Dr. Wendy Suzuki: Boost Attention & Memory with Science-Based Tools | Huberman Lab Podcast #73

My guest is Dr. Wendy Suzuki, Ph.D., Professor of Neural Science and Psychology and (soon) Dean of New York University, whose research focuses on memory, attention, brain plasticity and simple, daily habits that can be leveraged to improve learning, focus, memory and cognitive ability. We discuss the role of cardiovascular exercise, weight training, deliberate cold exposure, meditation, verbal affirmations, sleep, and other behavioral practices for enhancing learning, mood and stress management, and increasing attention span. Dr. Suzuki shares the mechanisms by which these practices change our brain in order to improve cognitive function fast and reduce age-related cognitive decline.

#HubermanLab #Memory

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- Welcome to the Huberman Lab Podcast, where we discuss science and science-based tools for everyday life. [upbeat rock music] I'm Andrew Huberman, and I'm a professor of neurobiology and ophthalmology at 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 Misunderstood 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,

00:02:50 AG1 (Athletic Greens), InsideTracker, Blinkist 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. In keeping with that theme, I'd like to thank the sponsors of today's podcast. Our first sponsor is Athletic Greens. Athletic Greens is an all-in-one vitamin, mineral, probiotic drink. I've been taking Athletic Greens since 2012, so I'm delighted that they're sponsoring the podcast. The reason I started taking Athletic Greens, and the reason I still take Athletic Greens once or twice a day, is that it meets all my foundational vitamin, mineral, and probiotic needs. In fact, whenever people ask me if I were to only take one supplement, which supplement should I take? I tell them Athletic Greens for the simple reason that it covers your base of vitamins, minerals, and probiotics, it also has important adaptogens, digestive enzymes for gut health. All of this is very important because we now know that gut health and the so-called gut-brain axis is very important for things like mood and brain function, and also contributes to immune system function. With Athletic Greens, you're covering all those bases. And of course you need to eat the nutrition and healthy diet that's right for you, but by taking Athletic Greens once or twice a day, you can be sure that there are going to be no gaps or deficiencies in your vitamin, mineral, or probiotic needs. I mix mine with water and a little bit of lemon juice or lime juice, I personally find it delicious. If you'd like to try Athletic Greens, you can go to athleticgreens.com/huberman to claim a special offer. They'll give you five free travel packs plus a year's supply of vitamin D3 K2, both of which are also vital for immediate and long-term health. So once again, if you go to athleticgreens.com/huberman, you can get a special offer of five free travel packs to make it easy to mix up Athletic Greens while you're in the car or otherwise traveling. Plus, they'll give you the year's supply of vitamin D3 K2. Today's episode is also brought to us by InsideTracker. InsideTracker is a personalized nutrition platform that analyzes data from your blood and DNA to help you better understand your body and help you reach your health goals. I've long been a believer in getting regular blood work done for the simple reason that many of the factors that impact your immediate and long-term health can only be analyzed from a quality blood test. And nowadays with the advent of modern DNA tests, you can also get insight into, for instance, what your biological age is and compare that to your chronological age. And of course your biological age is the number that really matters. With InsideTracker, there's a distinct advantage and the advantage is that while there are many blood tests and DNA tests out there, InsideTracker's blood and DNA tests come also with a platform, meaning a website platform that allows you to see exactly what you could or should do in order to adjust the numbers on things like hormone levels, metabolic factors, and lipids, and so on. It's a little popup window, it points to nutritional, supplementation, and behavioral regimens that you can take in order to put those numbers in the ranges that are optimal for you. If you'd like to try InsideTracker, you can visit insidetracker.com/huberman to get 20% off any of InsideTracker's plans. That's insidetracker.com/huberman to get 20% off. Today's episode is also brought to us by Blinkist. Blinkist is an app that has thousands of non-fiction books, each condensed down to just 15 minutes of key takeaways for those books. I love reading books from front to back. I like the actual physical book. I'm sort of old-fashioned in that way. And I do also listen to audiobooks. It's very rare that I don't finish a book that I've started. Nonetheless, I like to revisit some of my favorite books, I also like to write down key takeaways from those books. sometimes even before I listen to the full-length book. So I don't mind spoiling the takeaways because when I read non-fiction, generally I'm trying to extract the most valuable knowledge from them. So I'll often listen to a Blinkist 15-minute version, then the full-length book, or sometimes the full-length book, and then the Blinkist 15-minute version. Either way, Blinkist is a great way to get through any book and to extract the best from those books. I've used it for, for instance, Matt Walker's "Why We Sleep," an excellent book on why we sleep as well as Tim Ferriss's "The 4-Hour Body," Nassim Taleb's "The Black Swan," and so on, and so on. With Blinkist, you get unlimited access to read or listen to a massive library of non-fiction books. It really is a treasure trove of information. Right now, Blinkist has a special offer just for Huberman Lab Podcast listeners. If you go to blinkist.com/huberman, you can get a free seven-day trial and 25% off a Blinkist premium membership. Once again, go to blinkist.com/huberman to get

00:07:27 How Memories Form

a seven-day free trial and 25% off. 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. - Sure. - 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 say 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 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, this structure called the hippocampus.

00:10:14 Hippocampus: Memory, Association & Imagination

- Fantastic, so novelty, repetition, association, and emotional resonance. - Yes. - Could you tell us a bit more about the hippocampus? I think, at least for my generation, well, I'm a neuroscientist, but for most people of my generation, I think they first heard about the hippocampus from the movie "Memento." - Oh yeah, yeah. - Where the guy 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 you could, if you would, step us through kind of what this structure is, what it looks like, maybe a few of its subregions, because unlike vision, the topic that I've 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 kind of curlicue seahorse, that is accurate. Everybody, including neuroscientists, should know it's a beautiful structure. It is visually, anatomically beautiful with these kind of intertwining 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 kind of 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, by some 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 and neuroscience students know him. He was operated in 1954 and the paper was published in 1957. They removed both his 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 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 is that it's, you know, hippocampus is important for memory, so if you say that, you'll impress 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 too simple a way to think about it. What the hippocampus is important for is what we've already talked about, associating things together writ large. Anytime 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 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,

00:16:20 Encoding Long-Term Memory

medium-term, and long-term memories, and we could go down any of these rabbit holes. 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, in creating memories, but not in storing memories and that the memory storage was in the neocortex or the other overlying areas of the brain. Is that too general a 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. - Great, as I recall, HM could remember facts from before his surgery. - Yes. - He couldn't form new memories. - Correct. - And given that he had no hippocampus, it would at least partially support the idea that some 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 intended to remove of 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 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 HM had this mythical role in neuroscience and neurology and now it was complicated because he does have

00:18:48 One-Trial Memory

more of the hippocampus intact. - Got it, 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. - Right. - 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. It'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 roads do you have to traverse before you get there. What is it about one-trial learning? I mean, at a kind of top contour level, how can we learn certain things so fast and other things are tricky? And now every time I look at this white mug, it's queuing up something special simply by virtue of saying it. So is that one-trial memory? 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, they're memories, but they're fear memories. If I get mugged on the subway or, you know, there are 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 a Sunday afternoon and I came back and when I rounded the corner to my door of my apartment, it was crowbarred in. Somebody had taken a crowbar, opened up my door, and stole all of the nicest things in my apartment, which wasn't that nice, 'cause I wasn't making that much money. But ever since then, whenever I rounded that corner, I still had that memory. It was terrible because 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. So you forever will remember this particular corner

00:21:56 Tool: Foundational Habits to Enhance Brain Performance

or this hallway because that is where something really bad happened to you. - It seems like a location. We talk about conditioned place aversion, which is just a geek speak 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. Or even looking at a photograph of where you had a wonderful time with somebody and that can evoke all sorts of positive sensations. It seems like at some level, as complex as the brain is, the basic elements of feeling good or feeling lousy are states within the brain and body and linking those to places seems like it's a pretty straightforward formula, you know, link place to state, link state to place, etc., as your description just provided. When we learn more complex information, 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 are aware of that state, bodily state can be leveraged to enhance the speed or the quality of memories and memory formation? So to be clear about it, it seems there's something very important about this fourth, this emotional resonance component. Novelty, the crowbar into the doors, thank goodness sounds like it was novel, it wasn't repeated thing, 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. - Yes, I've been there, absolutely. - Yeah, 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 cold? - I do, I do. - Just take a moment and, and just tell us, what is your cold exposure protocol, then I'll take you back to what you're saying. - So my cold exposure protocol is at the end of every morning shower that I take, the shower 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 admit, it was really painful at the beginning, but it's much less painful. I could handle the cold water and my pipes give nice, really cold water. And it just, I could feel the awakedness kind of come up in me after that. And I miss it, if I forget to do it, sometimes I run back in and give myself that cold blast because it is upping, I think you talked about this on your podcast, what's happening in the brain? - Basically the cold stimulus, that shock, that catching your breath, etc., is adrenaline from the adrenals. But also from what we understand now, some new neuroimaging, there's epinephrine and norepinephrine released from locus ceruleus, which again is a brain structure in the back of the brain, kind of sprinklers the rest of the brain with a 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 2.5x of circulating dopamine. So they weren't looking directly in the brain admittedly, but it goes on for four or five hours. - Wow, yeah. - So the improved 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, 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. - Terrific, and I should just mention, 'cause you're too humble to do it, but I'll say it again that not only are you a full professor, 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 kind of what the practical steps are. Because knowing the science is important, mechanism I do believe is important for embedding protocols in people's minds and why they might want to do them, but really hearing 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, so I do this seven days a week, it's also not just 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 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 if you get out of the shower before the cold, you'll get back in. That's, to me, a really beautiful example of conditioned place preference. Now the cold shower has 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, 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, so our SEAL teams, but other branches in military too, which is that there are very few stimuli that you can give anyone and consistently get an adrenaline - Oh, interesting. - Release from that without harming them. With heat, eventually you need to use so much heat that you damage tissue. Or with exercise, you have to use so much 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 special operations has figured out that by 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, etc. So anyway, beautiful practice, thank you. I want to learn more about your tea meditation later in the episode.

00:30:39 Exercise & Improved Memory, Making a “Big, Fat, Fluffy Hippocampus”

But in any event returning to ways that we can improve memory formation. Maybe if you would tell us your story around this. I know you've told it before, but I think 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, three or four top memory researchers in the world. Textbook material is Suzuki. 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, and still at a very high level, but then things took a different direction. And maybe we could talk about your story and how you came to the place you are at now because I think it provides a number of tools that people could implement themselves. - 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. This was what was going on in my life. - They actually tell people to leave. If you don't get tenure, you're gone. - You have to leave your institution. And so, 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 haven't gone to a Broadway show in two years? And so I, 25 pounds overweight, I decided to go on vacation. And I went by myself 'cause I had no friends. And I went to, I did an adventure river rafting trip in Peru. And so I go by myself and meet other interesting people and I was the weakest person on this whole trip. Like they were so much in better shape, it was embarrassing and they won't say this, they won't admit this to me, but it was true. And I kind of came back and I said, okay, 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 try at least to lose this weight. And so I go to the gym, I notice 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. I'm a terrible hip hop dancer, but I still felt good after that class. And then fast forward a 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. And writing, writing, writing, and this thought goes through my mind that had never gone through my mind before during this six years of frantic grant writing when I was trying to get tenure, and that thought was grant writing went well today. You know, 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. - No, 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, like I'm able to focus longer, the sessions feel better to me. And at that point, the only thing that I changed in my life, it was a huge thing, but I had become a gym rat rather than a workaholic. And that's when my 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 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 grant 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. I still remember 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 was literally seven blocks from our house that I grew up in. And I knew that was hippocampal function. I suspected dementia. I suspected, oh, didn't want to admit Alzheimer's dementia, 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 engineer, not so active all his life, but would loved and sit and read books all day. My mom was the athlete. She played team tennis into her 80s. And it started to show at that point. And so 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 in my dad's brain. Really, really smart guy, engineer in Silicon Valley, helped 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 somebody who wants to get tenure, this is 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 some of them we've talked about, the good 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 neurotrophic 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. We all have that. 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. And 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 new long-term memories

00:39:35 Cardiovascular Exercise, BDNF (Brain-Derived Neurotrophic Factor) for facts 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 30 to 45 minutes of, 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. It 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 than it is to get a mouse to lift weights. Although people have put little ankle weights on mice and the ways of getting mice to do resistance work is actually a little bit barbaric - Little stressful. - 'Cause oftentimes they'll incapacitate a limb to overload another limb, so it's an asymmetric thing. It's not the same as sending them in to do squats, or deadlifts, or something. But cardiovascular exercise might be special. And what are your thoughts on that? And please first, though, tell us your routine. Your routine is 30 to 45 minutes of, are you a Peloton cycler? 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, it's called "Daily Burn," and is 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 weight. Sometimes I do it without weights. I love kickboxing, so they have a lot of kickboxing in there. It just 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 what I do. - And that's a daily thing, seven days a week? - Yeah, yeah. - Seven days a week, fantastic. So in terms of he way that some of these changes are being conveyed from the body to the brain, that fascinates me. I mean, as you and I know, and I'm sort of a repeating record on the podcast always saying, you got a brain but you also have a spinal cord and then your nervous system connects everything. Every organ in your body is basically signaled to by the nervous system and back to the nervous system, you're explaining everything. But so let's imagine your morning routine, you do your cardiovascular exercise, so you're pumping more blood, that's the definition of a higher heart rate, stroke volume of the heart goes up over time, you're getting fitter, so blood flow to the brain is increasing. Do we know how that gets translated to a signal to release more BDNF? And then it raises this other question, which is, does it matter where your mind is when you exercise? 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. I've always wondered about this. Can we enhance the effects of exercise by combining the enhanced blood flow with cognitive work during exercise? 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 partially because of the work of your colleague, Alia Crum, on mindset and the power of that to change how physiologically our body is responding. So how could it not work in her experiments or work in her experiments and not work for my morning or our morning exercise routine. But are there studies, point to a study, I don't know of one. So exercise neuroscientists out there, I'd love to see that study done. So yes, it works. Before I go into the aerobic thing, I always 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 sweating, I don't want to listen anymore. 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, noradrenaline 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 brain effects? 10 minutes of walking, anybody can do it. - Now is outside important? I'm a big believer in getting photons into the eyes. - I think that that study was done indoors on a treadmill. And the comparison wasn't done, but moving your, which is great, in the middle of the pandemic I walked around my apartment for 30 minutes sometimes just for some variety, felt like a rat on a running wheel, but yes. So that minimum amount of movement in your body can get you those mood effects. But what about the big, fat, fluffy hippocampus? What about the better performing prefrontal cortex? That's where you start to need the cardio workout. And from my reading of the literature, there haven't been enough studies directly comparing and contrasting kickboxing with running, with 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 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 neurotrophin that's increasing the growth of new hippocampal brain cells. The two pathways are the following. One is a myokine, which is a protein released by the muscles. And not your heart, these are striated muscles in your body. And so by running, these were studies done in rats on running wheels, they showed that the running rats had more of this myokine, released the myokine past the blood-brain barrier. so got into the rarefied, very protected bloodstream of inside the brain, and that myokine 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 generally. How do we know that, well, cortisol is released whenever we exercise. We need that sugar in our blood and 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 clearly. So 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 giving more BDNF precursors to get into our brain, to cause the upspike 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 anytime we're thinking about movement of the body and translating that to the brain, as you so clearly pointed out, that 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, I know some people are, most people are not, I imagine. There are ketones that are released in your brain

00:48:48 Neurogenesis (New Neuron Production) in Adults

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 my understanding is that the rodent literature is very clear that animals that run on wheels more often, it turns out rodents love to run on wheels. Do you know these studies by Hoppy Holster, which are pretty funny, they're very cool, by the way, Hoppy, Howard Hughes investigator, I'm not making light of them. They put running wheels in a field and wild rodents will run to the running wheel and run on that running wheel. - Oh, that's great. - They really enjoy it. Which I find amusing for reasons that probably only a neuroscientist would find amusing. In any case, in rodents, it seems that running more on a wheel can trigger neurogenesis, 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 in the olfactory bulb, probably not in the neocortex. Thinking back to the decades or more controversy between Liz Gould and Pasko Rakic. I hope they settled their differences there. Neuroscientists love to argue. It's kind of what we do. And in humans, I think it's been a bit controversial. Some people say absolutely, yes. Other people say absolutely no, there are new neurons added to the adult brain. I haven't followed that literature down to the detail. But I do remember one study that I don't think is contested, which is the work of Rusty Gage at the Salk Institute where they actually injected a sort of due type marker into the brains of terminally ill humans who very graciously offered to have their brains removed and dissected after death. And in some cases, these very old terminally ill humans, they did see evidence for new neurons being born in the hippocampus. 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 used in that original Rusty Gage study, which was groundbreaking at the time, 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 patients were in their 60s, then they died of cancer. But these new studies looking across the timeline, can we see, because the other thing was, yeah, maybe you have some when you're 20, but by the time you're older and you might need these new neurons, you have no new neuron growth.

00:51:50 Effects of Exercise on Memory

And so these studies seem to suggest that, yes, yes you do. And we all do even into old age. - 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 BDNF pathway, the pathway one that you mentioned, might be signaled, 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. But they should be done. If you would, could you tell us about some of the more specific effects of exercise on memory? Memory is a broad category 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 underpinnings. What has been demonstrated in the laboratory in animal models, but especially in humans, and if you want to share with us any results from your lab, published or unpublished, I'm sure that the audience would be delighted to learn about them. - Absolutely, let me start with kind of the immediate effects, acute effects as 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, there are three major effects that have been reproduced. I've seen it in my lab, many labs have reproduced this. So what do you get with the one-off? This is usually an aerobic-type exercise session, 30 to 45 minutes. What you get is that mood boost, very, very consistent. You get improved prefrontal function, typically tested with a Stroop test, which is a test that asks 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 speed at responding, often a motor kind of, but cognitive motor response is improved. Over the pandemic, one of the unpublished studies that I did looking at the effects of 30 minutes of age-appropriate workout in subjects ranging in age from their 20s all the way up to their 90s. So what are the things that I saw more consistently? Irrespective of your age, everybody got a decreased anxiety and depression and hostility score, which is very important. So 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 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 Stroop and Eriksen flanker task, which is another task dependent on really focusing in on different letters and paying attention to what letter is being shown. So these are consistent effects. How long do they last? One of the studies that I did publish 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 a pretty big bang for your buck. - That is. - One 30 minute. - Sorry to interrupt, I just want to make sure I understand. So 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 work? Just to be clear. - Yeah, that's a great question. So my study looked at two hours after you finish your workout 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 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 the exercise period.

00:56:31 Tool: Timing Daily Exercise, Cortisol

This was an hour of cycling that they did. These were young subjects in their 20s. - Okay, so if I finish my exercise at 9:00 AM, 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 I have evidence that it lasts for two hours. - And perhaps if I had started the cognitive work 45 minutes after my exercise ended, it would also be helpful. - Yes. - So there's no reason to think that there's a, that you have to wait before starting cognitive 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 comment section. We always strive for clarity here. So what this tells me is that exercising early in the day may have a special effect. I realize that some people cannot exercise until later in the evening, but you mentioned something earlier that I want to cue people to, it's 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. 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, that's a big spike in cortisol, probably not a good thing 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 Pizzo, was and is kind of famous still for jogging between the hours of, like, 4 and 5:00 AM, or five and six, and then running the medical school. And you're up early doing your exercise, and cold shower, and meditation, we'll 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, I know there are moms and dads out there and they just say, look, I have a kid, the kid's more important than my doing my exercise. So you will get benefits if you do it 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 morning for most of us is beneficial. That's why I do it in the morning and I'm lucky enough to be able to do that. But yeah, it makes sense with all, everything we know about how this works and how it benefits our brain. - I think about our colleague, Eric Kandel, who not incidentally has a Nobel Prize and studies memory. And rumor has it that he's been a swimmer for a lot of years. That he'll put in, I think nowadays he's in his '90s, now he'll put in half a mile, but he used to do swim a mile a day or something of that sort. - Wow, 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 of a lot of neuroscientists that probably should exercise more. And I don't say that to poke at them, I just would love to see them doing their incredible work for many more decades.

01:00:02 Age-Related Memory Loss, Daily Exercise

And everything that we're talking about today indicates that if one doesn't, unless you have incredible genetics, we all experience age-related dementia, right. I mean, the story of your father is a salient one. And we should remember that as we go forward. I also want to emphasize, and I'd love to get your thoughts on just memory and memory loss in general. It seems we all get worse at remembering and learning things, even if we don't get Alzheimer's. 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, well, everybody's anxiety level has gone up in the last couple of years, but that also has an effect. We don't remember as much in a highly stressful, highly anxious situation. So, as you know, it's hard to answer that question. People say, okay, just tell me how much exercise I have to do. - 30 to 45 minutes a day. But I love that per day, I've been doing this whole thing of telling people, oh, the data say 150 to 200 minutes of zone two cardio, which is kind of moderately hard but not excessively hard, but I love this everyday theme. Because whenever I do that, the questions that come back are, well, what if I take a long hike on the weekends? And so people start negotiating. There's something that's very powerful about non-negotiable, everyday. Sun in your eyes every day even through cloud cover. Exercise for 30 to 45 minutes. Cold shower every day. - Every day, yeah. - My understanding of the literature is that somewhere in our 50s or 60s, we start noticing little hiccups in memory, for some people younger, for some people later. But I have to imagine that doing the exercise throughout one's entire life is going to help offset some of this simply 'cause of the BDNF and other downstream effects. - Yeah, I mean, 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 on the effects of long-term exercise, but first I want to share one of my favorite 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 women in their 40s. And they characterized them as low fit, mid fit, high fit. Okay, and then 40 years later, they came back and found these women, 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 the women that were high fit were giving their brains this bubble bath, 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 in consistently. I am impressed by this 10-minute walk and the improvements in mood from just a 10-minute walk. But again, I think that daily repetition also I have to imagine has effects on the very pathways that allow plasticity. This is something we, in the realm of neuroplasticity, we don't often hear about or think about, even as a neuroscientist, 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 that stimulate plasticity. In other words, if one gets better at calming themselves down under stress, those circuits get better at doing that. - Yes, absolutely. - Neural circuits gain proficiency. 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 kind of an amplifying effect of exercise, 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, of course, is not an excuse for spending all day in the gym. 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

01:05:33 Tool: Exercise Protocol for Improving Cognition

the cognitive work also, it's not just exercise. So I'd love to hear about some of these new unpublished data. - 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 their 50s, maybe even their 30s and their 20s. Why, because that's when we, as humans are able, ready, willing, and able to increase our exercise and gets us set up to 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, how much exercise do 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 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 be in a group just like they were in a group for the spin class. We touched them cognitively at the beginning and the end of the session. What we found was two to three times a week of cardio in these people, they 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 and 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 Stroop task, 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 and coding task, and that is, can you differentiate similar items that we're asking you to remember, and a spatial episodic memory task, where we had them play one of those Doom like 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 this, it was so satisfying to do this study because I've been wanting to answer this question, what is a minimum amount or doable 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 going to be challenging, but absolutely doable. And so it makes sense with 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 are playing a role here, that absolutely makes sense 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. So I love that for its realness. - How long are those sessions again? - 45 Minutes. - 45 Minutes. - Yeah, 45 minutes, it's a typical spin kind of class. There's a warmup for five minutes and a cool down for five minutes, so it's really 35 minutes of they're really pushing you. - And so they're breathing reasonably hard. Heart rate is up. - Heart rate is up definitely up, yeah - I find that all of those results are really interesting that the results showing improvement in motivation to exercise is interesting, 'cause it gets back to this issue of kind of a self-amplifying effect. And the neuroscientist in me wants to think about kind of pre-motor circuits and the fact that 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 create a kind of anticipatory activity in our nervous system where our body craves a certain stimulus, you mentioned the cold and how you crave the cold. Now whether or not that's the adrenaline, and the dopamine, etc., or whether or not somebody who exercises, going from zero, less than 30 minutes per week to two to three times a week, 45 minutes, as you described for this study. I've had that experience before of that the cardio, that I tend to battle the most, I love lifting heavy objects, at least heavy for me. 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, and I've been doing it since I was in my teens, so 30 years. Cardio's 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 weight 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 physically I almost feel like my body needs to engage in that movement. Like the pre-motor circuits are kind of revving, kind of like revving then engine on a car while it's in park. So the motivation to exercise obviously

01:12:17 Anticipating Exercise, Daily Habits & Behaviors

could be multifaceted. 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, reverbatory activity into our nervous system? - Yeah, yeah, I agree with that because I also have those same kinds of thoughts and I do have anticipatory exercise when I can't do it. So I just got back from a week and a half in Paris, where I got to do a book launch of my last book, "Good Anxiety." And I really walked around a lot, but I did not do my exercise for that whole week and a half. But there was a lot of stress 'cause I had to do all these interviews in French. So I gave myself a break. - You speak French? - I speak French. - I was going to say, otherwise it would be really stressful. - That would be really stressful. - Then I'd be really impressed. Then I would definitely start exercising. Actually, I would follow your morning routine to a T, but okay, very impressive nonetheless. - But I got back and coming back this direction from Paris, I live in New York, is much easier. And so I was able to 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. It was like I wanted to come back. And I know it's because I worked up over years, now I could truthfully say seven days a week, but it was first it was four to five, then it was five to six, and yeah, seven, but that includes a yoga day, or sometimes I have to do it for 10 minutes instead of 30 because I have to leave. But that habit of you do that even for five minutes, you do either the weight 10-minute thing, or a five-minute thing, or a 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. And I apologize in advance to all the people I neglect in this statement, but I'm happy to put it in the comments, folks. BJ Fogg is there, has done-- - Yes, that's who I, - BJ's done really great work. And then James Clear wrote a book about habits and has a very popular newsletter about habits. We've done an episode about habits that covers some of their work 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 of day. I mean, one thing we know for sure is that the circadian system is part of our nervous system's way of anticipating when things will happen, not 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 as opposed to just saying, I'm going to do it seven days a week sometime today. But of course, getting it done sometime is better than not getting it done. - 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 one's entire life is really what it's about. As I always 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. - Exactly. - You absolutely 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 diet is a very barbed wire topic on the internet, which diets whether or not they work, etc., but in general, in 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 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, that you need for your study. If you also ask them, okay, fill out this survey to tell us exactly what you ate all day, they're going to say, forget you, I'm not 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 diets got better when they, you know, less processed foods,

01:17:09 “Every Drop of Sweat Counts” – Exercise & Cognitive Function

when they did adhere to this exercise. But lot more information needs to be gathered in that realm. The second study that I wanted to share unpublished, we're 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, we're already exercising, 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 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 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 and anxiety, higher amounts of good effect, 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 those of us that are regularly exercising and wondering, do 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 to a spin class seven times a week, but I love the message that our body is responsive to that. And you can get better hippocampal function, better overall baseline mood affect with a higher level. So it works for the mid fit people as well. - Fantastic, the more I learn from you, the more I'm starting to conceptualize the brain as an organ that is privileged in so many ways, has this unique blood-brain barrier, has this incredible quality of being able to predict things, and it's job mainly is, of course, to predict things 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. It isn't sufficient to just say that we can't take it for granted, that our brain is actually an organ that requires a signal in order to maintain its own function and it sounds like enhanced blood flow and 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, 35 minutes lately, and it should be more to daily. There's something really, again, really special about daily because it's nonnegotiable, you just do it. And it sounds like if one were to do higher intensity exercise, you know in a spin class, I've never taken a spin class, but I've seen there are times when they're standing up on the bike and pedaling very hard. So that is included in these kinds of workouts, right? - Absolutely, yeah. - Okay. - I mean, that's what the instructor is doing. I cannot control. We did monitor heart rate of all the subjects and it was clearly, compared to the video Scrabble, it was highly significant.

01:20:58 Positive Affirmations & Mood

- I would hope so. - Yes. - I guess it depends on how intense that game of Scrabble is. Could we just briefly talk about mindset and affirmations? - Yeah, sure. - You've talked a bit before about affirmations, and as you mentioned, the beautiful work of my colleague at Stanford, Alia Crum, we can summarize her work pretty simply, although we won't do it complete justice by it, she's already been on the podcast, just to say that one's beliefs about a 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 then 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 woo anymore once you understand what the brain is really doing. But what is, if any, the value of affirmation of telling yourself something positive about yourself, or of exercise, on not the exercise itself, but on mood, self image, memory, and brain function? - Yeah, so, I looked into this because I am also a certified exercise instructor and the form of exercise that I teach is called IntenSati. It's a form of exercise that was developed by this amazing 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 a word. And you know, 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 I felt idiotic, I was like what, I came into the wrong class, I don't want to come into this class. But then I saw they didn't care whether I thought they looked silly saying these affir-, not saying, yelling these affirmations out loud while doing the choreography at the same time. And then I tried it, okay, I didn't yell out, I kind of whispered it at first. 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 don't often say to 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, ah, I feel really good now. Man, I can't wait to come back to this class. Which is why I ultimately took teacher training to be able to teach that class. And so I started to look into what was known about affirmations and they were never combined with physical activity, but it was clear that there was a literature showing that positive affirmations, saying them or reading them could change mood in the same way as we're talking about, you know, Alia Crum's work. If you have this, it's a belief, once you start saying these things, these are not difficult things to believe, but it's amazing how much you don't say these kinds of 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 self affirmations. It really gets you into a habit of saying good things about yourself. And then you start to realize, oh my God, I'm so mean to myself. I have lots of negative thoughts going on about myself 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 IntenSati is the mood boost from the positive spoken affirmations together with all the other brain and affect boosts that we've been talking about for this whole podcast, from the exercise, because it's a sweaty workout as well. - 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 he's at University of Michigan in Ann Arbor, Ethan Kross 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 point that out. But that explicit statements to counter that negative chatter, I believe is one of the hallmarks of readjusting one's own, not just internal reference frame, but actually self-image generally. And it's a fascinating and, I think, a very important area of psychology and neuroscience because, and I acknowledge this, we're talking about this, two laboratory neuroscientists who record from neurons and label neurons and look at stuff down the microscope, we are now deep in the territory, in the deep water of what some of our colleagues and people who think about neuroscience would consider really out there on the kind of subjective edges. And yet I think it's worth pointing out that 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 look like in 10 years, or 100 years, or 1,000 years, but also high-level conceptual understanding of who we are and what we are about. And so even though it might seem a little bit out on the fringes, dare I say, I think that these are some of the more important untread landscapes of neuroscience. 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, That discovered exercise and its benefits for your grant writing and then on and on and on, and then became a certified

01:27:28 Meditation & Cognitive Performance

- Exercise instructor. - Instructor. 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 dove into it all in any depth, which is meditation. You mentioned this tea meditation. You had a publication recently on a 10-minute meditation. - Yes. - Right? Maybe you could tell us about this 10-minute meditation because it seems like such at tractable amount of time. And then if you would maybe tell us a little bit about the tea meditation. But sounds like you've discovered a minimum, a close to minimum threshold of meditation that can really benefit us. So maybe you could tell us about that study. - So the study was, as you very astutely 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 asked them to do it, how often? Daily, seven days a week, just 10 minutes a day. And the most shocking thing about this study is that we got more 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 great. - I'm going to just start leading meditations for three hours as opposed to doing a three-hour podcast. - 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 stress test to see how you responded to an unexpected, stressful situation. The meditators did much better. Their mood was better and their cognitive performance was also better. And this was my first little foray into meditation after I had started my personal tea meditation, that really shifted my relationship with meditation. But it is consistent with many other studies showing the beneficial effects of meditation. But the unique thing was we tried to make it doable that many, many people out there could actually follow this typical regimen, and so we're continuing that. In fact, my research in 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 meditations, visual meditations, walking, things that any college student, but we're obviously focused on NYU students, will do. 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, meditation. - If you would, and here's where we can highlight this again, as some highly educated speculation, if it's coming from you. What do you think is going on during meditation? I mean, so a body skin involves a kind of a interoceptive awareness, like interoception, of course, being an attention to what's going on 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 forebrain 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 as a neuroscientist, what do you think is going on 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 downstream

01:32:27 How Meditation Works, Focusing on the Present

of exercise and I think there's so much evidence, I know there's so much evidence that meditation is beneficial. 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 to do and how many hours am I going to have to be able to do that. Or I'm worried about, whatever, the email that wasn't as polite as it should be that I sent and what were the repercussions for that instead of focusing on this moment, which is fun, I get to talk to you, it's a beautiful day outside, 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 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 are the repercussions there? And I have a mother who's older and she's more susceptible to it, and there's a war, and what's going to happen there? Those are all future possibilities. 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 can 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 involved? Not exactly, that is not my area. I think there are some studies that have focused on that, that present moment kind of activity. But that is what I think is most important 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 just reliving of the terrible past, but you could enjoy the present moment. - Yeah, that really resonates. I think that going back to the earlier part of our conversation, 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 HM, 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 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 now 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. - 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 to the right location in the library, you actually can't get distracted by the books that you're interested in, if you need to go just reflexively, if you need to go study a particular topic. So that's kind of how I think about it. It makes us more linear perhaps in our way of being. - I think so, and it actually counteracts, not that I'm against technology, but having our phones and being connected to every good and bad thing 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 everyday life.

01:37:14 Tool: Strategies to Increase Attention

- Yeah, or even 10, 15 years ago it felt like smartphones weren't as intrusive. 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, and 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. So I'm so happy that you're going to do this and collect data. 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've mainly been talking about memory and cognition. 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, Ritalin use, Modafinil 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 data on this are, a colleague of mine at Stanford claims that something like two-thirds or more of college students use these without prescription for ADHD. 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 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, so I would say the top three tools that everybody right this minute today can use to up their capacity to attend where they want to include exercise for the reasons we've talked about. It has a direct effect on functioning of the prefrontal cortex. Meditation also, clear clinical studies showing improved ability to focus and particularly focus on the present moment. And the third has to be sleep. So sleep is, you can't, it's out of the three, it is the most physiological. I mean, I could live my whole life without meditating one minute. Could I survive without sleep? No, none of us could. So, it's more basic physiological, but it is so important for all core cognitive functions, including attention, including creativity, including just good basic brain function. That is why 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 brains work, 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 linked in, not LinkedIn, 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, one could use the freely available resource of gravity to do jumping jacks, or burpees, or pushups, or whatever, or sit ups, or all those in combination. - 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, I talk about breath meditation for my book, "Good Anxiety," and if you don't like the one that I suggest there's only about a million more on YouTube with ratings from one star to five stars, so use that resource. - It is a wonderful resource and you are 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 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.

01:42:50 Zero-Cost Support, YouTube Feedback, Spotify & Apple Reviews, Sponsors, Patreon, Momentous Supplements, Instagram, Twitter, Neural Network Newsletter

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 WendySuzuki.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/or 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 Huberman 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/andrewhuberman. And there you can support the podcast at any level that you like. On many episodes of the Huberman 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 Huberman 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 Huberman Lab Podcast are growing all the time. A good number of them are already there. You can go to livemomentous.com/huberman 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 Huberman 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 Huberman Lab Podcast, but a lot of it is distinct from the information contained on the Huberman Lab Podcast. So again, that's Huberman Lab on Instagram and Huberman 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 hubermanlab.com, just go to hubermanlab.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 signup 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. [upbeat rock music]