us to further reduce.

I mentioned that the brain gauge has lost 100 pounds. Yeah. In 20 years, it's now a lab and a mouse, but at the time, I think it weighed about 10, the device weight about ten pounds.

And when Office of Naval Research started sponsoring us, we could afford to pursue and start building this device smaller and smaller. We participated in a number of military studies, both in TBI, concussion, and sub-threshold.

of studies like sub-threshold concussion, where people are on the artillery range, they're experiencing subconcussive blast pressure. And we actually could detect, you know, very small dips in their performance that resulted from handling heavier artillery.

So what we're trying to do there was just trying help calibrate the exposure to the force and the modeling that was done on how much force were they getting impacted by.

They would wear force sensors, and then compare that to our data. Well, what changes are seen in a concussion in the brain and how is the Brain Gauge able to detect?

Well… It might be a very difficult question to answer, but… Okay, so like we said, all our measures are measures of connectivity and connectivity gets disrupted.

That's the easiest way to look at it. And we have multiple metrics. None of the… All these metrics are independent. They all target different things.

When you look at, say, somebody with a concussion on day one, certain measures will be impacted immediately. But day three through five, you'll see, other measures, will get impacted due to inflammation.

And then, different measures we'll get better. Which reduces their lateral inhibition, is that correct? Or did they sensory disperse? Yeah, lateral ambition is one of those metrics.

Other things like, timing perception, just delivering two stimuli and asking, which of these lasted longer. That's actually a cerebellar parietal pathway.

Before we started, you mentioned TMS, like one study. There are several studies. If you block cerebular activity with Tms, You cannot do that particular task.

That is one way that we know this. The other way we that cerebelum is involved is that people with injuries that are in the back of the head or have lesions in their cereblum have very difficult times with doing timing perception.

Other measures, like just asking the temporal order judgment or which, you know, delivering two stimuli and saying which of these came first, that's more frontal.

And even though it's a timing related task, it does not many times in concussion, sports concussions, You'll see somebody that is impacted by one on one measure, but not impacted on the other because it is front of the head versus back of head.

I'm sure you've seen that in your brain mapping. You know where some people, they have one part, not in the another part. So anyway, we, and what we've, the hard part is, well, We came along with a lot of different measures and initially our bat, our test battery was about 30 minutes, but we had to keep titrating it down because the demand was, Well, that's too long.

We finally got down to what We call a triage protocol and you know, what's the most, What's The biggest bang for the buck. And that just a five minute protocol where you get, over 90% accuracy and with TBI or concussion and we're actually evaluating concuss versus non-concussed or fighters or sports concussions, victims, students, people with sports, patients.

Fascinating. So anyway, typically what we found was, and, we also did studies with an animal models of concusions where we, you know, basically dropped with rats and drop weights on their heads.

And basically our measures paralleled what we found in people with the brain gauge, parallel to what found and those laboratory experiments with animals.

With the animal experiment, it was a very lightweight, this was mild concussion, I have to emphasize, because you drop the weight on the head and they're up and walking around right after it.

There are no balance problems, no perceivable problems. all the behavioral indicators are normal, yet we found things with recording, through external recording that change significantly.

And one of those is things like, you know, variability of response. You see lots of neural variability, and we could also measure that variability with sensory discrimination.

I imagine that maybe pain is particularly more interesting, I don't know, because of the experience of pain and I see a lot of patients who have pain or chronic pain, or history of We even have a clinical trial going on with phantom limb pain.

So I tell patients, well, there's the actual pain and then there is the imprinting of that pain in the brain itself as well. And then, of course, the memory of the pain, and there are a lot of psychological relationships to pain itself.

What can you tell us about your research in relationship that has pain has and cortical processing over time, say, with chronic pain? How does it change?

So this is a really good question. We've been studying pain. I've involved in pain studies since the 1980s. And as most people may not realize it, but they may see something they don't like.

They may hear something. You don' have any pain receptors in any other sensory component. Pain is in somatosensory. Now, mechanoreceptive inputs, things like vibrations on the skin, proprioception, et cetera, that goes to areas, cortical areas 3B1 and target there.

Mechanoreceptive go to one area. Pain receptors, like C fibers, delta fibers they project to a different part of somato sensory cortex called area 3A, which is right next to 3 B.

Is this a broadband area or is this what… It's in the brain.

Pain, migraines, and plasticity

In humans, it's a deep sulcus. It is kind of hard to reach. I know there have been some studies lately that targeted that area with ultrasounds and TMS.

People have tried to target those areas. They're very deep, very hard get to. But if they can, then it successfully reduces chronic pain. Another thing some people have pointed out is that there are studies where sensory testing, like the kind of sensory test we do, actually reduces pain because when you elevate activity in the area next door, remember lateral inhibition.

operates on multiple, multiple organizations, and multiple scales. It's a fractal organization. And one of the things that we studied both in animal models and in human models was those interactive, those tactile pain interactions.

How does pain impact tactile processing? How do pain impacts sensory discrimination? And it Basically, it's very disruptive, obviously, in many different ways.

I can go a lot of different directions with this. Basically you can do a lotta testing to see what helps with pain, what's modulating it, or is it getting better?

Well, anyway. Well by testing it first we're kinda measuring, localizing it I assume. You're talking a little bit about treatment, like treating an associated area through lateral inhibition that may reduce the pain to that area where the impact was made.

Is that just a simplified way of kind of… That's an example. People with migraineurs, one of the papers we published, 2013, I believe, migraneurs actually have lower the normal plasticity than people without migraines.

So when I say migraineur, I'm talking about non-episodic, not when they have an episode. They're not being tested during the episode, they just have lower than normal plasticity.

So lower-than-normal ability to mitigate new transactional incoming streams of data. Okay. One of the problems is that because they You know, they, well, yeah, it's, They have lower than normal plasticity.

Plasticity is your ability to adapt to the world. And so you can do that with the way, you know through sensory discrimination tasks, pretty straightforward, which you want to just measure and say, Well, how, How does somebody adapt this world very well?

And they don't adapt for it. If they have migraines, but you test them when they Don't have a migraine, You'll find that we're systemically different.

So if these pain patterns that are cortically present in the brain are and they're not plastic, how can they be potentially be retrained to be more plastic or to have that?

Yeah. Yeah. Well, I'm fascinated that your device, the BrainGage device actually has a way of measuring or quantitating that sensory effect as another objective layer for, say, tracking an intervention like psychedelics or TMS to how the brain is functioning.

How do you measure that change over time with the Braingage Device? We store all the data. All the date is stored. People track their responses. And you track how people are doing.

If an intervention is successful, we see their scores. Usually, if they're a patient, their score is not very good when they start. As they get better, they score gets better.

basically have a nice analysis app where people can follow their data. People look at their date quite often, both patients and clinicians. The brain gauge is used both in the clinic and it also, we have home units for patients or patients take units home as well.

When they take a unit home, the professional account or the clinical account can see whatever they're doing, see

what their activity is. Yeah. Would you be able to give us a little bit of a demonstration?

Sure. Yeah. Okay. Let's, I didn't realize I could share my screen. Can you show Ken? Okay, can you see this? Yes. Beautiful. So I'm going to jump out of here and go, exit this and show you, just do a little demo and I'll just type in my name.

and skip over this part, this is just where you enter session notes. This is the menu or the testing options. Brain gauge gym, we'll go over that in a minute, is where we go to the gym.

That's what I just jumped out of. Those are where the different exercises are. The standard battery is a battery which is used most often in research and that's where get we know what different brain gauge scores are like for example Um, not too long ago, somebody said, Hey, where are the study that we just completed?

And they just published a paper on depression and how the measures acted by depression. Well, we've got, you know, studies that go on and like I mentioned, developmental disorders, traumatic disorders pain, behavioral, like anxiety, depression, pharmaceuticals, everything.

I mean, there's a lot of papers going on because they got students of students writing papers that I don't even know about. Um, aging is also an area.

I'm not going to give you a demo on that. All of these are subsets. We had to keep getting things shorter and shorter. And then we finally, the trade off that we found was about four minutes for a triage to where we could still get about 90% accuracy.

But I'll just show you the quick check novice and show what it looks like. You pull this up and it comes up. This is just a simple reaction time test, but there's two things about this reaction.

Time test. Number one, it's very important that you use somatosensory system to do it. And I'll begin training here. And number two, it's very important that you, well, if you time out it doesn't work.

So basically- So somebody would be holding the device and- Holding the devices, right. Yeah. Okay. Then actually I'm going very slow because I- Click your pointer finger, D2, as soon as you feel the tap.

So I feel a tap on my middle finger then I respond with my other finger. And one thing is with this particular device, it has one third of a millisecond accuracy.

That's extremely important. It does everything.

Tracking change with BrainGage reports

This entire test is done outside a computer system. We did studies on different systems and found that they added anywhere from 100 to 400 milliseconds of error.

And your normal reaction time test should be about 200 milliseconds. I'm talking, so I am going to be really slow. And each time I feel a tap, I respond and hopefully I'll get faster.

It's going to be embarrassed. Okay. Let's see you do it in a few seconds. And at the end of this test, this is just a 90 second test and And you're clicking.

And basically, I'll show you the important feature of this are not just speed, but also reaction time variability. So as you see my numbers up here, they're bouncing around.

That's the variability, somebody with ADHD or poor focus has really high variability somebody who's really focused. They're going to have very low variability so this is, you know, these scores are really horrendous for me.

I'm normally in the way. There we go. So just had to do at least one without talking. Yeah. Two more. Scale bar is almost done. And then I'll show you what the report looks like.

This is a report for quick check. And this is what people are using and what I recommend people using at the clinic every time somebody. So just for the audience so that they didn't see because you, you're basically responding to the sensory.

I'm feeling a tap on one finger and I respond on the other finger. Other finger, okay. Okay, and there's a lot of reasons this is more accurate than other systems, but any online cognitive assessment that does reaction time is generally inaccurate.

We published that a few years ago and showed that the last 30 years of data out there is the people did reaction. Time was, was kind of garbage, which is going to get people upset.

But the paper got people. Even the finger tapping test that we do, we, do a CNS test, you need to have an accurate device. Like I said, yeah. less than a third of a millisecond error.

And if you've got 100 to If your normal reaction time is 200. So that can't be built in to this device itself, knowing that there's an error, a baseline error already, and it can be excluded from the response.

Yeah. Like we have one third of a millisecond of error. But if somebody has 200 milliseconds of air, sometimes it's 200, Sometimes it is 400. Sometimes is 100. It's not steady.

Okay. Its because Google and Microsoft don't care. about your timing issues. They are going to service whatever they service. So this is the 90 second tracking, lower numbers are better.

So I was mostly around 200 and then I bounced up, I wasn't talking too much, went down when I quit as much. My reaction time variability was still eight, which is in normals five to 15. This kind of slow for me, but we see, you know, elite is like under 160 milliseconds and that's what elite athletes are doing.

They like, they want to be the best of the The faster people are, the slower the rest of the world is. So you can see how that would be beneficial to somebody.

Um, so anyway, what we tell people when they're over 600 milliseconds, which by the way, if you use a cell phone and find an online app for doing reaction time, that time will be over six hundred.

I mean, it adds 400 milliseconds of error. Yeah. And a lot of people have tried to get around it, but they just can't. You know, It's, just better. Better go with something accurate.

You have an engineering background. I'm sure you understand that. Over here, this has been a research tool for well over 20 years. We converted it so that red is bad, green is good.

So this is a consumer version. All the research infrastructure is still there. And we still work with researchers. But we make it simple so you can sort of see what's going on.

So this would be an initial test that the patient would do. They would get their reaction time. And then over time, with post-treatment, you can measure that and track that.

Let me go here. So our audience is mostly patients and lay persons, but some providers and clinical work as well. OK. You can see this. When you, let's see, so this is somebody, well, here's somebody that was doing, he was during both the brain drain to maintain brain fitness.

Yeah. And then he got exposed to black mold. So sometimes things happen. Got exposed a black mole. Then he slowly got better. Um, when he get black, mold removed.

This is. What happened to his reaction time? It was actually time we got horrible. Yeah, it increased, but it looks like it's decreasing. It went to 427. 400. Oh, okay.

So it was doing it the other way. Whereas up here, he was at 179. That's pretty good. Then, you know, um, here's, uh, this was a kid with ADHD and he, was getting treatments where, when he started, didn't look all that good, scores weren't that great.

He got, got better. initially, so they took him off his meds a little too soon. He's off of his Meds here, but then after a while he got better. Now his focus score is perfect.

So, you know, that's another example. How would you measure plasticity here? Well, there's a lot of different ways to measure Plasticity. Basically, what we do is one way to do it is see how fast you're adapting and how well that like, how we deliver multiple stimuli, multiple vibrations and one by how much does one vibration have an impact on the next vibration and we can measure There's many different aspects of plasticity.

One is how well do you adapt? How fast does the brain get bored with what's going on? But also how much better is it getting over time? And it's sort of the opposite of brain fog.

Your brain gets sharper and sharper with a longer and longer stimulus, with the longer vibration. But when you change the vibration, it changes abruptly.

Classicity is poor, it doesn't change at all. So it's kind of a complicated protocol, but it parallels beautifully with what we did in animal models for measuring the same thing.

We'll show us some other features of this device. What's that? Can you show some of the features on this other device and what else we can measure?

BrainGage gym exercises and therapeutic use

What else can we measure. Well, accuracy is what we were talking about in terms of lateral inhibition. TOJ is temporal order judgment, which came first.

The frontal parietal measure. Timing perception is basically which one. And how would this be measured on the device itself? Could you demonstrate that?

Well they're all, okay, let's see. Let's go back to here. We'll go to the gym. I'll just go through the exercises real quick. So a patient would come in, they would go into this module and they wouldn't apply this as a kind of a workout for their…

This would be the workout that they do. So this is the therapeutic level of the brain gains. And there's 20 different levels. This is where people with stroke will start.

They might only be able to do level one. Level one is easiest, level five is hardest. And then it goes, there are four other pages. There's basics, basics plus, basic, basis plus et cetera.

Each gets harder and harder as you go on. And let me go back to there. Basically you're, okay, so like you were asking what are different things. So if I click here, it's gonna decide which tap came first.

I'll get two taps. If I hit the wrong button, that'll give me an X. And it'll do it again. It'll tap once and then tap twice. And if I hit the right one, the correct one.

Give me a checkmark. So some people have real trouble with sense of order. It's really hard to get these wrong. I have to do it on purpose just to show you what it looks like.

But if you get 80% or 100%, then the box is green. Do you see a difference between laterality? Because some of

your work has been on the hemispheres, the difference in hemisphere response with patients with injuries.

Would you be able to kind of train one side to train the other or vice versa? Well, like I said, somebody, when they don't have use of one hand, you have them use the opposite hand.

There's connectivity is waking up, is connected to other hand now, whether it has an impact or not. Who knows, we can't make any claims, obviously. We can claim that this diagnosis cures or treats anything, but I can just tell you what happens with different patients.

So when you use the opposite hand, your whole brain, you're whole network is connected. And so, you know, it's not limited to what side. So the temporal order judgment task I just showed you, that's a frontal measure and that is both sides.

And you actually have a study where TMS blocked what was going on locally in somatosensory, but because it didn't impact how you did on TOJ. because it's a frontal measure.

It engages the whole brain. Timing perception is the same way. You use all of the cerebellum. The cerebelum connects, you know, all the sensory cortices.

And that's like, it coordinates things with somatosensory and visual and auditory, and helps you move and navigate the world. People with poor balance have trouble with this particular exercise, but like, say, people with dyslexia have troubles with exercise.

We have a case study where somebody with Uh, very poorly on her tests with us, but when she started doing the exercises, we started getting better. So the whole idea was you get your scores better by exercising in the gym.

Yeah. It says, Oh, well, does that mean everything else is getting. Well, so far that seems to be true. So people with, let's try one more. Let's look at the plasticity is an exercise and it's just going to deliver two more, two vibrations.

And it was just gonna ask, you know, which one's more intense. I'm just answering on the which ones larger. They're both coming at same time. People with brain fog do very poorly at this one, but they actually get better after a while and their brainfog.

You know, they report that their brain fogs better. So this one is not time dependent at all. It's just, uh, something that, you know you do one, basically it's really hard to get them wrong.

When you're, when you start doing this and just is it a little bit like. It's really easy. It is very easy at this level, but people start advancing at their own pace on different levels.

Going to the gym, different exercises, or different weights, if you're thinking of this as a weight bench. or a pull-up bar with weights or whatever, you just…

Can medications or other pharmacological interventions produce measurable changes in processing? And how do they affect the response? Yeah, absolutely.

Medications will impact the responses. In some cases they're positive, in some case they are negative. And it really depends on the medication and whether this is helping or not.

When we first started studying, the very first group we studied was autism. That was the first… funded group that we got, and that's what launched us to build the world's first portable tactile stimulator.

And we were doing, we started doing studies and it was like, everything was coming out. Just, We sort of had a, there's sort a at the time of the test battery we're doing.

It was, like okay, this person is autism. This person, they fit the profile. We started getting a profile of how people did on different tests. and as we, in there was an, after every, And we'd been through a bunch of individuals, tested a whole bunch individuals and they tested very different from neurotypicals.

And then we started calling people back in like several months later, we called some of the people backend just for test, retest reliability. and for the most part, everybody tests exactly the way they had.

And one 15-year-old kid comes in and he says, like, oh my gosh, he doesn't look like he's got autism at all. What's going on? None of his scores fit the profile anymore.

They all look neurotypical. And so I asked somebody, I said, what's goin' on. Well, we can't tell you. Whaddya mean you can tell me? Is he in another study?

Medications, autism, and functional testing

Well we cant tell ya that. I finally got to the bottom of it. Okay, well he had a double-blind placebo study, blah blah, and I was like well that's gonna impact his score, isn't it?

And then I went and I tried to, okay, so really interesting study, but the other study you get in trouble. Why? I don't care. I'm old. The other stuff they were giving.

They're giving a medication, and they said, oh, we're going to show, We'll see if there's a difference using MRI. I said you got to be kidding. And said You're not going see that difference with MRI, you need to do a functional test.

Our test will show that different, your test, will not. But I finally got them to agree. It's like, okay, well we could work together. Yes, yes we can track your patients and show how the changes are.

Well, they quit doing the study because they didn't see any changes with the drug. I said, of course you don't say any change in the drugs, but they just stopped the.

All together. And I was like, we have a lot of anatomical changes. Yeah. You showed with this particular medication, it changes, makes these changes? Why don' we keep doing that?

Well we're not, and they're just kind of, yeah, that's not what we were funded for. We were founded for doing MRI. It's like well that number one approved that study.

That's the stupidest idea I've ever heard. Yeah. Yeah, but so you're saying that this intervention that the patient was undergoing was making an impact on the functional testing that you were conducting.

Functional testing showed. Wasn't seen on anatomical changes in MRI. Right. Right. And that's one thing to tell your, you know, people often wonder what is this?

And I was like, well, it's a functional assessment. Very true. This is the big gap, I think, in healthcare when we're really functional systems oriented, but we are not really looking at the whole picture, the connectivity.

I tell patients, The whole body is connected. It's not just your brain, It is your gut and your environment. You know it is such a dynamic situation. And yet we are very limited in healthcare by just focusing on saying that we're just going to look at the MRI or, you know, if somebody's got a head injury, nothing's seen on the MRI and the patient's like, well, I'm still having problems.

So having ways to assess functionality is such a critical part. And there's many ways, too. I see that there are many way to measure that and yours being one of them.

What is something people commonly believe about the brain say that your research suggests is wrong or at least incomplete? This is a question I have often about what lay persons believe.

Well, the very first we tackled at the beginning was… I get the reason we, the very first group that we work with was with autism. And the. We started working with that group is because I had studied many columns, smallest functional element.

That was one of the chapters in my dissertation. So I, and there was a bunch of literature about that. Manuel Casanova wrote a bunch of stuff about it.

And I had talked to him about ways to look at histology. It was very similar to what histologists in post-mortem, individual post mortem with autism. Yeah.

Basically, what is the structural, the basic structural unit and the interaction between those units? And it turns out that a lot of people like to say they had this almost a mantra in the autism field.

This was back in 2004. And they had this almost a mantra where they said, well, you know, people with autism have hyper-conductivity, hyper, hypo-connectivity locally and hy-po connectivity, broad, long range.

I was like, no, that makes no sense whatsoever. Because however the functional unit is working, the base functional units, brain is a fractal organization.

And Manuel Casanova is also of the same impression, because the cells are so close together, They have poor interconnectivity. And so the very first series of tests we did in autism, we're looking at the impact of that directly.

Nobody paid attention, but it did flip over in a way that it flipped that dogma. even though I still presented it to people and they still said some of that dogma because they didn't understand.

So you're saying the interconnectivity of the columns in the cellular matrix. leads to poor connectivity between columns, leads the poor conductivity between groups of columns et cetera.

It just, it's a front that keeps growing. And so all scalers are impacted by whatever the pour connectivity is on the lowest scale. and that's just makes sense from any kind of engineering perspective.

If things aren't connected well locally and it is a repetitive process, you're not going to have good long range connectivity and poor short range conductivity.

it just make no sense. So in your opinion, what would be a treatment for treating interconnectivity issues locally? Well, it's case by case and, you know, depends on the differences.

And for example, we do know that in some cases, a GABA-B agonist helps with individuals with autism with poor connectivity. Other cases it doesn't because they have different, and you can actually see it in the measures.

It's called feet forward inhibition is one thing that we measure. And that's by delivering a less really complicated protocol. Well, basically what you're looking at is feed forward inhibition is where you deliver a very small stimulus that can't be felt, something that sub threshold.

And normally as it grows, then there's two, as that stimulus grows is still ignored. and as a stimulus, it's continually ignored because feed, forward, inhibitions keeps turning off circuitry, even though it is a small, stimulus you can feel.

it can turn on circuitry that does turn off subsequent stimuli. And some individuals with autism we found had higher than normal feed-forward inhibition and some had lower than the normal.

The ones who had a lower-than-normal feed forward inhibitions benefit from a GABA-B agonist. Anyway, we looked at a lot of different cohorts on that and the other cohort who have lower the normals.

feedforward inhibition would be people with pain, chronic pain have, that's the difference between chronic and

acute pain. And also like diabetics have higher than normal feed forward inhibitions.

That's because it's tied to a neuro cell, a class of cell or glia form cells that actually produce insulin. So people do, don't realize that they have cells in their brain that produce insulins.

They think it is all, but anyways, I digress. Wow, I can see how this becomes more and more layered.

Where the evidence is strongest

And, you know, whenever we talk about a brain technology, when it appears, there's always a risk of that technology getting ahead of the science. So where is the evidence for brain gauge strongest today?

And where do you think people should be cautious about making claims that the research hasn't fully established yet? We did 25 years of laboratory animal research before we ever even did any of this.

So, you know, we never, were really slow bringing it commercially out. We're not getting ahead of anything that we've done. we got 150 plus publications where we looked at things like autism.

As far as just a assessment tool, We've got many, many papers in all these different areas where in that, as far, is, You know we're, not going to get ahead.

Were not making any claims. were just saying, here's how the score is different. or these different populations, and this is what the science tells us about those scores.

We've done collaborative work with people doing things like TMS, eFMRI, you know, EG, it's a quantitative EEG looking at, okay, so we have a better understanding of what our measures mean than pretty much anybody I mean to be in all humility.

we've been looking these measures and seeing, for years. because we're just a group of scientists and engineers and nerds, we really aren't marketing people.

So, yeah, and I've been accused of not making, you know, not jumping ahead as much as I should. And that's why we are not big in the marketing space. But I'm like, well, I am a scientist first.

Yeah. Somebody else might make claims, but I'll just claim those people's. Well, in comparing the different options here for treating with autism, drain injury, you know, depression or pain, what would you think would show, I guess, would be most beneficial for us to study in the larger clinical trials, the technology applied here, which will give us a greatest bang for our buck, say?

I think, well, I've seen a lot of case studies with stroke that are really fascinating. And I, there's a lotta bang for the buck there. I seen, we worked with people who are working with Parkinson's, but a study that, okay, one thing to keep in mind, and I'll back up and say, look, everything's spectrum.

People, you know, most people that aren't in the field, that're not in any of the fields, they say oh, this individual has autism. What they don't think about is, oh no, not all people with autism are alike.

There's a huge spectrum ranging with IQs ranging from 50 to 150. You know, it's, and there's different levels of educate, different like that in every single process, every, single disorder or issue such as Parkinson's and stroke and TBI even, I mean, TBL obvious.

because you have, but you know, none of this gets exploited as well as it could. I mean, we're seeing, I think low hanging fruit right now in case studies that I'm seeing is early dementia.

We're saying people turn around and I. That's probably a big bang for your buck too, is because so many people are shuffled off into memory care units where it can be prevented.

And that's a sad part. Yeah. there that's, I think there's a lot of Parkinson's stuff, not every person with Parkinson, but I there are a lotta Parkinson and Alzheimer's that could fall in that category of early dementia or early, it could be reversed.

just because you're seeing this huge exponential growth in neurological disorders. So tracking people, the way we track them seems to be extremely beneficial because number one, you can see what works and then you could say, well, take it into your own hands and you figure it out and people are taking this and they're tracking themselves and doing training and reversing things.

So I think that's the, that would be the biggest bang for the buck is actually in that elderly space that sees lots of stroke, lots dementia and just basically, or, and or Parkinson's.

But I've seen a lot of people. The, the far ends of the spectrum. Yeah. You just always got to remember everything's a spectrum, there's lot to overlap between everything, but just the main case is getting people to realize they can do something for their own brain health.

20 years ago, when we had the worlds, we built the first portable tactile stimulator, which was huge. We got 20 pounds. And I told my colleague, I said, you know, We're going to get this down to the size of a computer mouse and make it affordable and distributed for everybody.

He's like, no way. You're crazy. I Said, No, this is a way to do it because once people can understand and contract themselves, wouldn't have to worry about insurance.

That was a whole nother story. But anyway, I just think it's really important if people care about their brain health to try to do something about it.

Yes. And I imagine, also there's that spectrum that you're talking about optimization. You're taking about athletes, you talk about people who really want to performance based.

Yeah. That you can really assess and measure as well, both ends of the spectrum here. What are the few things you believe help protect brain health today?

What helps protect it in general? Well, okay. What you can do to protect your brain. Health is good diet. I mean, that's most of the stuff I eat is from my farm and, you know, organic foods, stay away from glyphosate.

That's, poison, and don't go out and spray Roundup. Cause what they replaced it with is even worse. Nobody sued for saying things like that. But, you know, stay away from chemicals and, in the air, clean water, Stay outdoors, exercise and exercise your brain too and be able to track it and see how you're doing.

I think those are the most important things to promote brain health. And good sleep. Yeah, exercise, mostly. And exercising, having something to exercise our brain besides our phones and work, you know, but having a way to, support brain health, just like a muscle.

I did used to tell my students, throw away your phone one day, 24 hours a week, don't look at it, at least one. Yeah. The ones that did it said, Oh my gosh, they were It makes a big difference.

Protecting brain health and daily habits

You're blown away. The difference that's contributing. Especially the younger brains. Well, yeah, I think attention spans have gone from about 12 minutes in the 1970s to three seconds.

And so we need to, and so it's going to be rare for somebody to get this far on a. But what people want to hear, they think, I can't tell you how many times people say, well, if you can tell me something in 30 seconds, then, you know.

Yeah, yeah. Very true, very true. Our attention spans have declined. And we're, phones are a form of neurofeedback. I tell patients, it's a formal neuro feedback.

You're training your brain, your training yourself to be distracted. So you're going to get distracted, that's exactly how it works. It's dopaminergic, and you get addicted to that same behavior.

That's right. So it is a form. And we have the capacity of plasticity. Plasticity, I believe it's a very important term to really disseminate in our culture is the ability that the body does change.

It's not fixed and optimization and change can happen. I see how your device is really, really eliciting this and having something to measure and to use.

Thank you for being here. We often close with some rapid fire questions and or a question that you have in mind for me. Like what is a curious question?

Because this is two curious MDs. And what would be a questions you'd like to ask me? Well, I mean, just talk about your practice a little bit. How would you integrate this in your process?

And that's what I'm always curious about. What I tell people is the best way to use this, is ask people every time they walk in the door, or do the two-minute test, and don't worry about testing them after whatever type of intervention you're doing.

But always test when one walks in. Then you get the long-term trend. I'm always curious if that will work. Yes, definitely. They're diagnostic. And I am a big believer in diagnosis, diagnostic interventions that help patients and validate patients.

You know, a lot of times when I entered this field, I was trained in integrative medicine. One of the things I saw was that psychiatry is this black box.

We're like, this is a blackbox, and we're treating a Black Box on dosing patients with all these chemicals and medications, treating side effects. And we were just like we are chasing our tail.

It didn't make sense to me, it made my head spin. I was like slow down. This is slowdown here for a second. So the concept of storytelling came in. You have to sit down and get to know this person, understand their story, see what's going on, learn about their history and the context of who they are.

So I call it the Context of Care. That was one element. And then came, of course, conventional medicine, which wasn't working, systems don't work. insurance systems are governing the process.

And so I stepped out of that. I was in academics and really interested in the science and research. Couldn't get time. So I said, look, I'll just do it myself here.

Then came psychedelics and ketamine treatments. Of course, then we staged into TMS and neural feedback. Because the ability of connecting again to the deeper consciousness space and altered ways in supportive ways with therapy.

So I can see your device being a very important part of kind of that assessment and giving patients kind have some ownership and some valid, you know, validating their symptoms essentially.

They see it, they can track it themselves and they, it empowers patients. It does. as well, and it gives them a sense of like autonomy and agency in their course of treatment.

And I, by doing, we do kind of testing, We do the QEG for that same reason to help. This is what we're seeing right now, And this is What we are seeing as we go.

So definitely see this, your device as a form of that diagnostic tool, as Well as an assessment of progress. One thing I've noticed with different people that are using the BrainGage is that it's switching from a doctor-patient relationship to almost like a coach-athlete relationship.

Because once the patient starts understanding, starts looking and paying attention to their scores, they start getting compliant, and they say, What you told me to do really worked.

And look at my scores. Oh, I did bad now this night. Why is that? Well, because you didn't sleep last night and different things. They, it's really fascinating, you know, to get more invested and start taking a bigger role in it instead of just trying to receive passively.

So we call our, call the brain gauge shim the active component and the you know, what most treatments are, are considered passive. It doesn't matter, the patient is passively receiving something.

But if they activate the heart and start working on basically physical therapy for the brain, then they start getting vested in how well they do each day.

And that's pretty interesting, pretty good. So rapid fire, you ready for rapid-fire questions?

Closing reflections and rapid-fire questions

No, this is rapidfire. Okay, ready? Okay. Neuroplasticity, overhyped or underappreciated? Underappreciated. Sleep or exercise, which has a bigger impact on the brain?

I think that depends on individual. When I exercise I sleep better. There you go. Can your fingertips really reveal what's happening in your brain? Absolutely.

Yes. Okay. I figured that would be. One brain health trend you're skeptical about. The trend of picking something out of the Krebs cycle or picking And, you know, whether it's all about, they say, oh, it is all magnesium, potassium, vitamin C.

It's like, no, It is not just one thing, its a system. That's true, very true. What's one things most people misunderstand about concussions? Well, if you've seen one concussion, You've Seen One Concussion.

And that is one true thing that's True. and that what they don't understand is very dangerous to get another concusion right away. Yeah. And in your opinion, will objective brain testing someday be a routine as checking blood pressure?

It is in the clinics that we're working with. I mean, where they take heart rate, blood, pressure, and they do the brain gate quit check. They do. So they did 90 second tests along with heart, rate and blood.

Every day, every day the patient comes in. Well, I want to thank you again for being here today. How can somebody find out more about your device or more?

Well the best thing to do is just find our website, which is, the name of the company is Cortical Metrics. But if you type in Brain Gauge, that will pop up right at the beginning of your search.

Come to the website. And if want talk to me, there's a place on there that says Schedule A Consult. That's me. If you want really learn more, come to one of our workshops.

We schedule them right now. workshops about every other week and where we do a deep dive into a deeper dive. The original workshop lasted all day. This one takes a couple of, you know, 90 minutes to two hours.

And it's really an introduction to some of the science behind the brain gate and some other cases. And if patients or people want to know more, we'll definitely post it in our show notes as well, along with all of your YouTube videos

and other works, even your publications.

If you want us to be somewhere, you can definitely put them in the shownotes because you've done an extensive amount of work, 40 years, 45 years with UN University of North Carolina, Northern California.

I'm still here in California, so extensive work. Really appreciate you being here today. It was a great conversation. Thank you. Thanks for joining us on the To Curious, MD podcast.

We hope today's episode inspired you to ask new questions and explore fresh perspectives. We challenge you to ask us those unasked questions that you're curious about in your medical practice, condition, health and wellness.

If you enjoyed the podcast, don't forget to subscribe, share it with somebody just as curious and leave us a review. It helps us keep the curiosity alive.

Post or comment with a question or curious inquiry that have and seek to explore or learn with us. Stay curious, and we'll see you next time.