Welcome to the Huberman Lab podcast where we discuss science and science-based tools for everyday life. I'm Andrew Huberman and I'm a professor of neurobiology and ophthalmology at Stanford School of Medicine. Today my guest is Dr. Wendy Suzuki. Dr. Suzuki is a professor of neuroscience and psychology at New York University and one of the leading researchers in the area of learning and memory. Her laboratory has contributed fundamental textbook understanding of how brain areas such as the hippocampus, which you will learn about today, how the hippocampus and related brain circuits allow us to take certain experiences and commit them to memory so that we can use that information in the future. Dr. Suzuki is also an expert public educator in the realm of science. A few years back she had a TED talk that essentially went viral. If you haven't seen it already you should absolutely check it out. In which she describes her experience using exercise as a way to enhance learning and memory. And on the basis of that personal experience she reshaped her laboratory to explore how things like meditation, exercise, and other things that we can do with our physiology and our psychology can allow us to learn faster, to commit things to memory longer, and indeed to reshape our cognitive performance in a variety of settings. As such I am delighted to announce that Dr. Suzuki is now not only running a laboratory at New York University, but she is the incoming dean of arts and science at New York University. And of course she was selected for that role for her many talents. But one of the important aspects of her program she tells me is going to be to incorporate the incredible power of exercise, meditation, and other behavioral practices for enhancing learning, for improving stress management, and other things to optimize student performance. Today you are going to get access to much of that information so that you can apply those tools in your daily life as well. Dr. Suzuki is also an author of several important books. The most recent one is entitled Good Anxiety, Harnessing the Power of the Most Mistunder-Stewed Emotion. And a previous book entitled Healthy Brain Happy Life, a personal program to activate your brain and do everything better. And while that is admittedly a very pop science type title, I will remind you that she is one of the preeminent memory researchers in the world and has been for quite a while. So the information that you'll glean from those books is both rich in depth and breadth and is highly applicable. By the end of today's discussion you will have learned from Dr. Suzuki a large amount of knowledge about how memories are formed, how they are lost, and you will have a much larger kit of tools to apply for your efforts to learn better, to remember better, and to apply that information in the ways that best serve you. Before we begin I'd like to emphasize that this podcast is separate from my teaching and research roles at Stanford. It is however part of my desire and effort to bring zero cost to consumer information about science and science-related tools to the general public. And now for my discussion with Dr. Wendy Suzuki. Wendy, great to see you again and to have you here. It's been a little while. It's been a while. So great to be here, Andrew. Thank you so much for having me. Yeah, delighted. I'd like to start off by talking about memory generally. And then I'd love to chat about your incredible work, discovering how exercise and memory interface and what people can do to improve their memory and brain function generally. Yes. But for those that are not familiar, maybe you could just step us through the basic elements of memory, a few brain structures perhaps. You know, what happens when I, for instance, this mug of tea is pretty unremarkable. But the fact that now I've talked about it, I don't know that I'll ever forget about it. Maybe I will. Maybe I won't. So what happens when I look at this mug and decide that it's something special for whatever reason? Yeah. Well, I like to see there are four things that make things memorable. Number one is novelty. If it's something new, the very first thing, the very first time we've seen something or experienced something, our brains are drawn to that, our attentional systems draw us to that. And when you are paying attention to something, that's part of what makes things memorable. Second is repetition. If you see that cup of tea every single day and every single time you do an interview, you talk about your cup of tea, you're going to remember it. That's just how our brains work, repetition works. Third is association. So if you meet somebody new that knows lots of people that you know, so you and I share many, many, many, many people that we both know, it's easy to remember, it's easier to remember you, especially if you were somebody new that I hadn't met before. We have met before. So association. And then the fourth one is emotional resonance. So we remember the happiest and the saddest moments of our lives. And that also includes, you know, funny, surprising things. That is the interaction between two key brain structures, the amygdala, which is important for processing lots of emotional, particularly threatening kinds of situations. But those threatening, surprising kinds of situations, the amygdala takes that information and makes another key structure called the hippocampus work better to put new long term memories in your brain. So that in fact is the key structure for long term memory, the structure called the hippocampus. Fantastic. So novelty, repetition, association, and emotional resonance. Yes. You can tell us a bit more about the hippocampus. I think at least for my generation, while I'm a neuroscientist, but for most people in my generation, I think they first heard about the hippocampus from the movie Memento. Oh, yeah. Where the eye says hippocampus. And for those of you that haven't seen that movie, it's a bizarrely constructed movie, but an interesting one nonetheless about memory. But even as a neuroscientist, sometimes I'm perplexed at how the hippocampus works. Maybe if you would step us through what this structure is, what it looks like, maybe a few of its subregions, because unlike vision, the top of the eye worked most of my career on where we know, okay, the eye does this part and the thalamus does this part and the cortex does that part. I've always been a little perplexed about the hippocampus, frankly. And I've read the textbooks and I've heard the lectures, but I'd love to get the update. What are the general themes of the hippocampus as a structure and its function? What do you think everyone, including neuroscientists, should know about the hippocampus? Absolutely. So let's start with the basics. The word hippocampus means seahorse. It is shaped. The structure is shaped like a curly, cute seahorse. That is accurate. Everybody, including neuroscientists, should know it's a beautiful structure. It is visually and atomically beautiful with these kind of intro-twining twirly subregions within it. And I think that's one of the reasons why early anatomists who were the very first neuroscientists got attracted to it because it's this interesting twirly structure deep in the heart of the brain. So that's anatomically functionally what does it do? Well, it's easiest to understand what it does when you look at what happens when you don't have a hippocampus anymore. What if you, what if by some, you know, disease or you have your hippocampus removed by accident, what happens? Well, we know this from the most famous neurological patient of all time. His initials were HM. So all psychology neuroscientists, neuroscientists know him. He was operated in 1954 and the paper was published in 1957. They removed both the hippocampi because he had very terrible epilepsy. And they knew that the hippocampus was the genesis of epilepsy. And this was experimental. His epilepsy was so bad that they decided not just to remove one hippocampus, but both. And what happened was immediate, immediate loss of all ability to form new memories for facts and events. Think about that for a second. All facts or events, you're not able to remember. I can't remember this interaction between us. I can't remember any of the facts that we were just chatting about in our neuroscience lives. None of that can move into our long term memory. So this hippocampus does something with all of these perceptions that are coming at us every single day, every minute of the day. And not for all of them, but for some of them that have these features that we just talked about. Maybe they're novel. Maybe they have associations. Maybe they're emotionally relevant. Maybe they've been repeated. Some of those things in the realm of facts or events get encoded in our long term memory. And that's the textbook of why the hippocampus is so important. I like to always add, and I mean, this is why I studied it for so many years. The hippocampus and what it does really defines our own personal histories. It means it defines who we are. Because if we can't remember what we've done, the information we've learned, and the events of our lives, it changes us. That's what really defines us. That's why I wanted to study the hippocampus. And I think the exciting new ideas about the hippocampus was, is that it's, you know, hippocampus is important for memory. If you say that, you'll be impressed all your people at your cocktail party. But what people have started to realize that it's not just memory. It's not just putting together associations for what, where and when of events that happened in our past. But it's putting together information that is in our long term memory banks in interesting new ways. I'm talking about imagination. So without the hippocampus, yes, you can't remember things. But actually, you're not able to imagine events or situations that you've never experienced before. So what that says is the hippocampus is important for memory is a two simple way to think about it. What the hippocampus is important for is what we've already talked about associating things together writ large. Any time you need to associate something together, either for your past, your present, or your future, you are using your hippocampus. And it takes on this much more important role in our cognitive lives when we think about it like that. That is kind of the new hippocampus that that neuroscientists are studying these days. That's fantastic. So it sounds like it really sets context, but it can do that with elements from the past, the present, or the future. Yes. And for neuroscientists, the phrase is domain. We say the time domain, meaning as opposed to just evaluating things in space. It sounds like the time domain of hippocampal functioning is incredibly interesting. It is. And even the fact that we can have short term, medium term, and long term memories. And we can go down any of these radicals. I'll ask you a true or false, mostly because I just really want to know the answer. A few years ago, the theme in various high profile reviews seemed to be that the hippocampus was involved in encoding and creating memories, but not in storing memories. And that memory storage was in the neocortex or the other overlying areas of the brain. Is that two general statement? That's a tricky statement because I think that ultimately, yes, that long term memories are stored in the cortex. But those memories are stored in the hippocampus sometimes for a very, very long time. So how long is too long where you say, oh, it's not the hippocampus anymore. If it's four years, does that mean that it's not stored in the hippocampus? I think that's a tricky question. And yes, it was coming up a lot because people were debating it. And some people did think that you shouldn't think about the hippocampus as a storage area. But I think it's a long, long, long term, kind of intermediate storage area, maybe not the long term storage area. That's why it's hard to answer that question. As I recall, HM could remember facts from before his surgery. He couldn't form new memories. And given that he had no hippocampus, it would at least partially support the idea that some of memories are retained outside the hippocampus. However, he did have part of his posterior hippocampus intact. So that's the tricky thing. I think initially, in fact, Scoville, the neurosurgeon, overestimated the number of millimeters he had wanted, he intended to remove the hippocampus. And then when they did this, the very historic MRI of HM later in his life, they showed that in fact, he did have that posterior hippocampus, part of the posterior hippocampus intact. So now it makes it a little bit more complicated to interpret what's going on, not that it was never uncomplicated. Any interpretation of a lesion in a patient, as you know, is complicated. But, you know, HM had this mythical role in neuroscience and neurology. And now it was, it was complicated because he does have more of the hippocampus intact. I did not know that. There are some memories that can be formed very quickly, so-called one trial learning. And I'm just looking at this list, again, novelty repetition association and emotional resonance. It seems like some experiences can bypass the need for multiple repetitions. Yeah, absolutely. And unfortunately, it seems that our nervous system is skewed toward creating one trial memories for negative events, which has a survival adaptive mechanism. What is the neural connection that allows that to happen? Is it the amygdala to hippocampus connection? I mean, as you and I know, it seems like every brain area ultimately is connected to everything else. There's just a question of, through how many nodes, just like every city is connected to another city. It's just a question of how many flights and routes do you have to traverse before you get there? What is it about one trial learning? At a kind of top contour level, how can we learn certain things so fast? And other things are tricky. Now, every time I look at this white mug, it's queuing up something special that's simply by virtue of saying it. So is that one trial memory? But what is it about very emotionally salient events that allow memories to get stamped in? Yeah, I mean, I think you've already alluded to it. That is, there is this protective function of our brains that has evolved over the last 2.5 million years. That you need to pay attention and remember certain things for your survival. So some things that get stamped in, their memories, but their fear memories, if I get mugged on the subway or their terrible things that could happen on the subway as we just learned. But if something terrible happens, if something very scary happens, you remember that and that fear and that memory of all those things. I mean, I have one, when I lived in Washington, DC, I went to work at NIH on the Sunday afternoon and I came back and when I rounded the corner to my door of my apartment, it was crowboy barred in. I had taken a crowbar, opened up my door and stole all of my, all of my, the nicest things in my apartment, which wasn't that nice because I wasn't making that much money. But ever since, ever since then, whenever I rounded that corner, I still had that memory. It was terrible because you know, it put me in a terrible state when I was just coming home. And that's a survival mechanism. Do you want to be alert to possible danger? Absolutely yes. So part of those one trial memories, I think, is often taking advantage of this evolutionarily developed system to tamp in things that could be potentially dangerous to you into your memory. You forever will remember this particular corner or this, this hallway because that is where something really bad happened to you. It seems like a location. We talk about conditioned place of origin, which is just a Geekspe for wanting to avoid the place where something bad happened or conditioned place preference, wanting to go back to a place where something positive happened. And even looking at a photograph of where you had a wonderful time with somebody and that kind of vocal sorts of positive sensations, it seems like at some level, the, as complex as the brain is, the basic elements of feeling good or feeling lousy are, are states within the brain and body. And linking those to places seems like it, it's a pretty straightforward formula, you know, link place to state, link state to place, etc. Description just provided. When we learn more complex information, you know, a poem, a concept, or we have to ratchet through a set of ideas, that also involves memory. I'm sure that we'll talk more about this, but is there any way that you're aware of that state bodily state can be leveraged to enhance the speed or the quality of the memories and memory formation? Because, you know, so to be clear about it, it seems there's something very important about this fourth, you know, this emotional resonance component. Right. Novelty, the crowbar into the doors, thank goodness, it sounds like it was novel, it wasn't repeated, thank goodness. So repetition is out, and the association is very, very strong. But for people trying to learn information that they're not that excited about, or that repetition is hard, or the novelty is simply that it's painful. Yeah, I've been there, absolutely. As have I, is there something that we can do to leverage knowledge of how the memory system works naturally to make that a more straightforward process? So I immediately turn to the things that I've studied that you talk about so beautifully on your podcast, which are strategies generally to make your brain work better. I was just reminding myself of your podcast about cold, because I use that every morning. Oh, you do call it. I do. I just take a moment and just tell us what is your cold exposure for? So my cold. So my cold exposure protocol is at the end of every morning shower that I take, you know, the showers is warm, but I give myself a big blast of cold at the end of that. And it makes me feel so good. And because I've been doing it for several years, it's so much less painful. Okay, I meant it was really painful at the beginning, but it's much less painful. I could, I could handle the cold water and my pipes are give nice, really cold water. And it just, I could feel, I could feel the, the awakeness kind of come, come up in me after that. And so, and I miss it. If I forget to do it, sometimes I run back in and give myself that cold blast because it is, it is uping. You know, I think you talked about this on your podcast. What's happening in the brain? Basically, the cold stimulus, that shock that, you know, catching your breath, et cetera, is adrenaline from the adrenals, but also from what we understand now, some new neuroimaging. There's epinephrine and neuroepinephrine release from locus cerulias, which again is the brain structure in the back of the brain. And got sprinklers, the rest of the brain with, with the kind of a wake up chemical. And there's a long arc on dopamine release. This paper back in 2000 showed that it's a steady increase up to about 2.5 acts of circulating dopamine. So they weren't looking directly in the brain admittedly, but it goes on for four or five hours. So they improve mood and the feeling of alertness is a real thing. Yeah, yeah. So I use that. I mean, so basically I use my morning routine. What is my morning routine? I get up. I do a 45 minute tea meditation. So meditating over the brewing and drinking of tea that I learned from a monk who has an institute in Taiwan, where he teaches tea meditation. Love it. I've learned all about tea, different kinds of tea. And then I do a 30 minute cardio weights workout. Then I take my shower with the hot cold contrast. And, oh, and before that, key thing, if I want to learn something, and I want to be able to get over the difficulty of repeating things, or just push myself to do stuff, sleep. So good, good sleep. I've learned that over the pandemic, I did sleep experiments on myself. And I learned that I was sleeping an hour less than I really needed. So I really need seven and a half to eight hours of sleep, and I was getting six and a half. And so now, you know, I get that seven and a half to eight hours every single night. And guess what? I come to different difficult tasks, and I am more willing to give it a try, to try longer, to try harder. And my brain works better. And so I think probably if you go back to all of your podcasts, you'll learn exactly why each one of those things that I do, which I would bet that you probably do too, is helping my brain. I guarantee they are, and I'm impressed that you do all these things, although not surprised. And I should say that the extra hour of sleep is really impressive. And extremely beneficial. I'm curious, do you get that in the early part of the night, by going to bed earlier? Yeah. Yeah. Terrific. And I should just mention, because you're too humble to do it, but I'll say it again, that yes, not only are you a full professor running a tenured full professor and running a laboratory, you teach undergraduates, you have an important role in public education, multiple books, and you're now dean of the College of Arts and Sciences at NYU. So the extra hour of sleep is benefiting you, and as a consequence, benefiting everybody else as well. Thanks for sharing with us your protocol. I took you off the trajectory of what one can do, but I think that people, and I appreciate knowing, you know, kind of with the practical steps. Yeah. Yeah. Yeah. Because knowing the science is important, mechanism I do believe is important for embedding protocols and people's minds and why they might want to do them. But really hearing that the mechanics of it is useful. It sounds like everything together takes about an hour. It's not an excessive amount of time, but it probably gives you an outsized positive effect on your day. Absolutely. I definitely notice it if I'm not able to do it. And when I don't, I do this seven days a week. It's also not just, you know, five days, seven days a week. And when I can't do it, it's usually early morning flights or things like that. And I get over it, but it's critical, critical for the working of my brain. I love it. And I'll just highlight one thing that you said before we move on, which is that you said when sometimes what if you get out of the shower before the cold, you'll get back in. That's to me a really beautiful example of condition plates preference. Now the cold showers become something that you sort of look forward to. I should say that nobody is immune from the adrenaline increase of cold. No matter how cold it is, this is what's interesting about cold. It's one of the reasons why it's such an important part of the screening for special operations. For seal teams, but other other branches of military to which is that they're fair very few stimuli that you can give anyone and consistently get an adrenaline release from that without harming them. You know, eventually you need to use so much heat that you damage tissue. Yeah. Or with exercise, you have to use one exercise that you can damage joints. And it's this very kind of brilliant. I don't know if it was intentional or not. It's sort of unintentional genius that they the special operations has figured out that they sending people back into the cold over and over. It never really gets easier. But over time, people actually start to crave it. And it provides this reduction in inflammation, et cetera. So anyway, beautiful practice. Thank you. I want to learn more about your team meditation later in the episode. In any event, returning to ways that we can improve memory formation. Yeah. Maybe if you would, tell us your story around this. I know you've told it before, but a lot of members of the audience and I would love to hear how you came to this because growing up in neuroscience, I knew you as one of the, I would say one of the three or four and they're all alongside one another. This isn't a hierarchical statement at three or four top memory researchers in the world, right? textbook material is Suzuki in the, my textbooks are filled with the word Suzuki your last name according to the information on memory and memory formation. So you were doing that. And doing the things that academics do. And then you're still doing that. But yes. And still at a very high level, but then things took a different direction. Maybe we could talk about your story and how you came to the place you are at now. Yeah. Because I think it provides a number of tools that people could implement themselves. Yeah. Yeah. So this story happened as I was working to get tenure at NYU. And as you know, it's a stress filled process. They give you six years to show your stuff. And you are judged in front of all your colleagues. And either they say, okay, you can join the club or they say, sorry, you are humiliated in front of everybody. They actually tell people to leave. Yeah. If you don't get tenure, you're gone. You have to leave your institution. And so, you know, you work really, really hard. And so my strategy was, I'm just going to not do anything but work. And I'm just going to work. And I'm going to just work as hard as I can for the six years. And what happens when you work and you don't have any sort of life outside of work and you live in New York where there's all sorts of really good takeout, you gain 25 pounds, which is exactly what I did. And you get really, really stressed. And you start to ask yourself, how come I'm living in New York City? And I love Broadway. And I've never, I haven't gone to a Broadway show in two years. And so I, so I, I, 25 pounds overweight. I decided to go on vacation. And I went by myself because I had no friends. And I went to, I did an adventure river rafting trip in Peru. And so I go by myself and, you know, meet other interesting people. And I, I was the weakest person on this whole trip. Like I was, I, there were so much in better shape. It was embarrassing. And they won't say this. They want to admit this to me, but it was true. And I kind of came back and I said, OK, I cannot be the weakest person. I'm in my late 30s. I have to do something. So I went to the gym. And I said, oh my god, I'm 25 pounds overweight. Let's, let's try at least to lose this weight. And so I go to the gym. I noticed how much better I feel when I go to just a single class. I remember the very first class I went to was a hip hop dance class. And then fast forward year and a half, I've lost the 25 pounds. So proud of myself. So much happier. And I'm sitting in my office doing what you and I do a lot, which is writing an NIH grant, which is our lifeblood. Right. And writing, writing, writing. And this thought goes through my mind that had never gone through my mind before, which what during this six years of grant of Friday. And that thought was, grant writing went well today. You know, that that felt good. I was like, I've never had that thought before what's going on here. This is really weird. I don't know that anyone has had that thought before. I'm sure people have had that thought. But I thought, maybe I'm just having a good day. But when I thought about it, I thought it's not just today. My grant writing seems to have been getting smoother. I'm able to focus longer. The sessions feel feel better to me. And you know, at that point, the only thing that I changed in my life, it was a huge thing. But I had become a Jim Rat, rather than a workaholic. And that's when my, you know, spidey sense for neuroscientists popped up. And I said, what do we know about the effects of exercise on your brain? Because if I think about it, what was better about my writing is I could focus longer and deeper, very important. And I could remember those little details that you try and pull together for your million dollar NIH grant from, you know, 30 different articles that you have open on your screen all at the same time. That's the hippocampal memory. I was studying that. I was writing the grants on, on hippocampal memory. And so that's when I got really interested in the effects of exercise on both prefrontal focus and attention function and hippocampal function. Because of my own observation and this kind of, I still remember where, where I was sitting, which office I was in when I had this revelation. But the thing that really sealed it for me that made me think, not just, oh, this is interesting, but I want to study this is right around that time. I got a phone call from my mom, who said that my dad wasn't feeling well. And that he had told her that he got lost driving back from the 7-11, which is literally seven blocks from our house that I grew up in. And I knew that was, that was hippocampal function. I suspected dementia. I suspected, though, didn't want to admit Alzheimer's dementia, which he, which he had. And it was funny because, I mean, it wasn't funny, but my mom and dad are two sides of a very different coin. My dad is the, the, the engineer, not so active all his life, but would loved and sit and read books all day. My mom was the athlete. She played tennis team tennis into her 80s and, and it started to show at that point. And so then I had, then I had even a more pressing reason to think about what the effects of exercise were because I noticed that all the things that were improving in my brain suddenly went away. And my dad's brain really, really smart guy, engineer and, you know, Silicon Valley helped help that push in Silicon Valley in the 70s happen. He had no more memory. He couldn't focus his attention. His mood was rock bottom. He's a very happy guy. And everything was the opposite in me. And I started thinking, this isn't just something to help, you know, somebody who wants to get tenure. And I thought, you know, I think it was something that could help millions and millions of people, most importantly, our aging population. What if, you know, what's happening? And so the thing that makes me wake up in the morning is when I realized that every single time you move your body, you are releasing a whole bunch of neurochemicals. And so that's why the thing that's happening in the morning is that you can see that the mood comes from dopamine and serotonin and noradrenaline. But the thing that gets released also, particularly with aerobic exercise, is a growth factor called brain derived norotrophic factor or BDNF. And that is so important because what it does is it goes directly to your hippocampus and it helps brand new brain cells grow in your hippocampus. And even if you're a couch potato, you can get new brain cells in your hippocampus to grow. But it's like giving your hippocampus a boost with this regular BDNF if you are exercising, which means that we all have the capacity to grow a bigger, fatter, fluffier hippocampus. So what I like to give people is this image of every single time you move your body, it's like giving your brain this wonderful bubble bath of neurochemicals, what's going on? I need my bubble bath of noradrenaline and dopamine and serotonin and growth factors. And with regular bubble baths, what am I doing? I'm growing a big fat fluffy hippocampus. And I'm not going to cure my father's dementia, Alzheimer's dementia. But you know what, if I go into my 70s with a big fat fluffy hippocampus, even if I had that in my genes and it starts to kick in, it's going to take longer for that disease to start to affect my ability to form and retain you long term memories for fax and events, which is my motivation for getting up. And doing my 30 to 45 minutes of aerobic exercise every day. Fantastic. Quick question about your protocol, just because, and then we'll discuss a few mechanistic things related to what signals the body might be sending the brain and a little bit more detail on BDNF and some circuitry. So, you 30 to 45 minutes, it sounds like cardiovascular exercise might be special. But as I say that, and I think about the literature that I'm aware of in mice and some in monkeys and certainly in humans, looking at the effects of exercise on brain function and typically the outcome is improvement almost always. I don't think I've ever seen a paper showing that when animals or humans exercise more that their brain gets worse. I just can't think of a single paper doesn't mean it doesn't exist. I'm sure someone will put one in the comment section. They'll find that one and thank you for if you can find that. But it seems like it's always cardiovascular exercise and experimentally in a lab. It's a lot easier to get a mouse to run on a treadmill. Then it is to get a mouse to lift weights, although people have put little ankle weights on mice and done. And the ways of getting mice to do resistance work is actually a little bit barbaric because oftentimes they'll incapacitate a limb to overload another limb. So it's an asymmetric thing. It's not the same as sending them into do squats or dead lifts or something. But cardiovascular exercise might be special. What are your thoughts on that? Please first tell us your routine. Your routine is 30 to 45 minutes of, are you a peloton, cyclor? Does it matter? I think that the data suggests that as long as your heart rate is getting up for these long term effects on your hippocampus and prefrontal cortex, you also get better at shifting and focusing your attention. For that, you need cardiovascular. And what I use is a video workout that I started even before the pandemic is called Daily Burn. And it's just thousands of different workouts. But I love they are 30 minutes that I sometimes add on a 10 to 15 minute stretch at the beginning or at the end. But I love the variety. Sometimes I do it with weights, sometimes I do it without weights. I love kickboxing. So they have a lot of kickboxing in there. It just fits my, fits my, fits my routine. And it's always there. And I don't have to get all dressed up to go to the gym to work out. So that's, that's what I do. And that's a daily thing. Seven days a week. Seven days a week. Fantastic. So in terms of the way that some of these changes are being conveyed from the body to the brain, that fascinates me. As you and I know, and I'm sort of a repeating record on the podcast, always saying, you know, you've got a brain, but you also have a spinal cord and then your nervous system connects everything. Every organ in your body is basically signal to buy the nervous system and back to the nervous system, it's spoiling everything. But so let's imagine you're morning routine, you, you, you, your cardiovascular exercise. Okay, so you're pumping more blood. That's the definition of a higher heart rate stroke volume of the, of the heart goes up over time. You're getting fitter. So blood flow, the brain is increasing. Do we know how that gets translated to a signal to release more BDNF? Yeah. And then it raises this other question, which is, does it matter where your mind is when you exercise? Yeah. Because ultimately the brain, of course, you can anchor your attention to the exercise or you can be listening to a podcast or something else. And I'm not sure if you're wondering about this. Yeah. Yeah. Can we enhance the effects of exercise by combining the enhanced blood flow with cognitive work during exercise? Yeah. Yeah. Or is it simply a matter of just getting more blood flow up to the hippocampus? Yeah. I wish I had the answer to that question too. My instinct is yes, it matters. And actually because of the work of your colleague, Alia Crom, on, on mindset and the power of that to change how physiologically our body is responding. So how could it not work in her experiments and work in her experiments and not work for my, my morning or our morning exercise routine? So, but, but are there studies point to a study? I don't know of when. So exercise neuroscientists out there. I'd love to see, you know, that that study done. So yes, it works. Before I go into the aerobic thing, I would like to start with the least amount of exercise to get something really useful because I don't want people to say, Oh, God, I hate, you know, sweaty and I don't want to listen anymore. So, so I always like to start with studies have shown that just 10 minutes of walking outside can shift your mood. That is part of that neurochemical bubble bath that you're getting dopamine serotonin or adrenaline. And 10 minute and anybody can walk for 10 minutes. And so that is for all of you thinking that out there, what is the minimum that I could get some of these benefits 10 minutes of walking anybody can do it is outside important. I'm a big believer in getting photons. I think that that study was done indoors on a treadmill. So, and the comparison wasn't done. But moving your which is great. I, you know, some in the middle of the pandemic, I walked around my apartment for 30 minutes sometimes just for some variety. I felt like a rat on a running wheel, but, but yes, so, so that that minimum amount of movement in your body can get you the those mood effects. But what about the big fat fluffy hippocampus? What about the better performing pfrontal cortex? That's where you start to need the cardio cardio workout. And from my reading of the literature, there haven't been enough studies, you know, directly comparing contrasting kickboxing with running with whatever whatever other cardio that you need to do. But any cardio workout that is done has these positive effects. So, I'm going to say my interpretation of that is that whatever way you get your heart rate up, including a power walk, a power walk can get your heart rate up. That that is beneficial. And what is happening? There are two pathways that have been studied about how you go from moving your body to more BDNF that that neuro trofen that's that's increasing the growth of new hippocampal brain cells. The two pathways of the following one is a myocaine, which is a protein released by the muscles. So, and not your heart, these are striated muscles in your body. And so by running this these were studies done in rats on running wheels. They showed that the running rats had more of this myocaine release the myocaine past the blood brain barrier. So, got into the the rarefied very protected bloodstream of inside the brain. And that myocaine stimulated the release of BDNF in the brain. That's pathway number one pathway number two comes through the liver because exercise is a stress on generally how do we know that well cortisol is released whenever we exercise it we need we need that sugar in our blood. And so so that's how the physiological mechanisms work. And so there is a ketone beta hydroxybutyrate that we've known for a very long time that gets released by the liver during exercise. And we also know that that particular ketone passes that blood brain barrier and it's another stimulant for BDNF. So, kind of the final common pathway seems to be BDNF stimulation in the hippocampus. Is it the only one? Probably not, but that's the one that has been studied most most clearly. So, it's you know it comes from all of our physiological systems our muscles working our liver responding to the stress of exercise and what is it doing it is making our you know giving more BDNF precursors to get into our brain to cause the up spike of BDNF which is part of your bubble bath that you're getting every time you move. I love that description of a factor from muscle and a factor from liver because any time we're thinking about movement of the body and translating that to the brain as you so clearly pointed out that needs to be true it needs to traverse the blood brain barrier not everything that happens in the body is communicated to the brain. And these seem like really important signals. Beta hydroxybutyrate you mentioned is a ketone I just want to underscore that doesn't mean folks that you need to be on a ketogenic diet. I think people hear ketone and they think that you know I know some people are most people are not I imagine. There are ketones that are released in your brain and body that can function even if you're ingesting carbohydrates and not ketogenic just for a point of clarification. This issue of new neurons is one that you hear a lot you know neurogenesis you're going to grow new neurons new neurons and in my understanding is that the rodent literature is very clear that animals that run on wheels more often turns out rodents love to run on wheels. You know the studies by Hoppy Hovster which are pretty funny they're very cool by the way Hoppy how to investigate drama not I'm not making light of them. They put running wheels in a field and wrote wild rodents will run to the running wheel and run on that running wheel. They really enjoy it. Yeah, yeah, I find amusing reasons that probably only a neuroscientist who find amusing in any case in rodents it seems that running more on a wheel can trigger neurogenesis that literally the birth of new neurons and the addition of new neurons to the hippocampus. In monkeys this has been controversial it seems it does happen in the hippocampus and the neocortex right thinking back to the decades more controversy between Liz Gould and Paschco Rikish I hope they settled their their differences there. Neuroscientist love to argue it's what we do and in humans I think it's been a bit controversial some people say absolutely yes other people say absolutely no their new neurons added to the adult brain. I haven't followed that literature down to the detail yeah, but I do remember one study that I don't think is contested which is the work of rusty gauge at the Salc Institute where they actually injected a sort of die type marker into the brains of terminally ill humans yeah who very graciously offered to have their brains removed and dissected after death yeah and in these very in some cases very old. Terminal human they did see evidence for new neurons being born in the hippocampus right can I trust that idea still is that generally accepted well so after that study which was quite a while ago there are more recent studies still controversial but showing and demonstrating using even new and better techniques than were using that that original rusty gauge study which was groundbreaking at the time that that suggest that it's not going to be a good thing. That suggest and I think show that there are new neurons born in adult human brains into the ninth decade of life so they not only did this I think those those patients were in their 60s then they they died of cancer. But these new studies looking across the timeline can we see because the other thing was yeah maybe you have someone you're 20 but by the time you're older and you might need these new neurons you have no new neuron growth and so these studies seem to suggest that yes yes you did yes you do and we all do even into old age so yeah. Great and I'll just take a moment to say that I am personally not aware of any studies looking at other forms of exercise besides cardiovascular exercise for sake of brain health and this I think is an important gap in the literature that ought to be filled whether or not for instance high intensity interval training or whether or not weight training. Which has other effects on the musculature so you can imagine perhaps the myokine to be DNF pathway the pathway one that you mentioned might be signal but maybe not the liver pathway maybe yes I'm speculating here those studies need to be done to my knowledge they just haven't been done yet and but they should be done. If you would could you tell us about some of the more specific effects of exercise on memory you know when memories abroad category of of effects and phenomena so things like what comes to mind is short term medium and long term memory reaction time. Learning math at least for me is quite a bit different than learning history although there's certainly overlap in the neural neural underpinnings what has been demonstrated in the laboratory in animal models but but especially in humans and if you want to share with us any results from your lab published or unpublished yeah sure that the audience would be delighted to learn about them absolutely let me start with kind of the immediate facts acute effects that they're called of exercise on the brain. So this is asking what does a one off exercise session do for your brain and there are three major effects that have been reproduced I've seen in my lab many labs have reproduced this so what you get with the one off this is usually an aerobic type type exercise session 30 30 to 45 minutes what you get is that mood boost very very consistent you get you get you get improved prefrontal function typically tested with a stoop test which is a test that asked you to shift and focus your attention in specific ways it's a challenging task and clearly dependent on the prefrontal cortex largely and significant improvements in reaction time so your your speed at responding often a motor kind of but cognitive motor response is is improved over the pandemic one of the unpublished studies that I did looking at the effects of 30 minutes of age appropriate work out in subjects ranging in age from their 20s all the way up to their 90s so what are the the things that I saw most consistently irrespective of your age everybody got a decreased anxiety and depression and hostility score which is very important you know it's so it's it's not just decreasing your anxiety and depression but decreasing your hostility levels making the world a better place making the world a better better place energy the feeling of energy went up and what we found is in the older population even more than in the younger population we saw improved performance on both stoop and Erickson flanker task which are which is another task dependent on really focusing in on different letters and paying attention to what letters being shown so so these are consistent effects how long do they last one of the studies that I did published in my lab showed that the immediate effects of exercise lasted up to two hours unfortunately that was the longest that we last they were still there at two hours so that's you know that's that's a pretty big bang for your buck that is one 30 minute sorry to interrupt I just want to make sure I understand so if when you say the effects lasted up to two hours does that mean up to two hours after you finished exercise or up to two hours of memory challenging working yeah just just to be clear yeah that's a great question so my study looked at two hours after you finish your work out we gave you these cognitive tests during that two hour period you were free to do anything except exercise or eat and so there was no no extra load on people but two hours later you did do significantly better on these focused attention tasks compared to a group that watched videos for for the exercise period this was an hour of cycling that they did these were young young subjects in their 20s okay so if I finish my exercise at 9 a.m. even if I start this cognitive work this mental work at 11 I'll still see benefits yes at least by 11 because I didn't go farther than two hours so it could last even longer than that but but I have evidence that lasts for two hours and and perhaps if I had started the cognitive work in 45 minutes after my exercise ended it would also be helpful yes so there's no reason I think that there's a there you have to wait before starting to work yeah no reason at all I'm asking questions of the sort that I get in the comments that we are going to get in the conversation we always strive for clarity here so what this tells me is that exercising early in the day may have a special effect right I realize that some people cannot exercise until later in the evening but you mentioned something earlier that I want to do is very very important I don't think I've ever mentioned this on the podcast which is any kind of physical activity will increase cortisol to varying degrees yes and so sometimes it's a healthy increase sometimes it's an unhealthy increase if you do two hours of really intense exercise and you're not prepared for it yeah that's a big spike in cortisol probably not a good thing yeah for most people but if you are going to do your cardiovascular or weight training later in the day that increase in cortisol can promote too much wakefulness for sleep etc shifting that cortisol spike early in the day is associated with a number of important things related to mood etc but more and more what I'm thinking and hearing is that exercise early in the day is key our former dean of the medical school Phil Piso what was in his kind of famous still for jogging between the hours of like four and five a m five and six and then running the medical school so and you're up early doing your exercise and cold shower and meditation will talk about meditation but this is more and more of a push I feel like or a stimulus for us to think about moving our exercise earlier in the day yeah I mean I like to say that you know I know there there are moms and dads out there and they just say look I have a kid that the kids more important than my doing my exercise so you will get benefits if you if you do it whenever whenever you can so that's great more power to you but what all the neuroscience data suggests is the best time to do your exercise is right before you need to use your brain in the most important way that you need to use it every day and so that is why the learning for most of us is beneficial that's why I do it in the morning I'm lucky enough to be able to do that but yeah it makes sense with all everything we know about how how this works and how it benefits our brain I think about our colleague Eric Kendall not incidentally has a Nobel Prize in studies memory and and rumor has it that he's been a swimmer for a lot of years yeah put in I think nowadays he's in his 90s now he'll put in half a mile but he used to swim a mile a day or something I heard that too that he was a swimmer and he does it very very religiously okay so there are a few other neuroscientists that do that I can think a lot of neuroscientist that probably should exercise more and I don't say that to poke it them I just would love to see them doing their incredible work for many more decades and everything that we're talking about today indicates that if one doesn't yeah unless you have incredible genetics yeah we all experience age-related dementia right I'm in the story of your father is it is a salient one and we should remember that as we go forward but I also want to emphasize and I love to get your thoughts on just memory and memory loss in general yeah it seems we all get worse at remembering and learning things even if we don't get Alzheimer's yeah when does that typically start for humans you know I think there's so much variability not only because we are individuals but because our stress levels are different and everybody's anxiety level has gone up in the last in the last couple of years but that also has an effect we we don't remember as much in a highly stressful highly anxious situation so so you know as you know it's hard to answer that question people say okay just tell me how much exercise I have to do okay just 30 to 40 my day but but I love that per day you know I've been doing this whole thing of telling people all the data say 150 to 200 minutes or zone to cardio which is kind of you know moderately hard but not excessively hard but I love this every day because what whenever I do that the questions that come back are what if I take a long hike on the weekends and so people starting to go she gave there's something that's very powerful about non-negotiable every day yes son in your eyes every day even cloud cover exercise for 30 for 45 minutes cold shower every day every day you know my understanding of the literature is that somewhere in our 50s or 60s we start noticing a little hiccups in memory yeah for some people younger for some people later yeah but I have to imagine that doing the exercise throughout one's entire life is going to help offset some of this simply because you're the BDNF and other downstream effects yeah yeah I mean that's that's what it suggests one of my favorite studies and then I want to get back to you wanted you invited me to share some of my unpublished data yes absolutely long term exercise but first I want to share one of my studies which is a longitudinal study done in Swedish women and this was published in 2018 and what they did was back in the 1960s they found Swedish women 300 Swedish Swedish women in their 40s and they characterize them as low fit mid fit high fit okay and then 40 years later they came back and found these they let them do live their lives and they asked what happened to these women as a function of whether they were low fit mid fit high fit in their 40s they're now in their 80s and what they found was that relative to the low fit or mid fit women the women that were high fit gained nine more years of good cognition later in life now this is not a randomized controlled study this is a correlational study but does it agree with everything that we've been talking about today yes does it agree with this idea that you know the women that were high fit were giving their brains this this bubble bath you know maybe not every day but very very regularly for that entire 40 years and that built up their big fat beautiful hippocampi yes it does so that's one of my favorite studies yeah another cause for getting the exercise inconsistently yes yeah there's no I am impressed by this 10 minute walk and the improvements in mood yes from just a 10 minute walk yeah but again I I think that daily repetition also I have to imagine has effects on the very pathways that allow plasticity this is something we did in the realm of neuroplasticity we don't often hear about or think about even as neuroscientists which is that the pathways for engaging plasticity probably can be probably I'm speculating here can be made better by engaging in the sorts of behavior this is that stimulate plasticity in other words if one gets better calming themselves down under stress those circuits get better at doing that there's a neural circuits gain proficiency yeah and so because blood vessels can grow capillaries can grow in the brain you can imagine that more pumping of blood to the brain delivery of these various muscle and liver factors would also establish larger or more efficient portals to getting that stuff there so you could imagine a kind of an amplifying effect of excess and again I'm speculating here but I've seen this over and over again in colleagues the ones who exercise consistently seem to be really really smart and doing amazing work well into their 80s and 90s and the ones who aren't some of whom actually pride themselves on how little they exercise they get worse over time you see them each meeting each decade and I'm not poking fun at them at all it's actually quite quite hard to see and they're kind of a fading light they're starting to flicker so there is this incredible relationship between body vitality and brain vitality that is of course is not an excuse for spending all day in the gym right the gym rats I enjoy working out so I could imagine doing that but that doesn't make us smarter unfortunately you actually have to do the cognitive work also right it's not just exercise right right so I'd love to hear about some of these new unpublished data yeah yeah okay so when I jumped into the exercise work everybody was studying people 65 or older because that's when cognitive decline begins and if the idea is exercise can help you with your cognition then makes sense however I thought well you know that it's great there's lots of work there I wanted to know what happens in people in their 40s and the 50s maybe even their their 30s and their 20s why because that's when we as humans are able ready will willing and able to increase our exercise and gets us set up to you know build our brains as we go into our 60s and so the first study that I did looked at low fit participants from their 30s to mid 50s and we wanted to ask this question you know how much exercise you really need to start seeing benefits do you see benefits or maybe you have to wait until you start seeing cognitive decline to get benefits that was one of the theories out there and so that's what I wanted to do and so what we did was three months of two to three times a week cardio it was a spin spin class so spin classes are great for cardio and the comparison group was two to three times a week of competitive video scrabble so no heart rate change but they had to come into my lab and being a group just like they were in a group for the spin class we tested them cognitively cognitively at the beginning of the end of the session what we found was two to three times a week of cardio in these people there are low fit which means specifically that they were exercising less than 30 minutes a week for the three months previous to the experiment so they went from that to two to three times a week of spin class what we found was changes in baseline rates of their positive mood states went up relative to the video scrabble group their body image got more positive because they were exercising which is great and really important their motivation to exercise went up significantly compared to the video scrabble group which is great so the more you exercise the more motivated you are to exercise what about cognition what changed in the cognitive circuits of their brain number one we got improved performance on the stupetask but we're headed towards my favorite structure which is the hippocampus what we found was improved performance on both a recognition memory task which was a memory encoding task and that is can you can you differentiate similar items that were asking you to remember and and spatial episodic memory task where we had them play one of those doom light games when they went into this spatial maze and they had to do things in a virtual city their performance there got better which is very very classically dependent on the hippocampus so so this I it was so satisfying to do this study because I've been wanting to answer this question what is a minimum amount or double amount of exercise that will get you these cognitive benefits and now I can say in 30 to 50 year olds that are low fit two to three times a week is that doable absolutely will it be hard if you're low fit yeah it's it's going to be challenging but absolutely doable and so you know that that is it makes sense with all of the all of the mechanisms that we are I didn't study the mechanisms just to be clear but with all the mechanisms we are imagining our plane a role here that absolutely makes sense and and it is doable this is not like you have to become marathon runner to get any of these benefits this is you have to start moving your body on a regular basis two to three times a week and I so I love that for its realness how long are those sessions again 45 minutes 45 minutes it's a typical spin spin kind of class is a warm up for five minutes and a cool down for five minutes so it's really 30 35 minutes 35 minutes of you know they're really pushing you yeah so and so they're breathing reasonably hard heart rate heart rate is up heart rate is definitely up yeah yeah I find that the all of those results are really interesting that the result showing improvement in motivation text or size is interesting because it gets back to this issue of kind of a self amplifying effect right and the neuroscientists in me wants to think about kind of premotor circuits and the fact that you know we have a motor system that can obviously do things like lift cups and walk and run if we want to or need to but that it's possible to do that it's possible to create a kind of anticipatory activity in our nervous system where our body and craves a certain stimulus you mentioned the cold and how you have the cold the weather not that's the adrenaline and the dopamine etc or whether or not somebody who exercise is started going from zero less than 30 minutes per week to two to three times a week 45 minutes as you're you describe for this study I had that experience before of if I'm job that the cardio that's I tend to battle the most and I like I love lifting heavy objects at least heavy for me I I'm happy to go to the gym every other day and just lift heavy objects for an hour it just makes me happy I like the way it feels yeah and I've been doing it since I was in my teens so 30 years cardio is a little bit trickier I like to run but if I stop running for a little while I find it very hard to get back into but if I start running three times a week for 30 to 45 minutes and I do this pretty consistently on the days I don't wait train I find that I start to crave it it's almost as if my body needs that in order to I always say clear out the cobwebs but it's like my mind doesn't function as well clearly now I understand why and why exercise helps but also my physically I almost feel like my body needs to engage in that movement like the premotor circuits are kind of revving the engine or car while it's a park yeah yeah so the motivation to exercise obviously could be multi-faceted it could be purely psychological but do you think there's any reason to speculate at least or believe that we can build an anticipatory revertory activity yeah yeah you know I I agree with that because I also have those same kinds of thoughts and and I do have anticipatory exercise when I can't do it so I just got back from a week and week and a half in Paris where I got to do a book launch of of my last book good anxiety and I I really I walked around a lot but I did not do my exercise for that whole week and a half and but there was a lot of stress because I have to do all these interviews in French so I gave myself break you speak French I speak French I would say otherwise it would be really stressful now I then I'd be really impressed then I would definitely start exercising I would actually I would follow your morning routine to a team but okay very impressive nonetheless so but I got back and and you know coming back this direction from from Paris I live in New York is is much easier and so I was able to get get up at a normal time the next day and that exercise session that first day is like okay I'm back in my home I'm back in my environment and it felt so good is like I wanted to come back and and I know it's because I I worked up over years now I could truthfully say seven days a week but it was you know first it was four to five then it was five to six and yeah seven but that includes a yoga day or sometimes I do for 10 minutes instead of 30 because I have to leave but but that habit of you do that even for five minutes you do either the the wait 10 minute thing or five minute thing or or stretch that is a tiny habit is that somebody at Stanford that invented this idea of tiny habits I thought it was well we've got a number of people there there's and I apologize and advanced all the people I neglect in this statement but I'm happy to put in the comments folks BJ fog is there has done yes and that's why yeah BJ's done really great work and then James clear wrote a book about habits and I has has a very popular newsletter about habits we've done an episode about habits that covers some of their work and and some of the more laboratory ish not ish laboratory science peer reviewed work on it daily behaviors also daily behaviors performed at roughly the same time on day I mean one thing we know for sure is that the circadian system is part of our nervous systems way of anticipating when things will happen just what will happen I'm telling you things you obviously know already but for the audience performing your exercise at roughly the same time each day will make it easier yes as opposed to just saying I'm going to do it seven days a week some time today but of course getting it done sometime is better than not getting it yes absolutely absolutely well those are impressive effects and I love that you're starting to look in populations that are a bit younger not because some of these older populations aren't important but I think that building good habits in across ones entire life is really what it's about right as I would say with anything related to longevity or offsetting an age related decline we don't know it's hard to know if things work because there's no within subject control but what we also know for sure is that you don't want to be the control experiment especially for something that's purely behavioral I mean you're not talking about ingesting a particular supplement you're not talking about changing your diet in any way but I am curious do you know diet is a very barbed wire topic on the on the internet which diets whether or not they work etc but in general did any of these studies do they evaluate whether or not people change their eating habits when they start to exercise more yeah I think I've seen one study that that controlled for that but I feel for them because it's hard enough to get people to exercise at the level and at the time and you know that you need for your study if you also ask them okay fill out the survey to tell us exactly what you ate all day they're going to say forget forget you I'm joining your study so it's a critical question and again there's only been one that I've seen and the evidence was that that diets got better when they you know less processed foods when when they did adhere to this exercise but lot more information needs to be gathered in that in that realm the second study that I wanted to share on publish were writing it up right now is part two of that study that I just described which was the low fit people next we move to mid fit people like what about us you know we're already exercising what how am I going to benefit from increasing my exercise so here again we collaborated with a great spin studio that had a whole bunch of mid fit people that that by our definition were exercising two to three times a week on a regular basis that's great all you people out there that are doing that you should know you're already benefiting your brain but our question was what if we invited them to exercise as much as they wanted at the spin studio for three months from you know two to three times all the way up to seven times a week and let's just see what happened and the control group we asked them not to change their exercise and so what we ended up with was a nice big array of starting with mid fit people that exercise between staying at two to three times a week all the way up to seven times a week and the bottom line from that study is every drop of sweat counted that is the more you change and you increase your workout up to seven times a week the better your mood was you had lower amounts of depression anxiety higher months of good good affect and the better your hippocampal memory was with the more you worked out again this was for three months so I love that too because it gives power to to those of us that are you know regularly exercising and wondering if I really need to I mean is it really going to help me and the answer is yes I mean not all of us can exercise go go to a spin class seven times a week but I love the message that our bodies responsive to that and and you can get better hippocampal function better overall baseline mood affect with with a higher level so works for the mid fit people as well fantastic the more I learned from you the more I'm starting to conceptualize the brain as an organ that is privileged in so many ways you know has this unique blood brain barrier as this incredible quality of being able to predict things and it's job mainly is of course to predict things among among other functions of course but that our brain isn't necessarily going to stay stable or get better over time that it needs a signal yeah it that it isn't sufficient to just say that we can't take it for granted that that our brain is actually an organ that requires a signal in order to maintain its own function yeah and it sounds like enhanced blood flow in these pathways that you described earlier these two pathways are at least among the more critical signals I'm tempted now to move my frequency of cardiovascular exercise from I confess it's about three days thirty five minutes lately and it should be more to daily there's something really again really special about daily because it's non negotiable you just do it right and it sounds like if one word to do higher intensity exercise you know in a spin class I've never taken a spin class but I've seen their times when they're standing up on the bike and pedaling very hard so that is included in these kinds of work absolutely yeah I mean that's what the instructor is doing I cannot control we did monitor heart rate you know of all the subjects and it was clearly you know compared to the video scrabble it was highly significant yes I guess it depends on how intense that game of scrabble is could we just briefly talk about mindset and affirmations yeah you've talked a bit before about affirmations and as you mentioned the beautiful work of my colleague at Stanford Alia Crom and who we can summarize her work pretty simply although we won't do it complete justice by she's already been on the podcast that just to say that one's beliefs about behavior also impact the outcomes of that behavior if you learn a lot of true facts about stress being good for you then you'll experience stress as better for you than if you only focus on or learn about the negative effects of stress if you learn about the positive effects of exercise you actually derive greater benefit from exercise believe it or not it's incredible incredible effects but they make sense when you understand what the brain is doing which is a lot of this predictive coding and mindsets don't seem as mysterious and who any more wants to understand what the brain is really doing but what is if any the value of affirmation of telling yourself something positive about yourself or exercise on not the exercise itself but on mood self image memory and brain function yeah so you know I I looked into this because I am also a certified exercise instructor in the form of exercise that I teach is called intense that it's a form of exercise that was developed by this amazing this instructor Patricia Moreno and she combined physical movements from kickbox and dance and yoga and martial arts with positive spoken affirmations so each move if you're punching back and forth as you would do in a kickbox class you don't just punch you say something like I am strong now which every punch is associated with the word and you know you you can create your own series of affirmations with the moves that you put together and the first time I did it I just wandered into her class I didn't know what it was and it felt idiotic is like what I came into the wrong class I clear I don't want to come into this class but then I saw they didn't care whether I thought they were they look silly saying these are not seeing yelling these affirmations out loud while doing the choreography at the same time and then I tried it you know OK I didn't yell out I kind of whispered it at first and then but by the end I was really yelling it out there's something about the declaration using your own voice of saying things that you you know don't often say yourself like I'm strong I'm inspired I believe I will succeed are all the kinds of affirmations you say and you walk out of that class or I walked out of that class thinking I feel really good now I can't come back to this class which is why ultimately you know took teacher training to be able to teach that class and so I I started to look into what was known about affirmations and they were never combined with with physical activity but it was clear that there was a literature showing that that positive affirmations saying them or reading them could change mood in the same ways we're talking about you know Aliah's crumbs work if you if you have this this it's a belief you once you start saying these things is or not you know difficult things to believe but it's amazing how much you you don't say these things to yourself or with your own voice you might say them about somebody else oh you're strong you're so smart do you say that about yourself and that's the thing about the the self affirmations it really gets you into a habit of of saying good things about yourself and then you start to remember start to realize oh my god I'm so mean to myself I have lots of negative thoughts going on about self in my head and which is part of the other reason why I loved this this particular form of exercise so what you get in intensity is the mood boost from the positive spoken affirmations together with all the other brain and affect boost that we've been talking about for this whole podcast from the exercise because it's a sweaty workout as well so interesting there's a book I confess I haven't read it but I have had the pleasure of having a discussion with a psychologist from I believe is at University of Michigan in Ann Arbor Ethan Cross wrote a book called chatter which focuses on the fact that so much of our inner dialogue it is indeed negative he certainly wasn't the first to to point that out but that explicit statements to counter that negative chatter I believe is one of the hallmarks of of readjusting one's own not just internal reference frame but actually self image generally yeah it's a fascinating and I think a very important area of psychology and neuroscience because and I and I acknowledge is we're talking about this too laboratory neuroscientists who record from neurons and label neurons and look at stuff down the microscope we are now deep in the territory the deep water of what some of our colleagues and and people who think about neuroscience would consider like really out there on the kind of subjective edges and yet I think it's worth pointing out that you know the brain does all these things it's responsible for simple reflexes and motor behaviors but also high level conceptual ideas about the universe and what it might contain years or a hundred years or a thousand years but also high level conceptual understanding of what we are and what we are about yeah and so even though it might seem a little bit out on the on the fringes dare I say I think that these are some of the more important untried landscapes of neuroscience yeah and I just want to acknowledge my appreciation for the fact that I'm going to connect the dots here and say you went from somebody who didn't exercise who went on this rafting trip yeah the discovered exercise and its benefits for your grant writing and then and then on and on and on and then became a certified yeah exercise instructor so so you don't do anything halfway either as it's clear I'd like to touch on something you mentioned earlier but we haven't been to it all in any depth which is meditation yeah you mentioned this team meditation you had a publication recently on a 10 minute meditation right maybe you could tell us about this 10 minute meditation it seems like such a tractable amount of time right and then if you would maybe tell us a little bit about the team meditation but sounds like you've discovered a minimum a close to minimum threshold meditation that can really benefit us yeah so maybe you tell us about that that study yeah so the study was as you as you very stuitly pointed out very practical study just 10 minutes not 30 minutes not an hour meditation that's too hard 10 minutes guided meditation they logged into a site so we can tell that they logged in and they listened to a it's a body scan very basic but easy to follow kind of meditation and we ask them to do it how often daily seven days a week you know just 10 minutes a day and the shock and the most shocking thing about the study is that we got more adhesion adherence to the 10 minute daily meditation than the 10 minute daily podcast listening which was our control so the highest retention rate I've ever gotten in any this kind of study that I've done exercise or meditation they wanted to do it 10 minutes a day it was it was great I'm going to just start leading meditations yeah for three hours as I was doing three hour podcasts so we looked at cognitive effects before and after this it was eight weeks of daily it was actually 12 minute meditation 12 minutes of body scan meditation and what we found was significant decreases in stress response so we did the strior stress stress test to see how how you responded to unexpected stressful situation the meditators did much better their mood was better and their their cognitive performance was also better and this was my first little foray into meditation after I had started my my personal team meditation that that really shifted my relationship with with meditation and but it's consistent with many other studies showing the beneficial effects of meditation and but the unique thing was we tried to make it doable that many many people out there could actually follow this this typical regimen and and so we're we're continuing that in fact my my research and my lab right now is all about those doable short things that NYU college students will do not just at the beginning of the semester but at the end of the semester when the stress and anxiety levels are now at record breaking high levels and they need something to bring that level down so that they could show their professors what their brains can actually do and so it includes very short meditations sound sound meditations visual meditations walking things that any college student but we're obviously focused on NYU students will do to and you know I want to get at graduation rates I want to get at class performance with these kinds of interventions but it started with that study that I just described. If you would and here's where we can highlight this again as some educated spec highly educated speculation. Yeah coming from you. What do you think is going on during meditation? Yeah. I mean so a body skin involves a kind of interreceptive awareness like you know interreception of course being in an attention to what's going on with on the surface of and within the confines of our skin as opposed to the outside world. Drawing our attention to anything inside us or outside us involves four brain function prefrontal cortex presumably and other things typically eyes are closed typically it's relaxing so there are a lot of variables that could be feeding into a number of different effects but but as a neuroscientist what do you think is going on that just that this period of kind of an self-induced somewhat unusual state. What do you think is going on in terms of network behavior and networks within the brain that it can have these long term effects because we got to some of the ones relate downstream of exercise and I I think there's so much evidence I know there's so much evidence that meditation is beneficial. Yes. How do you think it's working or what do you think it's doing? Yeah I think that one of the most important things that gets worked when we are doing a simple 10 minute or 12 minute body scan meditation regularly this 10 minutes a day 12 minutes a day is the habit building and the practice of focusing on the present moment. I think that is very hard for us modern humans to do because I'm worrying about the thing that's due at the end of the week that I need I need to do and how many hours am I going to have to be able to do that or I'm worried about you know whatever the email that wasn't as polite as it should be that I sent in what or the reprecussions for that instead of focusing on this moment which is fun I get to talk to you. It's a beautiful day outside it's I'm feeling good right at this moment and I think that those all of the meditative practices that I've done and this one also whether you know it or not is getting you to focus on on this moment and I think it's even more important in this day and age where anxiety levels and the next variant might come out and what what are the reprecussions there and I have a mother who's older and she's more susceptible to it and there's a war and and what's going to happen there those are all future possibilities and and we should be worried about that that is a possibility you need to plan for that but you also need to focus on this moment right now. I'm healthy I could breathe I get to have this interesting conversation right in this moment if I start thinking about other things then it takes away from this moment do I know what circuits are being are involved. Not exactly that is not my area I think there are some studies that have have focused on that that moment present moment kind of activity but that is what I think is most important about about the practice of meditation or one of the important things that calms us down because if you know how to do that that gives you this powerful tool for the rest of your day you're not locked into that fearful future thinking that so many of us have or that that that just reliving of a terrible past but you could enjoy enjoy the present moment. Yeah I that really resonates I think that going back to the earlier part of our conversation you know this the hippocampus has this incredible storage capacity and ability to set context about past present and future and that's a beautiful thing because as much as I like to think he had some semblance of a healthy life none of us want to be hm right none of us want to be in the position of not being able to form new memories and have no context to the past or or the present. So we're grateful that we should all be grateful that our hippocampus can draw from past present and future in various combinations and we should support it through the daily exercise and other habits let's call them habits so that people make them habits that you've highlighted. But if we are not deliberately anchoring within past present and future according to what we need and we're just shuffling between past present and future that is not a good way to live. No. No. It's not effective. No. It sounds like meditation can really help us go to the right stacks I guess people don't go to libraries anymore but in the old days you would go you need to go to the right location library you actually can't get distracted by the books that you're interested if you need to go just reflexively you need to go study a particular topic. Yeah. So that's kind of how I think about it. Yeah. It makes us more linear perhaps in our way of being. I think so and it actually counteracts you know not that I'm against technology but having our phones and being connected to every good and bad thing going along going on in the world today is incredibly distracting and takes you away from the present moment virtually 24 hours a day. And so we have to work extra hard right now compared to in the 40s when we didn't have all this technology or at the same level. So yeah it becomes even more important practice I think for every day life. Yeah or even 10 15 years ago it felt like smartphones weren't as intrusive. Yeah. One final question and maybe a request as the new incoming dean of College of Letters and Sciences and I must say I'm delighted thrilled actually to hear that a lot of the practices that we've been discussing today and that you've pioneered are going to be incorporated into undergraduate education. I predict and I'd be willing to wager that that will become a template for how universities and non-university systems should function because if indeed the end it is true that there's this incredible relationship between physical movement and mental deliberate practices and performance. Any corporation, school, household would be crazy, would be self limiting and even self destructive to not incorporate those. I'm so happy that you're going to do this and collect data. Yeah. Please we'll have to touch back with you and hear what comes to that. But one of the main things that I hear so much about today are issues with attention. And we haven't talked about attention we mainly been talking about memory and cognition. Yes. But you know a lot about attention. And here I'm not being disparaging. I think people have done what I'm about to say as a consequence of need and lack of other resources. There's an immense amount of Adderall use, Riddle and use, Medaphine will use, and caffeine abuse. Now I happen to like caffeine. I don't use the other compounds I described. But it's just incredible to me how the date on this our colleague of mine at Stanford claims that you know something like two thirds or more of college students use these without prescription for ADHD. Yeah. What can we expect in terms of the effects of regular exercise on attention? And are there any other things besides exercise and meditation that you would like to see people do in terms of trying to increase their powers of attention? Because I think the ability to to focus and attend is really the distinguishing feature between those that will succeed in any endeavor and those that won't. And that's a scary thing for a lot of people to hear because a lot of people think they have ADHD. They may they may not. But I bet that a number of students at both Stanford and NYU feel challenged with holding their attention to the thing that they need to hold their attention to. Yeah. Yeah. So I would say the top three tools that everybody read this minute today can use to up their capacity to attend. Where they want to include exercise for the reasons we've talked about has a direct effect on functioning of the prefrontal cortex meditation. Also clear clinical studies showing improved ability to to focus and particularly focus on the present moment. And the third has to be sleep. So sleep is you you can't it's out of the three. So it's the most physiological. I mean, I could I could live my whole life without meditating one minute. Could I could I survive without sleep? No, none of us could. So it's it's it's more basic physiological. But it is so important for all core cognitive functions, including attention, including creativity, including just, you know, good good basic brain brain function. That is why it's you know, it's so critical to get that information that basic neuroscience information into the heads of these students that are trying their best to show us how their brain work. But but being hampered because they're not moving enough. They're not meditating. And there's all these distracting things that they include in their lives. Some of which a little bit is good. But you know, 24 hours a day on your phone and and linked in not linked in but but linked to your phone is damaging to your attention. So exercise meditation, sleep can help you learn, retain and perform better than if you do not have these three things in your life. Wonderful music to my ears. And also either very low cost or zero cost considering that the exercise doesn't require a class. So one could do use the freely available resource of gravity to do jumping jacks or burpees or push ups or whatever or sit ups or all those. And don't forget YouTube the freely accessible millions of YouTube videos. If you don't want to do your jumping jacks by yourself, I always say this, you know, I talk about breath meditation in for my book Good Anxiety. And you know, if you don't like the one that I suggest, there's only about a million more on YouTube with with ratings from one star to five stars. So use that resource. It is a wonderful resource. And you're an amazing resource. Wendy, thank you so much for coming here today to have this discussion and share your knowledge about not just existing data, but new data coming coming out soon. And for your leadership in the university system, for your leadership in public education, for the decades of important work on memory and neural circuitry, which we got to learn about today as well. Thank you ever so much. Thank you, Andrew. Fun conversation. Thank you for joining me today for my discussion about learning and memory and how to get better at learning and remembering with Dr. Wendy Suzuki. If you'd like to learn more about Dr. Suzuki's work, you can go to WendySazuki.com. There you will also find titles and links to her popular books, as well as her social media handles. We've also placed those in the show note captions. If you're learning from and are enjoying this podcast, please subscribe to us on YouTube. That's a terrific zero cost way to support us. In addition, please subscribe to the podcast on Spotify and or Apple. And on both Spotify and Apple, you can leave us up to a five star review. If you have suggestions about guests or topics that you'd like us to cover on the Hubertman Lab podcast, or you'd like to give us feedback of any kind, please leave that in the comment section on YouTube. That's the best place to give us feedback. Please also check out the sponsors mentioned at the beginning of today's episode. That's the best way to support this podcast. We also have a Patreon. It's patreon.com slash Andrew Hubertman. And there you can support the podcast at any level that you like. On many episodes of the Hubertman Lab podcast, we discuss supplements. While supplements are certainly not necessary for everybody, many people derive tremendous benefit from them for things like accelerating the transition into sleep and getting better, deeper sleep, as well as enhancing focus and learning and other aspects of human performance and health. We're excited to announce that we've partnered with momentous supplements. The reason we partnered with momentous is several fold. First of all, we wanted to have one location where Hubertman Lab podcast listeners could go in order to find all the supplements that we talk about and to find those in a form where they could systematically try one or the other. This is a real issue in the supplement industry. A lot of supplement brands out there, combine different ingredients in ways that don't really allow you to pinpoint exactly what you need and what you don't need. So getting supplements that have low doses or just the minimal effective dose of particular ingredients and being able to mix and match those ingredients yourself and really establish what's best for you is really key. In addition, we came to realize that a lot of our listeners want supplements, but they reside outside of the United States. So we're pleased to tell you that momentous ships both within the US and internationally. And of course, momentous supplements are of the very highest quality ingredients and the precision of the amounts of those ingredients is tightly regulated. If you're interested in momentous supplements, the catalog of supplements related to the Hubertman Lab podcast are growing all the time. A good number of them are already there. You can go to live momentous.com slash Hubertman in order to find them and there will be additional supplements added to that site as we go forward. If you're not already following Hubertman Lab on Twitter and Instagram, I post neuroscience and other science related information and tools on a regular basis. Some of that information overlaps with the content of the Hubertman Lab podcast, but a lot of it is distinct from the information contained on the Hubertman Lab podcast. So again, that's Hubertman Lab on Instagram and Hubertman Lab on Twitter. We also have a neural network newsletter. What that is is a monthly newsletter in which I distill critical points from different podcast episodes, provide links to useful resources. If you want to sign up for that newsletter, I should mention it is zero cost and we do not share your email with anybody and we have a very clear privacy policy posted at Hubertman Lab.com. Just go to Hubertman Lab.com. Click on the menu. You'll see the neural network newsletter. You can also look at examples of newsletters without having to sign up to make sure that you actually do want to sign up. But if you are interested, the sign up is there very easy and you can receive our monthly newsletter. So once again, thank you for joining me today for our voyage into the neuroscience of learning and memory and tools to get better at learning and memory. And as always, thank you for your interest in science.