

Controlling Your Dopamine For Motivation, Focus & Satisfaction | Huberman Lab Podcast #39

This episode serves as a sort of “Dopamine Masterclass”. I discuss the immensely powerful chemical that we all make in our brain and body: dopamine. I describe what it does and the neural circuits involved. I explain dopamine peaks and baselines, and the cell biology of dopamine depletion. I include 14 tools for how to control your dopamine release for sake of motivation, focus, avoiding and combating addiction and depression, and I explain why dopamine stacking with chemicals and behaviors inevitably leads to states of overwhelm and poor performance. I explain how to achieve sustained increases in baseline dopamine, compounds that injure and protect dopamine neurons including caffeine from specific sources. I describe non-prescription supplements for increasing dopamine—both their benefits and risks—and synergy of pro-dopamine supplements with those that increase acetylcholine.

#HubermanLab #Dopamine #Motivation

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- Welcome to the Huberman Lab Podcast, where we discuss science and science-based tools for everyday life. [energetic music] I'm Andrew Huberman, and I'm a professor of neurobiology and ophthalmology at Stanford School of Medicine. Today, we are going to talk all about dopamine and what drives you to do the things that you do. We're going to talk about motivation and desire and craving, but also how dopamine relates to satisfaction and our feelings of wellbeing. And of course, any discussion about dopamine

has to include a discussion about the potential for dopamine induced addiction. Indeed, dopamine lies at the heart of addiction to all things. But today we are mainly going to focus on, how what we do and how we do it, and how we conceptualize those things leads to changes in this amazing molecule in our brain and bodies that we call dopamine. I'm going to teach you what dopamine is and what it is not. There are a lot of myths about the molecule dopamine. We often hear about so-called dopamine hits. Today, we are going to dispel many common myths about dopamine, and we are going to talk about how dopamine actually works. We're going to discuss the biology of dopamine, the psychology. We will discuss some neural circuits and a really exciting aspect of dopamine biology or so-called dopamine schedules. In other words, we are going to discuss how things like food, drugs, caffeine, pornography, even some plant-based compounds can change our baseline levels of dopamine and in doing so, they change how much dopamine we are capable of experiencing from what could be very satisfying events, or events that make us feel not so good because of things that we did or took prior. So I promise you it's going to be a vast discussion, but I will structure it for you, and you'll come away with a deep understanding of really what drives you. You will also come away with a lot of tools, how to leverage dopamine so that you can sustain energy, drive and motivation for the things that are important to you over long periods of time. Before we dive into the meat of today's discussion, I'd like to share with you a fascinating result that really underscores what dopamine is capable of in our brains and bodies, and underscores the fact that just through behaviors, no drugs, nothing of that sort, just through behaviors, we can achieve terrifically high increases in dopamine that are very long and sustained in ways that serve us. This is a result that was published in the European Journal of Physiology. I'll go into it in more detail later, but essentially what it involved is having human subjects get into water of different temperatures. So it was warm water, moderately cool water and cold, cold water. Had them stay in that water for up to an hour, and they measured by way of blood draw things like cortisol, norepinephrine and dopamine. What was fascinating is that cold water exposure led to very rapid increases in norepinephrine and epinephrine, which is also just called adrenaline. It also led to increases in dopamine. And these increases in dopamine were very significant. They kicked in around 10 or 15 minutes after submersion into the cold water. And I should mention the head wasn't below water is just up to the neck. And the dopamine release continued to rise and rise and rise, and eventually reached 250% above baseline. Now, what was interesting is after subjects got out of this cold water,

that dopamine increase was sustained. And I know nowadays many people are interested in using cold water therapy as a way to increase metabolism and fat loss, but also to improve sense of well-being, improve cognition, improve clarity of mind. There's something really special about this very alert, but calm state of mind that seems to be the one that's optimal for pretty much everything except sleep, but for all aspects of work and for social engagement and for sport that highly alert, but calm state of mind really is the sweet spot that I believe most of us would like to achieve. And this cold water exposure done correctly really can help people achieve that state of mind through these increases in dopamine that lasts a very long time. So I will later detail the specifics of that study, what it entailed in terms of how long, the variations, the different subjects experienced, as well as how to limit the amount of stress hormone, cortisol, that's released as a consequence of the cold water. And we will also talk about compounds, supplements

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that people can take in order to increase their levels of dopamine should they choose. 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 Roka. Roka makes sunglasses and eyeglasses that are of the absolute highest quality. I've spent a lifetime working on the visual system. And I can tell you that the visual system has to go through a lot of work in order to maintain clarity of what you see when there are shadows, when you go into different types of indoor lighting, and so on. And a lot of glasses don't work well because you put them on, and then you're in bright light and you can see fine, but then you move into a shadow and then you have to take them off and they don't adjust, or they don't adjust quickly enough. With Roka their eyeglasses and sunglasses are designed with the visual system biology in mind. So you always see things with perfect clarity. The glasses are also terrific because they're very lightweight, and they won't slip off your face if you're exercising, if you're running or biking. In fact, they were designed for the purpose of being able to be worn while you're engaging in those sorts of activities or simply working at your desk. I happen to wear readers at night or when I drive or when I work, and I love their sunglasses cause I can

wear them anywhere. And also the aesthetics of their sunglasses and eyeglasses are terrific. Unlike a lot of other performance glasses that frankly make people look like cyborgs. The aesthetics on Roka's are really terrific. You could wear them anywhere you'd like to go. If you'd like to try Roka glasses, you can go to www.roka.com. That's R-O-K-A.com and enter the code Huberman to save 20% off your first order. That's Roka, www.R-O-K-A.com. Enter the code Huberman at checkout. Today's podcast 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'm a big believer in getting regular blood work done. And now with the advent of modern DNA tests, you can also analyze your DNA to see what you ought to be doing for your immediate and long-term health. We hear a lot these days about optimization, optimizing hormones, optimizing your metabolism, optimizing this, optimizing that, but unless you know the measurements of metabolic factors, hormones and other things that are in your blood and DNA, you don't know what to optimize. With InsideTracker it makes all of that very easy. They can come to your house to take the blood and DNA test, or you can go to a nearby clinic. They send you the information and you take those results. And unlike a lot of laboratories doing blood work out there and DNA tests, they have a simple platform, a dashboard that walks you through your results and helps you identify what sorts of nutritional or behavioral or other types of practices you might want to incorporate into your life in order to positively impact your immediate and long-term health. It's a very easy system to use, and you will gain a ton of information simply by doing that test. Whether or not you end up making changes to what you're doing or not. If you'd like to try InsideTracker, you can go to www.insidetracker.com/huberman to get 25% off any of InsideTracker's plans. Just use the code Huberman at checkout. Today's episode is also brought to us by Headspace. Headspace is a meditation app backed by 25 published studies and has over 600,005 star reviews. I've been meditating for a long time, but I confess sometimes I meditate and sometimes I'm very inconsistent about my meditation. Ideally, I would meditate every day for 20 or 30 minutes, but what I found over the years is that, I'll start a meditation practice and then as life gets more stressful or busier, which is exactly when I need to meditate more, I tend to meditate less often. Switching over to Headspace as a meditation app really helped me stay consistent with my meditation practice. And that's because they have a huge range of meditations to select from. Some are short, some are longer. And in general, I try and get 20 minutes of meditation in every day, but some

days it's just five minutes and they have some terrific just five minute meditations. The science says that even a five minute meditation can be beneficial for different aspects of our brain and body. If you want to try Headspace, you can go to www.headspace.com/specialoffer. And if you do that, you'll get one month as a free trial with full library of meditations that you can use in any situation. This is the best deal offered by Headspace right now. So if you're interested, go to www.headspace.com/specialoffer

00:09:10 Upcoming (Zero-Cost) Neuroplasticity Seminar for Educators

to get one free one month trial with Headspace's full library of meditations. I'd like to announce that there's an event that some of you may find very useful. This is an event put on by Logitech that I will be speaking at. It's called Rethink Education, the Biology of Learning Reimagining Learning through Neuroscience. And at this event, I will be speaking, there will be other speakers as well, and I will be talking about neuroplasticity and its applications for teaching and for learning. I will describe what I call the plasticity super protocol that incorporates all of what we know about rapid learning, efficient learning and the best ways to teach and learn. It's geared towards educators of all kinds. It is zero cost. So please feel free to sign up. The event is September 30th, 2021 at 3:00 p.m Eastern.

00:09:58 What Dopamine (Really) Does

You can find the registration link in the caption for this episode. So let's talk about dopamine. Most people have heard of dopamine, and we hear all the time now about dopamine hits. But actually there's no such thing as a dopamine hit. And actually the way that your body uses dopamine is to have a baseline level of dopamine. Meaning an amount of dopamine that's circulating in your brain and body all the time. And that turns out to be important for how you feel generally, whether or not you're in a good mood, motivated, et cetera. And you also can experience peaks in dopamine above baseline. Now, this has a very specific name in the neurobiology literature, so-called tonic and phasic release of dopamine. And I'll explain what that means in a couple of minutes. But if you remember nothing else from this episode, please remember this, that when you experience something or you crave something really desirable, really exciting to you,

very pleasurable. What happens afterwards is your baseline level of dopamine drops. Okay? So these peaks in dopamine, they influence how much dopamine will generally be circulating afterward. And you might think, oh, a big peak in dopamine after that, I'm going to feel even better because I just had this great event. Not the case. What actually happens is that your baseline level of dopamine drops. And I will explain the precise mechanism for that. Okay? In the neuroscience literature, we refer to this as tonic and phasic release of dopamine. Tonic being the low level baseline that's always there circulating, released into your brain all the time. And then phasic these peaks that ride above that baseline. And those two things interact. And this is really important. I'm going to teach you the underlying neurobiology, but even if you have no background in biology, I promise to make it all clear. I'll explain the terms and what they mean. And I'm excited to teach you about dopamine, because dopamine has everything to do with how you feel right now as you're listening to this, it has everything to do with how you will feel an hour from now, has everything to do with your level of motivation and your level of desire, and your willingness to push through effort. If ever you've interacted with somebody who just doesn't seem to have any drive they've given up, or if you've interacted with somebody who seems to have endless drive and energy, what you are looking at there in those two circumstances is without question a difference in the level of dopamine circulating in their system. There will be other factors too, but the level of dopamine is the primary determinant of how motivated we are, how excited we are, how outward facing we are and how willing we are, to lean into life and pursue things. Dopamine is what we call a neuromodulator. Neuromodulators are different than neurotransmitters. Neurotransmitters are involved in the dialogue between neurons nerve cells. And neurotransmitters tend to mediate local communication. Just imagine two people talking to one another at a concert, that communication between them is analogous to the communication carried out by neurotransmitters, whereas neuromodulators influence the communication of many neurons. Imagine a bunch of people dancing where it's a coordinated dance involving 10 or 20 or hundreds of people. Neuromodulators are coordinating that dance. In the nervous system what this means is that, dopamine release changes the probability that certain neural circuits will be active and that other neural circuits will be inactive. Okay? So it modulates a bunch of things all at once, and that's why it's so powerful at shifting not just our levels of energy, but also our mindset, also our feelings of whether or not we can, or cannot accomplish something. So how does dopamine work and what does it do? Well, first of all, it is not just responsible for

pleasure, it is responsible for motivation and drive. Primarily, at the psychological level, also for craving. Those three things are sort of the same. Motivation, drive and craving. It also controls time perception, and we will get deep into how dopamine can modulate time perception, and how important it is that everybody be able to access increases in dopamine at different timescales. This turns out to be important to not end up addicted to substances, but it also turns out to be very important to sustain effort and be a happy person over long periods of time. Which I think most everybody wants. It certainly is adaptive in life to be able to do that. Dopamine is also vitally important for movement. I'll explain the neural circuits for dopamine and mindset, and dopamine in movement in a moment, but in diseases like Parkinson's or Lewy bodies dementia, which is similar to Parkinson's in many ways. There's a depletion or death of dopamine neurons at a particular location in the brain which leads to shaky movements, challenges and speaking, challenges in particular in initiating movement. And because dopamine is depleted elsewhere to people with Parkinson's and Lew's bod, excuse me, Lewy body dementia also experience drops in motivation and affect, meaning mood. They tend to get depressed and so on. When those people are properly treated, they can, not always, but they can recover some fluidity of movement, some ability to initiate movement. And almost without question, those people feel better psychologically,

00:15:30 Two Main Neural Circuits for Dopamine

not just because they can move, but also because dopamine impacts mood and motivation. So what are the underlying neural circuits? For those of you that are not interested in biology and specific nomenclature, you can tune out now if you want, but it's actually pretty straightforward. You have two main neural circuits in the brain that dopamine uses in order to exert all its effects. The first one is a pathway that goes from this area in the what's called the ventral tegmentum. That's a fancy, but ventral just means bottom, and tegmentum actually means floor. So it's at the bottom of the brain, and it's the ventral part of the floor. So it's really low in the back of the brain, the ventral tegmentum. And it goes from the ventral tegmentum to what's called the ventral striatum and the prefrontal cortex. Now, that's a lot of language, but basically what we call this is the, mesocorticolimbic pathway. This is the pathway by which dopamine influences motivation, drive and craving. It involves structures that some of you may have heard of before. Things like nucleus accumbens and the prefrontal cortex. This is the pathway

that really gets disrupted in addictions where in particular drugs that influence the release of dopamine like cocaine and methamphetamine. We'll talk about those drugs today. They tap into this pathway. But if you are pursuing a partner, a boyfriend or girlfriend, if you're pursuing a degree in school, if you're pursuing a finish line in a race, you are tapping into this so-called mesocorticolimbic pathway. This is the classic reward pathway in all mammals. The other pathway emerges from an area in the brain called the substantia nigra. So-called because the cells in that area are dark, and the substantia nigra connects to an area of the brain called the dorsal striatum. This is not surprisingly called the nigrostriatal pathway. For those of you who have never done any neuroanatomy, I'm going to teach you a little trick right now. Everything in neuroanatomy, the first part of a word tells you where the neurons are. And then the second part tells you where they are connecting to. So when I say nigrostriatal pathway, it means that the neurons are in substantia nigra and they connect to the striatum, nigrostriatal pathway. So while it's a lot of language there, some logic there. Okay? So we've got these two pathways. One, mainly for movement, right? This is the substantia nigra to dorsal striatum. And we've got this other pathway, the so-called mesocorticolimbic pathway, that's for reward, reinforcement and motivation. I want you to remember that there are two pathways. If you don't remember the two pathways in detail, that's fine. But please remember that there are two pathways,

00:18:14 How Dopamine Is Released: Locally and Broadly

because that turns out to be important later. Now, the other thing to understand about dopamine is that, the way that dopamine is released in the brain and body can differ. Meaning it can be very local, or it can be more broad. Now, most of you have probably heard of synapses. Synapses are the little spaces between neurons, and basically neurons nerve cells communicate with one another by making each other electrically active, or by making each other less electrically active. So here's how this works. You can imagine one nerve cell and another nerve cell with a little gap between them, a little synapse. And the way that one nerve cell causes the next nerve cell to fire. What we call fire really means to become electrically active is that it vomits out these little packets, what we call vesicles. They're little bubbles filled with a chemical, when that chemical enters the synapse, it some of it docks or parks on the other side, in the other neuron. And by virtue of electrical changes in the, what we call the postsynaptic neuron, that

chemical will make that neuron more electrically active or less electrically active. Dopamine can do that like any other neurotransmitter or neuromodulator. So it can have one neuron influence another neuron. But dopamine can also engage in what's called a volume metric release. Volumetric release is like a giant vomit that gets out to 50 or a hundred or even thousands of cells. So there's local release what we call synaptic release, and then there's volumetric release. So volumetric release is like dumping all this dopamine out into the system. So dopamine is incredible because it can change the way that our neural circuits work at a local scale and at a very broad scale. And for those of you that are only interested in tools, like how do I get more dopamine? Let me tell you this part is really important because if you were to take a drug or supplement that increases your level of dopamine, you are influencing both the local release of dopamine and volumetric release. This relates back to the baseline of dopamine and the big peak above baseline. And that turns out to be important. And I'll just allude to why it's important. Many drugs and indeed many supplements that increase dopamine will actually make it harder for you to sustain dopamine release over long periods of time. And to achieve those peaks that most of us are craving when we are in pursuit of things. Why? Because if you get both volume metric release, the dumping out of dopamine everywhere, and you're getting local release, what it means is that the difference between the peak and baseline is likely to be smaller. And this is very important, how satisfying or exciting or pleasurable a given experience is, doesn't just depend on the height of that peak, it depends on the height of that peak relative to the baseline. So if you increase the baseline and you increase the peak, you're not going to achieve more and more pleasure from things. I'll talk about how to leverage this information in a little bit, but just increasing your dopamine. Yes, it will make you excited for all things. It will make you feel very motivated, but it will also make that motivation very short-lived. So there's a better way to increase your dopamine. There's a better way to optimize this peak to baseline ratio. For now what we've talked about is two main neural circuits, one for movement, and one for motivation and craving with dopamine. And we've talked about two main modes of communication between neurons with dopamine. One is this local synaptic release. One is more volume metric release. And in the back of your mind,

00:22:03 Fast and Slow Effects of Dopamine

you can relate this back to, again, this baseline versus peaks above baseline. So that's a

description of what we would call the spatial effects or the spatial aspects of dopamine. I said this connects to that, that connects to this. You can get local or more broad volumetric release. What about the duration of release or the duration of action for dopamine? Well, dopamine is unique among chemicals in the brain, because dopamine unlike a lot of chemicals in the brain works through what are called G protein-coupled receptors. And for those of you that are about to pass out from the amount of detail, just hang in there with me. It's really not complicated. There are two ways that neurons can communicate or mainly two ways. There are third and fourth, but mostly neurons communicate by two modes. One, are what we call fast electrical synapses ionotropic conduction. All right? You don't need to know what that means, but basically one neuron activates another neuron and little holes open up in that neuron, and ions rush in. Sodium is the main ion salt by which one neuron influences the electrical activity of another neuron because sodium ions contain a charge. Okay? There are other things like chloride and potassium. If you're interested in looking this up, just look up ionic conductances in the action potential, or I could do a post on it some time and we could go into detail. But just understand that when neurons want to influence each other, they can do it by way of this fast ionotropic conduction. This is a really quick way for one neuron to influence the next. Dopamine doesn't communicate that way. Dopamine is slower. It works through what are called G protein-coupled receptors. So what happens is dopamine is released in these little vesicles that I've mentioned before, get vomited out into the synapse. Some of that dopamine will bind to the so-called postsynaptic neuron, it'll bind to the next neuron, and then it sets off a cascade. It's kind of like a bucket brigade of one thing, getting handed off to the next, to the next, to the next. It's G protein-coupled receptors. And anytime you hear about these GPCRs or G protein-coupled receptors, pay attention because they're really interesting. They're slow, but they also can have multiple cascades of effects. They can impact even gene expression at some level. They can change what a cell actually becomes. They can change how well or how poorly that cell will respond to the same signal in the future. So dopamine works through the slower process. These G protein-coupled receptors. And so its effects tend to take a while in order to occur. This aspect of dopamine transmission is important because it now underscores two things. One, there's two pathways for dopamine to communicate. One for movement, one for motivation and craving. There's two spatial scales at which dopamine can operate synaptically or volumetrically. And dopamine can have slow effects, really slow effects, or even very long lasting effects.

00:25:03 Dopamine Neurons Co-Release Glutamate

And it even can control gene expression. It can actually change the way that cells behave. One thing that's not often discussed about dopamine, but is extremely important to know is that dopamine doesn't work on its own. Neurons that release dopamine co-release glutamate. Glutamate is a neurotransmitter and it's a neurotransmitter that is excitatory, meaning it stimulates neurons to be electrically active. So now even if you don't know any cell biology, you should start to gain a picture that dopamine is responsible for movement, motivation and drive. It does that through two pathways, but also the dopamine stimulates action in general, because it releases this excitatory neurotransmitter. It tends to make certain neurons that are nearby or even that are far away, because of volumetric release, it tends to make those more active. So dopamine is really stimulating. And indeed we say that dopaminergic transmission or dopamine tends to stimulate sympathetic arousal. Sympathetic doesn't have anything to do with sympathy. It's just simply means that it tends to increase our levels of alertness. It tends to bring an animal or a human into a state of more alertness, readiness and desire to pursue things outside the confines of its skin. So if I were to just put a really simple message around dopamine it would be, there's a molecule in your brain and body that when released tends to make you look outside yourself, pursue things outside yourself, and to crave things outside yourself. The pleasure that arrives from achieving things also involves dopamine, but is mainly the consequences of other molecules. But if ever you felt lethargic and like just lazy and you had no motivation or drive, that's a low dopamine state. If ever you felt really excited, motivated, even if you're a little scared to do something. Maybe you did your first skydive, or you're about to do your first skydive, or you're about to do some public speaking and you really don't want to screw it up, you are in a high dopamine state. Dopamine is a universal currency in all mammals, but especially in humans for moving us toward goals and how much dopamine is in our system at any one time compared to how much dopamine was in our system a few minutes ago, and how much we remember enjoying a particular experience of the past. That dictates your so-called quality of life and your desire to pursue things. This is really important. Dopamine is a currency, and it's the way that you track pleasure. It's the way that you track success. It's the way that you track whether or not you are doing well or doing poorly. And that is subjective, but if your dopamine is too low, you will not feel

motivated. If your dopamine is really high, you will feel motivated.

00:28:00 Your Dopamine History Really Matters

And if your dopamine is somewhere in the middle, how you feel depends on whether or not you had higher dopamine a few minutes ago or lower dopamine. This is important, your experience of life and your level of motivation and drive depends on how much dopamine you have relative to your recent experience. This is again, something that's just not accounted for in the simple language of dopamine hits. Okay? A simple way to envision dopamine hits is every time you do something you like, you get a piece of chocolate, dopamine hit. You look at your Instagram, dopamine hit. You see someone you like, dopamine hit. All these things described as dopamine hits neglect the fact that if you scroll social media and you see something you really like, dopamine hit. Sure there's an increase in dopamine, but then you get to something else and you go, hmm, not that interesting. However, had you arrived at that second thing first, you might think that it was really interesting. If you had arrived to that second Instagram post three days later or four days later, you might find it extremely interesting. Again, how much dopamine you experience from something depends on your baseline level of dopamine when you arrive there, and your previous dopamine peaks. Okay? That's super important to understand, and it's completely neglected by the general language of dopamine hits. This is why when you repeatedly engage in something that you enjoy, your threshold for enjoyment goes up and up and up. So I want to talk about that process. And I want to explain how that process works, because if you understand that process, and you understand some of these schedules and kinetics as we call them around dopamine, you will be in a terrific position to use any dopamine enhancing tools that you decide to use. You'll be in an excellent position to modulate and control your own dopamine release for optimal motivation and drive. I realized that was a lot of information about the biology of dopamine, sort of like trying to make you drink from the fire hose of dopamine biology. However, I realized that some people probably want even more information about the biology of dopamine transmission. If you're interested in that, I'll post a link to an absolutely stellar review that was published in Nature Reviews Neuroscience called spatial and temporal scales of dopamine transmission. It is quite detailed, but they have beautiful diagrams and can walk you through all the things that I just described and get into even more detail.

00:30:30 Parkinson's & Drugs That Kill Dopamine Neurons. My Dopamine Experience

We'll put a link to that in the caption on YouTube. Right now, I want to share with you two anecdotes, one from my own life, and one from some fairly recent history that illustrate some of the core biology of dopamine and how profoundly it can shape our experience. The first one is a really tragic situation that occurred. This was in the 80s, there was an outbreak of what looked like Parkinsonian symptoms in a young population. So many of you heard of Parkinson's disease. Parkinson's disease is a disease in which people initially start to quake, can't generate smooth movements, they'll have issues with speech, sometimes cognition as well. There are examples like Michael J. Fox, which are kind of early onset. Parkinson's typically it hits people a little bit later in life. There's a genetic component. But there is this question, and there's always been this question whether or not certain lifestyle factors can also create Parkinson's? And some years ago there was a situation where street laboratories, illicit laboratories were trying to make a drug called MPPP, which is an opioid light compound. It's a bit like heroin, and heroin addicts seeking heroin went out and bought what they thought was MPPP. Unfortunately, it was not MPPP. I mean, it would have been tragic if it was anyway because they were drug addicts, but what they ended up taking turned out to be a lot worse. What they ended up taking was MPTP, and MPTP can arise in the synthesis of MPPP. So someone in a lab someplace, this was mainly in the Central Valley in California, but elsewhere as well. Somebody created MPTP, and what ended up happening was a large number of young people who were opioid addicts became completely boxed in paralyzed. Couldn't speak, couldn't blink, couldn't do anything. Couldn't function, couldn't move. So both aspects of dopamine transmission were disrupted. They had no motivation and drive. They couldn't generate any movement of any kind. They were literally locked in frozen. And sadly, this is irreversible. It's irreversible, because what MPTP does is it kills the dopaminergic neurons of the substantia nigra that nigrostriatal pathway that's involved in generating movement. And it kills the dopaminergic neurons of the so-called mesocorticolimbic pathway. I was in college when this whole MPTP thing happened. And I remember hearing this story. At the time, I had no understanding of what it is to have very high levels of dopamine or extremely depleted levels of dopamine. There was no reason why I should have that understanding. I mean, of course I had experienced different pleasures of different kinds

and I've had lows in my life, but nothing to the extreme that I'm about to discuss. I got Giardia. And Giardia is a stomach bug that if any of you ever had it, it is terrible. It's terrible diarrhea. You end up very dehydrated very quickly. You drop a ton of weight and it is extremely unpleasant. I ended up going to the emergency room, and in the emergency room, I begged them for something to stop up my guts. And they gave it to me. They put a saline line into rehydrate me and they injected something into the saline bag. And within minutes I felt more sadness, more overwhelming sense of depression, basically, lower than I'd ever felt in my entire life. It was absolutely profound. I was crying endlessly without knowing why I was crying. I was miserable. And I asked them, what did you inject? And they said, "We injected Thorazine." Thorazine is an antipsychotic drug. It's actually used to block dopamine receptors. It's what's given to people who have schizophrenia. Often is given to people who have schizophrenia, because schizophrenia involves among other things elevated levels of dopamine. It was horrible. The experience of it was miserable, unlike anything I'd ever experienced. And so I actually said to them, "What did you give me?" They said, "Thorazine." And I said, "You have to give me L-DOPA." "You have to give me something to get my dopamine levels "back up again." And they did. They gave me an injection of L-DOPA into the bag, went straight to my bloodstream. And within minutes I felt fine again. It was incredible. And it really opened up my mind and my experience to what it is to have absolutely plummeted levels of dopamine. And there's nothing more miserable than that I'll tell you. And these poor souls who had this MPTP experience, unfortunately, they couldn't recover those cells. People who have severe Parkinson's are struggling with this as well, because in Parkinson's and in Lewy body dementia, the dopaminergic neurons often die. It's not just a problem with those neurons releasing enough dopamine. Later, we're going to talk about some approaches to maintaining dopaminergic neuron health and things that we can all do for that. But I will tell you these dopamine neurons that we all have are very precious for movement and mood and motivation. Having experienced what it is to have very, very low levels of dopamine or in this case to have my dopamine receptors blocked from Thorazine was eye-opening to say the least, and has given me tremendous sensitivity to the fact that dopamine is perhaps one of the most powerful molecules that any of us has inside of us. And the one that we ought to all think very carefully about how we leverage, because while most experiences and most things that we do, and take and eat and cetera, won't create enormous highs and enormous lows in dopamine. Even subtle fluctuations in dopamine really shape our perception of life and what we're

capable of, and how we feel. And so we want to guard those and we want to understand them. So let's lean into that understanding about dopamine. And then let's talk about some tools that we can all use to leverage dopamine in order to keep that baseline in the appropriate, healthy place, and still be able to access those peaks in dopamine.

00:36:58 Tool 3 Controlling Dopamine Peaks & Baselines

Because those, after all are some of what makes life rich and worth living. So let's talk about the baseline of dopamine that we all have and the peaks in dopamine that we all can achieve through different activities and things that we ingest. All of us have different baseline levels of dopamine. Some of this is sure to be genetic. Some people just simply ride at a level a little bit higher. They're a little bit more excited, they're a little bit more motivated, or maybe they're a lot more excited or a lot more motivated. Some people are a little mellower, some people are a little less excitable. And some of that has to do with the fact that dopamine doesn't act alone. Dopamine has close cousins or friends in the nervous system. And I'll just name off a few of those close cousins and friends.

Epinephrin also called adrenaline is the main chemical driver of energy. We can't do anything, anything at all, unless we have some level of epinephrin in our brain and body. It's released from the adrenal glands which right on top our kidneys. It's released from an area of the brainstem called locus coeruleus. And its release tends to wake up neural circuits in the brain and wake up various aspects of our body's physiology and give us a readiness. So it should come as no surprise that dopamine and epinephrin aka adrenaline hang out together. In fact, epinephrin and adrenaline are actually manufactured from dopamine. There's a biochemical pathway involving dopamine which is a beautiful pathway. If ever you want to look it up, you can just look up biochemistry of dopamine. But what you'll find is that, L-DOPA is converted into dopamine. Dopamine is converted to two noradrenaline. Norepinephrin, it's also called. And noredrenaline, norepinephrin is converted into adrenaline. So not only are dopamine and epinephrin aka adrenaline close cousins, they are actually family members. Okay? They're closely related. I'm not going to get too deep into epinephrin today. I'm not going to talk too much about those pathways, but anytime I'm talking about dopaminergic transmission or that you have a peak in dopamine, inevitably, that means that you have a peak and release of epinephrin as well. What dopamine does is dopamine really colors the subjective experience of an activity to make it more pleasurable, to make it something

that you want more of. Epinephrin is more about energy. Epinephrin alone can be fear, paralysis, trauma. Not physical paralysis, but mental paralysis, you know, frozen in fear or being traumatized or scared. But the addition of dopamine to that chemical cocktail, if dopamine is released in the brain, well, then that epinephrin becomes one of excitement. Okay? I'm using a broad brush here, but essentially what you need to know is that, dopamine and epinephrin aka adrenaline are family members.

00:40:06 Chocolate, Sex (Pursuit & Behavior), Nicotine, Cocaine, Amphetamine, Exercise

And they tend to work together like a little gang to make you seek out certain things. So what sorts of activities? What sorts of things increase dopamine? And how much do they increase dopamine? Well, let's take a look at some typical things that people do out there or ingest out there that are known to increase dopamine. So let's recall that you have a baseline level of dopamine and that everybody does. And even within a family, you might have family members who are very excitable, happy and motivated, and others who are less excitable, happy and motivated. But your level of dopamine has everything to do with those genetics, but also with what you've experienced in the previous days and the previous months and so on. When you do or ingest certain things, your levels of dopamine will rise above baseline transiently. And depending on what you do or ingest, it will rise either more or less, and it will be very brief or a last a long time. So let's take a look at some of the typical things that people take and do and eat. Some are good for us, some are not good for us. And let's ask how much dopamine is increased above baseline? Now, of course, these are averages, but these are averages that have been measured in so-called micro dialysis studies in animals. So actually extracting from particular brain areas how much dopamine is released? Or from measuring the serum, the circulating levels of dopamine in humans. Chocolate. They didn't look at milk versus dark chocolate. But chocolate will increase your baseline level of dopamine 1.5 times. Okay? So it's a pretty substantial increase in dopamine. It's transient. It goes away after a few minutes or even a few seconds. I'll explain what determines the duration in a minute. But 1.5 times for chocolate. Sex. Both the pursuit of sex and the act of sex increases dopamine two times. So it's a doubling above baseline. Now, of course, there's going to be variation there, but that's the average increase in baseline dopamine caused by sex. Later, I will talk about how the different aspects of the

so-called arousal art, the different aspects of sex, believe it or not have a differential impact on dopamine. But for now as a general theme or activity, sex doubles the amount of dopamine circulating in your blood. Nicotine. In particular, nicotine that is smoked like cigarettes and so forth, increases dopamine two and a half times above baseline. So there's a peak that goes up above baseline two and a half times higher. It is very short-lived. Anyone who's ever been a chain smoker or observed a chain smoker understands that the increase in dopamine from nicotine is very short-lived. Cocaine will increase the level of dopamine in the bloodstream two and a half times above baseline. And amphetamine another drug that increases dopamine will increase the amount of dopamine in the bloodstream 10 times above baseline. A tremendous increase in dopamine. Exercise. Now, exercise will have a different impact on the levels of dopamine, depending on how much somebody subjectively enjoys that exercise. So if you're somebody who loves running, chances are it's going to increase your levels of dopamine two times above your baseline, not unlike sex. People who dislike exercise will achieve less dopamine increase or no increase in dopamine from exercise. And if you like other forms of exercise like yoga or weightlifting or swimming or what have you. Again, it's going to vary by your subjective experience of whether or not you enjoy that activity. This is important. And it brings us back to something that we talked about earlier. Remember that mesocorticolimbic pathway? Well, the cortical part is important. The cortical part actually has a very specific part, which is your prefrontal cortex. The area of your forebrain that's involved in thinking and planning and involved in assigning a rational explanation to something, and involved in assigning a subjective experience to something, right? So for instance, the pen that I'm holding right now, it's one of these Pilot V5s. I love these Pilot V5s. They don't sponsor the podcast. I just happen to like them. I liked the way that they write, how they feel. If I spent enough time thinking about it, or talking about it, I could probably get a dopamine increase just talking about this Pilot V5. And that's not because I have the propensity to release dopamine easily, it's that as we start to engage with something more and more and what we say about it, and what we encourage ourselves to think about it, has a profound impact on its rewarding or non rewarding properties. Now, it's not simply the case that you can lie to yourself, and you can tell yourself I love something and when you don't really love it, and it will increase dopamine. But what's been found over and over again, is that if people journal about something or they practice some form of appreciation for something, or they think of some aspect of something that they enjoy, the amount of dopamine that that behavior

will evoke tends to go up. So for people that hate exercise, you can think about some aspect of exercise that you really enjoy. However, I will caution you against saying to yourself, I hate exercise or I hate studying or I hate this person, but I love the reward I give myself afterward. Later, we're going to talk about how rewards given afterward actually make the situation worse. They won't make you like exercise more or study more, they actually will undermine the dopamine release that would otherwise occur for that activity. So certain things chemicals have a universal effect. They make everybody's dopamine go up. So some people like chocolate, some people don't of course, but in general, it make has causes this increase in dopamine. But sex, nicotine, cocaine, amphetamine, those things cause increases in dopamine and everybody that takes them. Things like exercise, studying, hard work, working through a challenge in a relationship or working through something hard of any kind that is going to be subjective

00:46:46 Tool 4 Caffeine Increases Dopamine Receptors

as to how much dopamine will be released. And we will return to that subjective component in a little bit. But now you have a sense of how much dopamine can be evoked by different activities and by different substances. One that you might be wondering about is caffeine. I'm certainly drinking my caffeine today, and I do enjoy caffeine in limited quantities. I drink yerba mate and I drink coffee and I love it. Does it increase dopamine? Well, a little bit. Caffeine will increase dopamine to some extent, but it is pretty modest compared to the other things that I described. Chocolate, sex, nicotine, cocaine, amphetamine and so on. However, there's a really interesting paper published in 2015. This is Volkow et al. You can look up it's very easy to find. That showed that regular ingestion of caffeine, whether or not it's from coffee or otherwise, increases up regulation of certain dopamine receptors. So caffeine actually makes you able to experience more of dopamines effects. Because as I mentioned before, dopamine is vomited out into the synapse or it's released volumetrically, but then it has to bind someplace and trigger those G protein-coupled receptors. And caffeine increases the number, the density of those G protein-coupled receptors. Now, sitting back and thinking about that, you might think, oh yeah, you know, sometimes I'll notice people, at least in the old days that used to be a cigarette and a cup of coffee. Or when people drink alcohol, oftentimes they'll smoke. And it's well-known that different compounds like alcohol and nicotine or caffeine and nicotine or certain behaviors and certain drugs can

synergize to give bigger dopamine increases. And this is not terribly uncommon. There are a lot of people nowadays who for instance take pre-workout energy drinks. They'll drink, I won't name names, but they'll drink a canned energy drink or they'll drink a pre-workout and they'll try and get that big stimulation that stimulant effect for the dopamine, the norepinephrin, that family of molecules that works together to make you motivated. And then they'll also exercise to try and get even more of a dopaminergic experience out of that workout. Sometimes it's also to perform better as well, of course, but as we'll talk about in a few minutes, that aspect or that approach rather of trying to just get your dopamine as high as you possibly can, in order to get the most out of experience, turns out to not be the best approach. And what you'll find as we talk about dopamine schedules is that layering together multiple things, substances and activities that lead to big increases in dopamine, actually can create pretty severe issues with motivation and energy right after those experiences and even a couple of days later. So I'm not saying that people shouldn't take the occasional pre-workout if that's your thing, or drink a cup of coffee or two before working out now and again. Some people really enjoy that. I certainly do that every once in a while, but if you do it too often, what you'll find is that your capacity to release dopamine

00:49:54 Pursuit, Excitement & Your "Dopamine Setpoint"

and your level of motivation and drive and energy overall will take a serious hit. Now, I've been alluding to this dopamine peaks versus dopamine baseline things since the beginning of the episode. I talked about tonic and phasic release and so forth. But now let's really drill into what this means, and how to leverage it for our own purposes. In order to do that, let's take a step back and ask, why would we have a dopamine system like this? Why would we have a dopamine system at all? Well, we have to remember what our species primary interest is? Our species like all species has a main interest, and that's to make more of itself. And it's just about sex and reproduction. It's about forging for resources. Resources can be food, it can be water can be salt, it can be shelter, it can be social connection. Dopamine is the universal currency of forging and seeking, right? We call sometimes talk about motivation and craving, but what we mean in the evolutionary adaptive context, what we mean is forging and seeking. Seeking water, seeking food, seeking mates. Seeking things that make us feel good and avoiding things that don't make us feel good. But in particular seeking things that will provide

sustenance and pleasure in the short-term and will extend the species in the long-term. Once we understand that dopamine is a driver for us to seek things, it makes perfect sense as to why it would have a baseline level and it would have peaks. And that the baseline and peaks would be related in some sort of direct way. Here's what I mean by that. Let's say that you were not alive now, but you were alive 10,000 years ago. And you woke up and you looked and you realized you had minimal water and you had minimal food left. Maybe you have a child, maybe you have a partner, maybe you're in an entire village, but you realize that you need things. Okay? You need to be able to generate the energy to go seek those things. And chances are there were dangers in seeking those things. Yes, it could be saber-tooth tigers and things of that sort, but there are other dangers too. There's the danger of a cut to your skin that could lead to infection. There's the danger of storms, there's the danger of cold, there's the danger of leaving your loved ones behind. So you go out and forage, right? You could be hunting, you could be gathering, or you could be doing both. The going out and foraging process was we are certain driven by dopamine. I mean, there's no fossil record of the brain, but the circuits have existed. We know for tens of thousands, if not hundreds of thousands of years. And they are present in every animal, not just mammals, but even in little worms like *C. elegans*, it's the same process. It's mediated by dopamine. So dopamine drives you to go out and look for things. And then let's say you find a couple berries, and these ones are rotten, these ones are good. Maybe you hunt an animal and kill it, or you find an animal that was recently killed and you decide to take the meat. You are going to achieve, or I should say, experience some sort of dopamine release. You found the reward. That's great. But then it needs to return to some lower level. Why? Well, because if you just stayed there, you would never continue to forage for more. It doesn't just increase your baseline and then stay there. It goes back down. And what's very important to understand is that it doesn't just go back down to the level it was before, it goes down to a level below what it was before you went out seeking that thing. Now, this is counter-intuitive. We often think, Oh, okay, I'm going to pursue the win, right? Let's move this to modern day. I'm going to run this marathon, I'm going to train for this marathon. Then you run the marathon and you finish, you cross the finish line, you feel great. And you would think, okay, now I'm set for the entire year, I'm going to feel so much better, I'm going to feel this accomplishment in my body, it's going to be so great. That's not what happens. You might feel some of those things, but your level of dopamine has actually dropped below baseline. Now, eventually it will ratchet back up.

But two things are really important. First of all, the extent to which it drops below baseline is proportional to how high the peak was. So if you cross the finish line pretty happy, it won't drop that much below baseline afterward. If you cross the finish line ecstatic, well, a day or two later, you're going to feel quite a bit lower than you would otherwise. You might not be depressed, because it depends on where that baseline was to begin with. But the so-called postpartum depression that people experience after giving birth or after some big win a graduation or any kind of celebration that postpartum drop in mood and affect and motivation is the drop in baseline dopamine. This is very important to understand, because this happens on very rapid timescales and it can last quite a long time. It also explains the behavior that most of us are familiar with, of engaging in something that we really enjoy. Going to a restaurant that we absolutely love, or engaging in some way with some person that we really, really enjoy. But if we continue to engage in that behavior over and over again, it kind of loses its edge. It starts to kind of feel less exciting to us. Some of us experienced that drop in excitement more quickly and more severely than others, but everyone experiences that to some extent. And this has direct roots in these evolutionarily conserved circuits. Some of you may be hearing this and think, no, no, no, no that's not how it works for me. I'm just riding higher and higher all the time. I love my kids, I love my job, I love school, I love wins, I don't want losses. I agree. We all feel good when we are achieving things, but oftentimes we are feeling good because we are layering in different aspects of life, consuming things and doing things that increase our dopamine. We're getting those peaks, but afterward the drop in baseline occurs, and it always takes a little while to get back to our stable baseline. We really all have a sort of dopamine set point. And if we continue to indulge in the same behaviors or even different behaviors that increase our dopamine in these big peaks over and over and over again, we won't experience the same level of joy from those behaviors or from anything at all. Now, that has a name. It's called addiction. But even for people who aren't addicted, even for people don't an attachment to any specific substance or behavior, this drop in dopamine below baseline after any peak in dopamine is substantial. And it governs whether or not we are going to feel motivated to continue to pursue other things. Fortunately, there's a way to work with this, such that we can constantly stay motivated,

00:56:46 Your Pleasure-Pain Balance & Defining "Pain"

but also keep that baseline of dopamine at an appropriate, healthy level. A previous guest on the Huberman Lab Podcast was Dr. Anna Lembke. She's head of the Addiction Dual Diagnosis Clinic at Stanford. Has this amazing book, "Dopamine Nation: Finding Balance in the Age of Indulgence". If you haven't read the book, I highly encourage you to check it out. It's fantastic. The other terrific book about dopamine is the "Molecule of More", which is similar in some regard, but isn't so much about addiction, it's more about other types of behaviors. Both books really focus on these dopamine schedules and the relationship between these peaks and baselines of dopamine. In Dr. Lembke's book, and when she was on the Huberman Lab Podcast and other podcasts, she's talked about this pleasure pain balance that when we seek something that we really like, or we indulge in it, like eating a little piece of chocolate, if we really liked chocolate, there's some pleasure. But then there's a little bit of pain that exceeds the amount of pleasure, and it's subtle, and we experience it as wanting more of that thing. Okay? So there's a pleasure pain balance, and I'm telling you that the pleasure and the pain are governed by dopamine to some extent. Well, how could that be? Right? I said before, when you engage in an activity or when you ingest something that increases dopamine, the dopamine levels go up, you know, to substantial degree with all the things I listed off. Where's the pain coming from? Well, the pain is coming from the lack of dopamine that follows. And you now know what that lack of dopamine reflects. How do you know? Well, earlier we were talking about how dopamine is released between neurons. And I mentioned two ways. One, is into the synapse where it can activate the postsynaptic neuron. And the other was what I called volumetric release where it is distributed more broadly. It's released out over a bunch of neurons. In both cases it's released from these things we call synaptic vesicles, literally little bubbles, tiny, tiny little bubbles that contain dopamine. Prrr! They get vomited out into the area or into the synapse. Well, those vesicles get depleted. For the synaptic physiologists out there, we call this the readily releasable pool of dopamine. We can only deploy dopamine that is ready to be deployed. That's packaged in those little vesicles and ready to go. It's like when you order a product and they say out of stock until two months from now. Well, it's not ready to be released. Same thing with dopamine. There's a pool of dopamine that's synthesized, and you can only release the dopamine that's been synthesized. It's the readily releasable pool. The pleasure pain balance doesn't only hinge on the readily releasable pool of dopamine, but a big part of the pleasure pain balance hinges on how much dopamine is there? And how much is ready and capable of being released into the

system? So now we've given some meat to this thing that we call the pleasure pain balance, and now it should make perfect sense why if you take something or do something that leads to huge increases in dopamine,

01:00:00 Addiction, Dopamine Depletion, & Replenishing Dopamine

afterward your baseline should drop because there isn't a lot of dopamine around to keep your baseline going. Fortunately, most people do not experience or pursue enormous increases in dopamine leading to the severe drops in baseline. Many people do, however, and that's what we call addiction. When somebody pursues a drug or an activity that leads to huge increases in dopamine. And now you understand that afterward the baseline of dopamine drops because of depletion of dopamine, that readily releasable pool. The dopamine is literally not around to be released, and so people feel pretty lousy and many people make the mistake of then going and pursuing the dopamine evoking the dopamine releasing activity or substance again thinking mistakenly that it's going to bring up their baseline. It's going to give them that peak again. Not only does it not give them a peak, their baseline gets lower and lower because they're depleting dopamine more and more and more. And we've seen this over and over again when people get addicted to something then they're not achieving much pleasure at all. You can even see this with video games. People will play a video game, they love it, it's super exciting to them, and then they'll keep playing and playing and playing, and either one of two things happens typically both. First of all, I always say addiction is a progressive narrowing of the things that bring you pleasure. So oftentimes what will happen is the person only has excitement and can achieve dopamine release to the same extent doing that behavior and not other behaviors. And so they start losing interest in school, they start losing interest in relationships. they start losing interest in fitness and wellbeing and depletes their life. And eventually what typically happens is, they will stop getting dopamine release from that activity as well, and then they drop into a pretty serious depression and this can get very severe and people have committed suicide from these sorts of patterns of activity. But what about the more typical scenario? What about the scenario of somebody who is really good at working during the week, they exercise during the week, they drink on the weekends? Well, that person is only consuming alcohol maybe one or two nights a week, but oftentimes that same person will be spiking their dopamine with food during the middle of the week. Now, we all have

to eat and it's nice to eat foods that we enjoy. I certainly do that. I love food in fact. But let's say they're eating foods that really evoke a lot of dopamine release in the middle of the week, they're drinking one or two days on the weekend, they are one of these work, hard play hard type. So they're swimming a couple miles in the ocean in the middle of the week as well. They're going out dancing once on the weekend. Sounds like a pretty balanced life as I describe it. Well, here's the problem. The problem is that dopamine is not just evoked by one of these activities, dopamine is evoked by all of these activities. And dopamine is one currency of craving motivation and desire and pleasure. There's only one currency. So even though if you look at the activities, you'd say, well, it's just on the weekends so this thing is only a couple of times a week. If you looked at dopamine simply as a function, as a chemical function of peaks and baseline, it might make sense why this person after several years of work hard, play hard would say, yeah, you know I'm feeling kind of burnt out. I'm just not feeling like I have the same energy that I did a few years ago. And of course there are age-related reasons why people can experience drops in energy, but oftentimes what's happening is not some sort of depletion and cellular metabolism that's related to aging. What's happening is they're spiking their dopamine through so many different activities throughout the week, that their baseline is progressively dropping. And in this case it can be very subtle. It can be very, very subtle. And that's actually a very sinister function of dopamine we could say. Which is that it can often drop in imperceptible ways, but then at once it reaches a threshold of low dopamine, we just feel like, hmm, we can't really get pleasure from anything anymore. What used to work doesn't work anymore. So it starts to look a lot like the more severe addictions or the more acute addictions to things like cocaine and amphetamine which lead to these big increases, these big spikes in dopamine, and then these very severe drops in the baseline. Now, of course, we all should engage in activities that we enjoy. I certainly do, everybody should. A huge part of life is pursuing activities and things that we enjoy. The key thing is to understand this relationship between the peaks and the baseline, and to understand how they influence one another. Because once you do that, you can start to make really good choices in the short run and in the long run to maintain your level of dopamine baseline. Maybe even raise that level of dopamine baseline and still get those peaks and still achieve those feelings of elevated motivation, elevated desire and craving. Because again, those peaks and having a sufficiently healthy high level of dopamine baseline are what drove the evolution of our species, and they're really what drive the evolution of anyone's life progression too. So they're a good thing.

Dopamine is a good thing. Just very briefly, because it was also covered in the interview episode I did with Anna Lembke about addiction. Some of you might be asking, what should I do if I experience a drop in my baseline level of dopamine because of engagement with some activity or some substance that led to big peaks? Just to put some color and example on this, a few episodes ago I talked about a friend who I've known a long time. So it actually the child of a friend who has basically become addicted to video games, he decided actually after seeing that episode with Anna to do a 30-day complete fast from phone, from video games and from social media of all kinds. He's now at day 29 has really accomplished this, not incidentally, his levels of concentration, his overall mood are up. He's doing far far better. What he did is hard. In particular first 14 days is really hard, but the way that you replenish the releasable pool of dopamine is to not engage in these dopaminergic seeking behaviors. Because remember typically people arrive at a place where they want to stop engaging in these behaviors or ingesting substances when that dopamine is depleted, when they're not getting the same lift. In his case, he was feeling depressed. He thought he had ADHD. They were starting to treat it as ADHD. And certainly there are people out there who have ADHD, but what he found was that his levels of concentration are back. He does not need to be treated for ADHD. And actually the psychiatrist wondered if he did prior to this video game, social media fast. He's feeling good. He's exercising again. I'm not making this up. This is really a very specific, but very relevant example of how the dopamine system can replenish itself. Of course, if there's a clinical need for ADHD treatment, by all means pursue that. But I think a lot of ADHD does go misdiagnosed because of this depletion in dopamine that occurs because of overindulgence in other activities in the drop in baseline. So for anyone that's experienced a real drop in baseline who has addictive tendencies, whether or not their behaviors or substances, that is always going to be the path forward. Is going to be either cold turkey or through some sort of tapering to limit interactions with the, what would otherwise be the dopamine evoking

01:07:50 Tool 5 Ensure Your Best (Healthy) Dopamine Release

behavior or substance. So let's talk about the optimal way to engage in activities or to consume things that evoke dopamine. And by no means am I encouraging people to take drugs of abuse. I would not do that, I am not doing that. But some of the things on these lists of dopamine evoking activities are things like chocolate, coffee, even if it's

indirect. Sex and reproduction, provided it's healthy consensual context appropriate, age appropriate, species appropriate of course, is central to our evolution and progression as a species. So certain things like cocaine, amphetamine, I will put in the classification of bad. I'm willing to do that. And other things are part of life, food, exercise if that evokes your dopamine. How are we supposed to engage with these dopamine evoking activities in ways that are healthy and beneficial for us? How do we achieve these peaks, which are so central to our wellbeing and experience of life without dropping our baseline? And the key lies in intermittent release of dopamine. The real key is to not expect or chase high levels of dopamine release every time we engage in these activities. Intermittent reward schedules are the central schedule by which casinos keep you gambling. The central schedule by which elusive partners or potential partners keep you texting and pursuing on either side of the relationship. Intermittent schedules are the way that the internet and social media and all highly engaging activities keep you motivated and pursuing. And we can take this back to our evolutionary adaptive scenario where you are out there looking for water, looking for food, not every trail, not every pursuit, not every hunch about where the animals will be? Where the food will be? Where the berries will be? Not every single one of those played out. There's something called dopamine reward prediction error. When we expect something to happen, we are highly motivated to pursue it. If it happens great, we get the reward. The reward comes in various chemical forms including dopamine, and we are more likely to engage in that behavior again. This is the basis of casino gambling. This is how they keep you going back again and again and again, even though on average the house really does win. You can transplant that example to any number of different pleasurable activities. If you're not a gambler and that doesn't appeal to you, I have to imagine there's something that appeals to you, something that you do repeatedly because you enjoy it. And almost inevitably it's because there's an intermittent schedule. There's a intermittent schedule by which dopamine sometimes arrives, sometimes a little bit, sometimes a lot, sometimes a medium amount. Okay? That intermittent reinforcement schedule is actually the best schedule to export to other activities. How do you do that? Well, first of all, if you are engaged in activities school, sport, relationship, et cetera, where you experience a win, you should be very careful about allowing yourself to experience huge peaks in dopamine, unless you're willing to suffer the crash that follows and waiting a period of time for it to come back up. What would this look like in the practical sense? Well, let's say you are somebody who really does enjoy exercise, or let's say you're

somebody who kind of likes exercise, but forces yourself to do it, but you make it pleasurable by giving yourself your favorite cup of coffee first, or maybe taking a pre-workout drink or taking an energy drink or listening to your favorite music. And then you're in the gym and you're listening to your music. That all sounds great, right? Well, it is great except that by layering together all these things to try and achieve that dopamine release, and by getting a big peak in dopamine, you're actually increasing the number of conditions required to achieve pleasure from that activity again. And so there is a form of this where sometimes you do all the things that you love to get the optimal workout. You listen to your favorite music, you got your favorite time of day, you have your pre-workout drink, if that's your thing. You do all the things that give you that best experience of the workout for you. But there's also a version of this where sometimes you don't do the dopamine enhancing activities. You don't ingest anything to increase your dopamine. You just do the exercise. You don't do the exercise and expect dopamine to arrive through some what we call exogenous source as well. You might think, well, that sounds lame. I want to continue to enjoy exercising. Ah, well, that's exactly the point. If you want to maintain motivation for school, exercise, relationships or pursuits of any duration in kind, the key thing is to make sure that the peak in dopamine, if it's very high, doesn't occur too often. And if something does occur very often that you vary how much dopamine you experience with each engagement in that activity. Now, some activities naturally have this intermittent property woven into them, right? We sometimes have classes that we like and other classes we don't like. We don't always get straight A's, sometimes we don't get rewarded with the outcome that we would like. We don't always have the perfect relationship outcome, but understand that your ability to experience motivation and pleasure for what comes next is dictated by how much motivation and pleasure and dopamine you experienced prior. The reason I can't give a very specific protocol like delete dopamine or lower dopamine every third time, is that that wouldn't be intermittent. The whole basis of intermittent reinforcement is that you don't really have a specific schedule of when dopamine is going to be high, and when dopamine is going to be low and when dopamine is going to be medium. That's a predictable schedule, not a random intermittent schedule. So do like the casinos do certainly works for them and for activities that you would like to continue to engage in over time, whatever those happen to be. Start paying attention to the amount of dopamine and excitement and pleasure that you achieve with those, and start modulating that somewhat at random. That might be removing some of the dopamine releasing chemicals that you might take prior.

Maybe you remove them every time, but then every once in a while you introduce them,. Maybe it involves sometimes doing things socially that you enjoy doing socially, sometimes doing the same thing, but alone. There are a lot of different ways to do this. There are a lot of different ways to approach this, but now knowing what you know about peaks and baselines in dopamine and understanding how important it is not just to achieve peaks, but to maintain that baseline at a healthy level, it should be straightforward for you to implement these intermittent schedules. For those of you that are begging for more specificity, we can give you a tool. One would be, you can flip a coin before engaging in any of these types of activities and decide whether or not you are going to allow other dopamine supportive elements to go for instance, into the gym with you. Are you going to listen to music or not? If you enjoy listening to music, well then flip a coin, and if it comes up heads, bring the music in, if it comes up tails, don't. Okay? It sounds like you're undercutting your own progress, but actually you are serving your own progress

01:15:28 Smart Phones: How They Alter Our Dopamine Circuits

both short-term and long-term by doing that. Now, the smartphone is a very interesting tool for dopamine in light of all this. It's extremely common nowadays to see people texting and doing selfies and communicating in various ways, listening to podcasts, listening to music, doing all sorts of things while they engage in other activities or going to dinner and texting other people or making plans, sharing information. That's all wonderful, it gives depth and richness and color to life, but it isn't just about our distracted nature when we're engaging with the phone, it's also a way of layering in dopamine. And it's no surprise that levels of depression and lack of motivation are really on the increase. Everything that we've talked about until now sets up an explanation or interpretation of why interacting with digital technology can potentially lead to disruptions or lowering in baseline levels of dopamine. I can use a personal example for this. I happen to really enjoy working out, I've always really enjoyed it. But in recent years I noticed that, if I was bringing my phone to my workouts, then not only was I a little bit more distracted and not focusing on what I was doing as much as I could have or should have, but also I started to lose interest in what I was doing. It wasn't as pleasurable, I would feel like it just didn't have the same kind of oomph. And I was beginning to question my motivation. As I started learning more about this relationship between the

peaks and the bass lines in dopamine. What I realized was that some time ago I probably experienced an incredible increase in the amount of dopamine during one of my workouts, because I enjoy working out and I enjoy listening to music. I also enjoy listening to podcasts, I also enjoy communicating with people. Those are all wonderful pursuits, but I had layered in too many of them too many times. And then it essentially wasn't working for me anymore. Much in the same way a drug wouldn't work for somebody who takes it repeatedly because their baseline of dopamine is dropping. So at least for this calendar year, I've made a rule for myself, which is I don't allow my phone into my workouts at all. No music, at least not from the phone. It can be in the room. I might listen to a podcast in the room, but I don't listen to anything or engage in anything on my phone. No texting whatsoever. And most of the time I just don't even bring it with me for that period of time. It's only a short period of time. I'm not training that often. This is something that I think has been misinterpreted as people can't be alone now. People talk about, oh, you know, they can't walk across the street or they can't go anywhere, ride the bus, can't be on the plane without being in contact. They can't handle just their thoughts. I don't think that's really what's going on. I think what's happened is that we achieved the great dopamine increase that comes from this incredible thing which I personally enjoy being able to communicate by phone, by text and exchange pictures and send links and these kinds of things, social media. But then what happens is it doesn't have that same fulfilling aspect to it. And it tends to remove the excitement and the pleasure of the very activities that we are engaged in. So I know this is a hard one for many people, but I do invite you to try removing multiple sources of dopamine release or what used to be multiple sources of dopamine release from activities that you want to continue to enjoy, or that you want to enjoy more. And now you understand the biological mechanisms that would underlie a statement like that. It takes a little bit of working with, I know it can be challenging in the first week or so of not engaging with the phone during any kind of workout. That actually was really tough, but now I'm back to a place where I enjoy it that much more. I also feel as if I conquered something in terms of the circuitry related to dopamine. I now understand why something that I enjoyed so much had become less pleasurable for me. And there's a deep, deep satisfaction that comes from understanding, okay, there wasn't anything wrong with me or what I was doing or anything at all. It was just there was something wrong with the approach I was taking,

01:19:45 Stimulants & Spiking Dopamine: Counterproductive for Work, Exercise & Attention

which was layering in all these sources of dopamine and dropping my baseline. For this very same reason, I caution people against using stimulants every time they study or every time they work out or every time that they do anything that they would like to continue to enjoy and be motivated at. There's one exception which is caffeine, because as I mentioned before, if you like caffeine, that actually could be a good thing for your dopamine system, because it does upregulate these D2, D3 receptors. So it actually makes whatever dopamine is released by that activity, more accessible or more functional within the biochemistry and the pathways of your brain and body. However, a number of energy drinks and particular pre-workouts contain things that are precursors to dopamine, and on their own, even if you didn't engage in the activity would cause the release of dopamine to a substantial degree. They do cause the release of dopamine to a substantial degree. And over time that will deplete your dopamine. So energy drinks, pre-workout drinks, drugs of various kinds that people take to study and pay attention. We talked about some of these for the ADHD episode, things like Adderall, Ritalin, armodafinil or modafinil taken repeatedly over time will reduce the level of satisfaction and joy that you get from the activities you engage in while under the influence of those compounds. I'm not trying to demonize those compounds for their clinical use. What I'm saying is taking stimulants and then engaging in activities that you would like to continue to feel pleasurable is undercutting the process. And inevitably might not happen tomorrow, might not happen in a month, but inevitably you will have challenges with motivation and drive related to those activities. Now, some people can keep it right in check. They can just do the one can have the energy drink or they only do their pre-workout before really hard days, for instance. More power to you. I actually do that sometimes, frankly. But people who are trying to get into that peak super motivated, driven, driven state, really focused every time they engage in an activity, you are absolutely undercutting the process and you are undermining your ability to stay motivated and focused. So just as we talked about intermittent reward schedules a moment ago, intermittent spiking of dopamine if you do it at all is definitely the way to go, and chronically trying to spike your dopamine in order to enhance your motivation, focus and drive

01:22:20 Caffeine Sources Matter: Yerba Mate & Dopamine Neuron Protection

will absolutely undermine your motivation focus and drive in the long run. Ingestion of caffeine is somewhat of an exception among the other examples of things I've mentioned to avoid before what would otherwise be dopamine increasing activities. Because again, caffeine can increase the density and the efficacy of these dopamine receptors. It turns out that the source of caffeine could also matter while coffee or tea or other forms of caffeine will have this effect of increasing dopamine receptors. Yerba mate something I've talked about before on this podcast has some interesting properties. First of all, it contains caffeine. It's also high in antioxidants. It also contains something called GLP-1 which is favorable for management of blood sugar levels. Yerba mate turns out has also been shown to be neuroprotective specifically for dopaminergic neurons. Now, I should mention this is just a couple of studies, so we don't want to conclude too much from these studies more needs to be done. But they showed that in a model of damage to dopamine neurons, ingestion of yerba mate, and some of the compounds within yerba mate can actually serve to preserve the survival of dopamine neurons in both the movement related pathway and the motivation pathway. So perhaps you need that incentive in order to ingest your yerba mate, perhaps you don't need any incentive. In my case, I don't need any incentive. I already enjoy yerba mate as my principle source of caffeine, although I do drink coffee as well. But if one were going to consume caffeine, you might consider consuming that caffeine in the form of yerba mate both for sake of upregulating dopamine receptors and getting more of a dopamine increase. And of course, for the similar properties of caffeine if that's what you're seeking. And in addition to that,

01:24:20 Caffeine & Neurotoxicity of MDMA

because your yerba mate does appear to have some sort of neuroprotective and a particular dopamine neuron protective properties. Now, that doesn't mean that caffeine is always beneficial. And actually there's one instance related to dopamine where caffeine can be particularly dangerous. And this relates to MDMA so-called ecstasy. MDMA is under investigation in various clinical trials for its potential to treat trauma and depression. It's also of course, a drug that's used recreationally. It's still illegal at least in the United States. Whether or not MDMA is neurotoxic has been very controversial.

Early on it was thought that it is neurotoxic that it can destroy serotonergic neurons. There were other papers that came out which argued that's not the case. And that's in particular because one of the early papers published in science magazine claiming that MDMA was neurotoxic. That paper was retracted. It turns out that that study had mistakenly used methamphetamine instead, and methamphetamine is known to be neurotoxic. I think most of the data point to the idea that MDMA might not be neurotoxic, but in any case, caffeine has been shown to increase the toxicity of MDMA receptors. And you might say, "Well, how could that be?" Well, now you understand why that could be. Caffeine increases the density and efficacy of these dopamine receptors, D2 and D3 receptors. MDMA is a potent drug for increasing concentrations of dopamine as well as serotonin and other neuromodulators. And it appears that caffeine ingestion by upregulating these receptors, can lead to more toxicity of MDMA. So caffeine can be a beneficial substance in one context, and actually can be a detrimental

01:26:15 Amphetamine, Cocaine & Detrimental Rewiring of Dopamine Circuits

if not dangerous substance in another context. Two substances that greatly increase dopamine, namely amphetamine and cocaine can cause long-term problems with the dopaminergic pathways. And this is largely based on a study that was published some years ago, 2003, but still holds a lot of merit. This is a paper published in *proceeds in the National Academy of Sciences*, a very high tier stringent journal. First author is Kolb, K-O-L-B. And the title of the paper pretty much tells the story. Amphetamine or cocaine limits the ability of later experience to promote structural plasticity in the neocortex and nucleus accumbens. Neocortex is the outer shell of the brain more or less. And the nucleus accumbens is part of that, mesolimbic dopamine pathway for motivation drive and reinforcement. Neuroplasticity of course, is the brain's ability to change in response to experience. And neuroplasticity is the basis of learning and memory and essentially remodeling of our neural circuitry in positive ways of all kinds. And this study was really one of the first to show that ingesting amphetamine and cocaine because of the high peak in dopamine that it creates and the low dopamine state, the baseline drop that it creates afterwards, limits plasticity and learning subsequent to taking amphetamine and cocaine. It was at least in this study shown to be a long lasting effect. I doubt it's a permanent effect, but this should serve as a serious cautionary note that amphetamine and cocaine not only can cause a drop in baseline dopamine, but can actually put the

brain into a state

01:27:57 Ritalin, Adderall, (Ar)Modafinil: ADHD versus non-Prescription Uses

in which it cannot learn and modify itself to get better at least for some period of time. In a previous episode on ADHD, I talked about the widespread use of drugs like Adderall, Ritalin, modafinil and armodafinil, all of which lead to very large increases in dopamine, and for people with ADHD can really improve their symptoms. But of course there's a lot of non-prescription, non-clinical use of those compounds as well. And it stands to reason that the use of those substances to increase dopamine could very well provide the same sort of blockade of neuroplasticity that cocaine and amphetamine do. Because when you look at the amount of dopamine increase that's triggered by those compounds, it's really comparable. So again, a cautionary note against spiking one's dopamine

01:28:45 Tool 6 Stimulating Long-Lasting Increases in Baseline Dopamine

too much on a regular basis, unless there's a valid clinical need for doing that. So we've been focusing a lot for the last few minutes on the kind of darker side of dopamine and how getting big peaks in dopamine can be detrimental, but I want to acknowledge the truth, which is that dopamine feels great. Being in pursuit and motivated and craving things feels wonderful. And I don't want to demonize dopamine. What I'm trying to do today is to illustrate how dopamine works in your brain so that you can continue to engage in dopamine evoking activities. And certainly there is a place for ingesting things that can increase dopamine provided that they are safe for us in the short and long-term. There are activities that we can do that will give us healthy, sustained increases in dopamine, both the peaks when they happen and to maintain or even increase our baseline levels of dopamine. So how do we do that? What are some of these activities? Well, in recent years, there's been a trend toward more people doing so-called cold exposure. In part, this was popularized by Wim Hof, the so-called 'Iceman' getting into cold showers, taking ice baths, exposing oneself to cold water of various kinds can in fact increase our levels of dopamine as well as the neuromodulator norepinephrine. This is not a new phenomenon. In the 1920s, a guy by the name of Vincent Priessnitz was one of the first people to popularize and formalize cold water therapies. He was an advocate of cold water exposure in order to boost the immune system and increase

feelings of wellbeing. And actually this practice dates back long before Vincent's popularized it. And Wim Hof is the more recent iteration of this. First of all, some of the safety parameters. Let's establish those first. Getting to very, very cold water. You know, 30 degree Fahrenheit or even low 40 degree Fahrenheit can put somebody into a state of cold water shock. I mean, people can die doing that. So obviously you want to approach this with some caution, but for most people getting into 60 degree water or 50 degree water, or if you're acclimated and comfortable with it, you know, 40 degree water or 45 degree water can have tremendously beneficial results on your neuromodulator systems, including dopamine. What temperature of water you can tolerate will depend on how cold water adapted you are, and how familiar you are with the experience of getting into cold water. And when I say comfortable with, I should mention, there is never a case in which getting into cold water does not evoke a release of epinephrin. So the quickening of the breath, the widening of the eyes, the feeling as if you can't catch your breath and even some physical pain at the level of the skin that happens almost every time, or every time that you get into cold water, even if your cold water adapted. What almost everybody knows and understands is that, that wall, as I like to refer to it is coming. That's always the first experience of getting into cold water. There's no real way around that. Now, this study that I mentioned earlier, human physiological responses to immersion into water of different temperatures, really interesting study that was done and published in the university of, excuse me, the European Journal of Applied Physiology. I can provide a link to that study in the show caption. It's a really interesting study. They looked at people getting exposed to water that was warm, moderately cold or very cold. It was 32 degrees Celsius, 20 degrees Celsius, or 14 degrees Celsius. You can just put those online and do the conversion, or you can do the conversion to Fahrenheit if you like. But in any case, what they looked at were the concentrations of things like epinephrin and dopamine and so on. And what they found was really interesting. First of all, upon getting into cold water, the changes in adrenaline and noradrenaline, epinephrin and norepinephrine were immediate and fast, and these were huge increases. So that's the getting into the cold water that everybody experiences these huge increases in adrenaline. But then what was interesting is they observed that dopamine levels started to rise somewhat slowly and then continued to rise and reach levels as high as 2.5 times above baseline. That's a remarkably high increase. Remember if we go back to our examples of chocolate, sex, a doubling above baseline, nicotine two and a half times above baseline, cocaine. The increase in dopamine from a

cold water exposure of this kind was comparable to what one sees from cocaine, except, except in this case, it wasn't a rise and crash. It was actually a sustained rise in dopamine that took a very long time up to three hours to come back down to baseline. Which is really remarkable, and I think this explains some of the positive, mental and physical effects that people report subjectively after doing cold water exposure. One question that many of you are probably asking is just how cold should the water be? Well, you could mimic what was done in this study and do 14 degrees Celsius. But for some people that won't be cold enough, for some people that will be too cold. They did look at the release of stress hormones like cortisol in addition to the release of things like epinephrin and adrenaline. And it's interesting that they noted that in all cases, but especially at that coldest temperature, there was an increase in cortisol, but that it was transient, That eventually people's cortisol, the stress hormone subsided a bit. There are basically two different approaches to remaining in the cold when it's uncomfortable. One is to try and relax yourself. Two, try and practice slow breathing, to try and dilate your gaze. I've talked about this before in previous podcasts, you go into panoramic vision to essentially try and calm yourself so that it's not as stressful in the cold. Other people however, take the approach of trying to ramp up their level of internal autonomic arousal, meaning to get really energized and kind of lean into the friction of the cold. And they find that easier. Other people distract themselves, they recite the alphabet, or they do something, anything to try and distract themselves from the discomfort. To be totally honest, it does not matter for sake of dopamine release. Because the dopamine release is triggered and then continues even after you get out of the cold water. Now, in this study, it was long exposure to cold water. It was an hour. That's a long period of time. And I do warn you against getting into cold water that's so cold that it will make your temperature drop and make you hyperthermic for an hour. That actually could be dangerous for a lot of people. You might have a hard time reheating, and hypothermia is not a good thing. They had people monitoring subjects in these studies and paying attention to their core body temperature. They were able to reheat them afterwards. It's well-established now that getting into cold water, whether or not it's a shower, an ice bath circulating cold water, a stream, et cetera, that can evoke the norepinephrine release immediately, and the long arc of that dopamine release. Why would that be good? Up until now, I've basically said getting increases in dopamine are detrimental to your baseline. Well, this does appear to raise the baseline of dopamine for substantial periods of time. And most people report feeling a heightened level of calm and focus

after getting out of cold water. So cold water exposure turns out to be a very potent stimulus for shifting the entire milieu, the entire environment of our brain and body and allowing many people to feel much, much better for a substantial period of time after getting out of the ice bath or cold water of any kind than they did before. Now, you might ask how often to do this? Some people do this every day. It can be very stimulating. So typically doing it early in the day, it's going to be better. I don't necessarily recommend doing it right before sleep, but some people do it in the afternoon. And some people will indeed do that seven days a week, other people three days a week, other people every once in a while. What I can say is once you become cold water adapted, once it no longer has the same impact of novelty and feeling a bit like a, I don't want to say a shock to your system, 'cause you don't want to go into cold water shock, but once it is comfortable for you, then it will no longer evoke this release. There really does seem to be something in the pathway from cold water exposure through the norepinephrine pathway and into the mesolimbic brainstem that causes this release in dopamine. But nonetheless, it's a basically zero cost. I mean, you need access to water of some sort, cold water shower, et cetera, but basically zero cost way of triggering a long lasting increase in dopamine without ingesting anything, no pharmacology whatsoever. Please again, approach it with a safety and caution in mind, but it is a very potent stimulus.

01:37:55 Tool 7 Tuning Your Dopamine for Ongoing Motivation

Again, 250% of a rise in baseline, two and a half times rise in baseline rivals that of cocaine which is really remarkable. Now, I'd like to talk about the positive aspects of rewards for our behavior, and the negative aspects of rewards for our behavior. And from that, I will suggest a protocol by which you can achieve a better relationship to your activities and to your dopamine system. In fact, it will help tune up your dopamine system for discipline, hard work and motivation. Hard work is hard. Generally, most people don't like working hard. Some people do, but most people work hard in order to achieve some end goal. End goals are terrific and rewards are terrific whether or not they are monetary social or any kind. However, because of the way that dopamine relates to our perception of time, working hard at something for sake of a reward that comes afterward, can make the hard work much more challenging and make us much less likely to lean into hard work in the future. Let me give you a couple examples by way of data and experiments. There's a classic experiment done actually at Stanford

many years ago in which children in nursery school and kindergarten drew pictures, and they drew pictures cause they like to draw. The researchers took kids that liked to draw and they started giving them a reward for drawing. The reward generally was a gold star or some thing that a young child would find rewarding. Then they stopped giving them the gold star. And what they found is the children had a much lower tendency to draw on their own. No reward. Now, remember this was an activity that prior to receiving a reward, the children intrinsically enjoyed and selected to do. No one was telling them to draw. What this relates to is so-called intrinsic versus extrinsic reinforcement. When we receive rewards, even if we give ourselves rewards for something, we tend to associate less pleasure with the actual activity itself that evoked the reward. Now, that might seem counterintuitive, but that's just way that the way that these dopaminergic circuits work. And now understanding these peaks in baselines in dopamine which I won't review again, this should make sense. If you get a peak in dopamine from a reward, it's going to lower your baseline and the cognitive interpretation is that you didn't really do the activity because you enjoyed the activity. You did it for the reward. Now, this doesn't mean all rewards of all kinds are bad, but it's also important to understand that dopamine controls our perception of time. When and how much dopamine we experience is the way that we carve up what we call our experience of time. When we engage in an activity, let's say school or hard work of any kind or exercise because of the reward we are going to give ourselves a receive at the end, the trophy, the sundae, the meal, whatever it happens to be. We actually are extending the time bin over which we are analyzing or perceiving that experience. And because the reward comes at the end, we start to dissociate the neural circuits for dopamine reward that would have normally been active during the activity. And because it all arrives at the end over time, we have the experience of less and less pleasure from that particular activity while we're doing it. Now, this is the antithesis of growth mindset. My colleague at Stanford, Carol Dweck, as many of you know, has come up with this incredible theory and principle, and actually goes beyond theory and principle called "Growth Mindset", which is this striving to be better to be in this mindset of I'm not there yet, but striving itself is the end goal. And that of course delivers you to tremendous performance. It's been observed over and over and over again, that people that have growth mindset, kids that have growth mindset end up performing very well because they're focused on the effort itself. And all of us can cultivate growth mindset. The neural mechanism of cultivating growth mindset involves learning to access the rewards from effort and doing. And that's hard to do because you

have to engage this prefrontal component of the mesolimbic circuit. You have to tell yourself, okay, this effort is great, this effort is pleasurable. Even though you might actually be in a state of physical pain from the exercise, or I can recall this from college, just feeling like I wanted to get up from my desk, but forcing myself to study, forcing myself and forcing myself. What you find over time is that you can start to associate a dopamine release. You can evoke dopamine release from the friction and the challenge that you happen to be in. You completely eliminate the ability to generate those circuits and the rewarding process of being able to reward friction while in effort, if you are focused only on the goal that comes at the end. Because of the way that dopamine marks time. So if you say, oh, I'm going to do this very hard thing, and I'm going to push and push and push and push for that end goal that comes later. Not only do you enjoy the process of what you're doing less, you actually make it more painful while you're engaging in it. You make yourself less efficient at it, because if you were able to access dopamine while in effort, dopamine has all these incredible properties of increasing the amount of energy in our body, and in our mind, our ability to focus by way of dopamine's conversion into epinephrin. But also you're undermining your ability to lean back into that activity the next time. The next time you need twice as much coffee and three times as much loud music, and four times as much energy drink and the social connection just to get out the door in order to do the run or to study. So what's more beneficial in fact can serve as a tremendous amplifier on all endeavors that you engage in. Especially hard endeavors is to A, not start layering in other sources of dopamine in order to get to the starting line, not layering in other sources of dopamine in order to be able to continue, but rather to subjectively start to attach the feeling of friction and effort to an internally generated reward system. And this is not meant to be vague, this is a system that exists in your mind, that exists in the minds of humans for hundreds of thousands of years, by which you're not just pursuing the things that are innately pleasurable, food, sex, warmth, water when you're thirsty. But the beauty of this mesolimbic reward pathway that I talked about earlier is that, it includes the forebrain. So you can tell yourself the effort part is the good part. I know it's painful, I know this doesn't feel good, but I'm focused on this. I'm going to start to access the reward. You will find the rewards, meaning the dopamine release inside of effort if you repeat this over and over again. And what's beautiful about it is that, it starts to become reflexive for all types of effort. When we focus only on the trophy, only on the grade, only on the win as the reward, you undermine that entire process. So how do you do this? You do this in those moments of the most intense

friction. You tell yourself this is very painful and because it's painful, it will evoke an increase in dopamine release later, meaning it will increase my baseline in dopamine, but you also have to tell yourself that in that moment you are doing it by choice and you're doing it because you love it. And I know that sounds like lying to yourself, and in some ways it is lying to yourself, but it's lying to yourself in the context of a truth which is that you want it to feel better. You want it to feel even pleasurable. Now, this is very far and away different from thinking about the reward that comes at the end, the hot fudge sundae for after you cross the finish line and you can replace hot fudge sundae with whatever reward happens to be appealing to you. We revere people who are capable of doing what I'm describing. David Goggins comes to mind is a really good example. Many of you are probably familiar with David Goggins, former Navy SEAL who essentially has made a post-military career out of explaining and sharing his process of turning the effort into the reward. There are many other examples of this too, of course. Throughout evolutionary history, there's no question that we revered people who were willing to go out and forage and hunt and gather and caretake in ways that other members of our species probably found exhausting and probably would have preferred to just put their feet up or soaked them in a cool stream rather than continue to forage. The ability to access this pleasure from effort aspect of our dopaminergic circuitry is without question the most powerful aspect of dopamine and our biology of dopamine. And the beautiful thing is it's accessible to all of us. But just to highlight the things that can interfere with, and prevent you from getting dopamine release from effort itself,

01:47:40 Tool 8 Intermittent Fasting: Effects on Dopamine

don't spike dopamine prior to engaging in effort. And don't spike dopamine after engaging in effort, learn to spike your dopamine from effort itself. One straightforward example of learning to attach dopamine to effort and strain as opposed to a process or a reward that naturally evokes dopamine release is so-called intermittent fasting. I know this is very popular nowadays. Some people like to do intermittent fasting, some people don't. Some people have a 12 hour feeding window every 24 hours, some people do long fasts of two to three days even. I personally don't monitor a feeding window with a lot of precision. I tend to skip one meal a day, either breakfast or lunch, and then I eat the other two meals of the day depending on which meal I skipped. So it's either breakfast, lunch and maybe a little something in the evening, or I'll skip breakfast and do

lunch and dinner and so on. Many people are now eating this way in part, because many people find it easier to not eat at all than to eat a smaller portion of some food. And that has everything to do with the dopamine reward evoking properties of food. When we ingest food or when we are about to ingest food, our dopamine levels go up. And typically when we ingest food, if it evokes some dopamine release, then we tend to want even more food. Remember dopamine's main role is one of motivation and seeking. And what dopamine always wants more of is more dopamine. More activity or thing that evokes more dopamine release. Well, let's just look at fasting from the perspective of dopamine schedules and dopamine release and peaks and baselines. Typically, when we eat we get dopamine release, especially when we eat after being very hungry. If you've ever gone camping, or you're very, very hungry, the food tastes that much better. And that's actually because of the way that deprivation states increase the way that dopaminergic circuits work. Our perception of dopamine is heightened when the receptors for dopamine have not seen much dopamine lately, they haven't bound much dopamine. So when you fast, fast, fast, fast, fast, and then you finally eat, it evokes more dopamine release. So this is the big reward that comes at the end. Even bigger because you deprived yourself. This is true for all rewarding behaviors and activities by the way. The longer you restrict yourself from that activity, the greater the dopamine experience when the dopamine is finally released, because of an upregulation of the receptors for dopamine. but I just spent five minutes or more telling you that you should avoid too much reward at the end, and you should actually focus on the dopamine that you can consciously evoke from the deprivation strain and effort. And in fact, this is what happens for many people that start doing fasting and take a liking to it. Many people say that their state of mind when they fast is clearer, that they actually start to enjoy the period of fasting. In fact, some people start pushing out their eating window or skipping entire days of eating more and more in order to get deeper into that state of mind where surely it's not just dopamine, but dopamine is released. They will track their clock. Oh, I've been fasting 12 hours, 16 hours, et cetera. They are starting to attach dopamine release or create dopamine release from the deprivation, not from the food reward itself. And this I think makes it an interesting practice. And one that certainly has been practiced by for centuries in different cultures and different religions of deliberately restricting food, not just to increase the rewarding properties of food itself, but also to increase the rewarding properties of deprivation. And I should emphasize that a lot of the subjective aspects of the knowledge of the benefits of fasting serve as reinforcing

dopamine amplifying aspects to fasting, meaning if somebody does intermittent fasting and they are deep into their fast and they're telling themselves, oh, my blood lipid profiles are probably improving. And my glucose management is probably improving. My insulin sensitivity is going up, and I'm going to live longer. All these things that have some basis from animal studies and some basis or not from human studies, it's all kind of still an emerging literature, but it does seem to be pointing in that direction that fasting can encourage things like autophagy, the engulfment of dead cells and things of that sort. Well, as people tell themselves these things, they are enhancing the rewarding properties of the behavior of fasting. And so this is a salient example of where knowledge of knowledge can actually help us change these deep primitive circuits related to dopamine. And this illustrates how the forebrain, which carries knowledge and carries interpretation and rational thought can be used to shape the very circuits that are involved in generating reward for what would otherwise just be kind of primitive behaviors, hardwired behaviors. And that's the beauty of these dopamine circuits. That's the beauty of dopamine. It's not just attached to the more primitive of food, sex, heat, et cetera. It's also attached to the things that we decide are good for us and are important for us. So telling yourself that exercise or fasting or studying or listening better or any kind of behavior is good for you

01:53:09 Validation of Your Pre-Existing Beliefs Increases Dopamine

will actually reinforce the extent to which it is good for you at a chemical level. And a somewhat eerie example of what I just mentioned was a study that was published last year in the journal Neuron, Cell Press journal, excellent journal. That showed that hearing something that reinforces one's prior beliefs actually can evoke dopamine release. So the dopamine pathway is so vulnerable to subjective interpretation that it actually makes it such that when we see something or hear something that validates a belief that we already have, that itself can increase dopamine release. Along the lines of how dopamine and dopamine schedules

01:53:50 Tool 9 Quitting Sugar & Highly Palatable Foods: 48 Hours

and our perception of things can shape the way that we experience things as pleasurable or not. There are beautiful studies mainly looking at sugar appetite and our sense of

pleasure from sweet things, but also for savory foods, et cetera. And essentially the results that come out of this are the following. If you ingest something that you like, it tastes good to you, but then you ingest something that's even sweeter or even more savory. And then you go back to the food that you ate previously. Well, you don't like it as much, and that might seem like a duh, obviously. But that shift in perception can be blocked by blocking the shift in dopamine. And so this really speaks to these peaks and valleys in dopamine that I mentioned before and how your experience of anything is going to depend on your prior experience of other things that evoke dopamine. Big dopamine release makes it more challenging to experience more big dopamine release. So dopamine is one of those things that you don't want too high or too low for too long. It's all about staying in that dynamic range and that's going to be different for everybody. So for the very savory foods that are now everywhere, those highly savory foods or I think they call them highly palatable foods are making more bland foods, whole foods, meaning foods that aren't processed. It's making those tastes less good at least for a while. And all it takes is a short period of time, even just days, two days or so of not consuming any highly palatable foods and suddenly broccoli with just a little bit of seasoning tastes delicious to you. All right? So again, this just speaks to the fact that dopamine is this universal currency. It establishes value based on,

01:55:36 Pornography

not just what you're experiencing in the moment, but what you experienced in the days and minutes before. Now, that you understand how your previous level of dopamine relates to your current level of dopamine, and how your current level of dopamine will influence your future level of dopamine, it should become obvious why things like pornography, not just the accessibility of pornography, but the intensity of pornography can negatively shape real world romantic and sexual interactions. This is a serious concern. The discussion is happening now. The underlying neurobiological mechanisms you now understand. And this isn't to pass judgment on whether or not people like or don't like pornography, that's an ethical discussion, and it's a moral discussion that has to be decided for each individual by virtue of age, et cetera. But again, any activity that evokes a lot of dopamine release will make it harder to achieve the same level and certainly the greater level of dopamine through a subsequent interaction. So yes, indeed many people are addicted to pornography and yes, indeed many people who regularly

indulge

01:56:50 Wellbutrin & Depression & Anxiety

in pornography experienced challenges in real-world romantic interactions. You now understand the mechanisms behind what I'm telling you. Now, there are circumstances in which increasing levels of dopamine is desirable and advantageous and clinically helpful. Good example of this would be the drug Wellbutrin also called bupropion which increases dopamine and norepinephrine. Wellbutrin bupropion was developed as an alternative treatment for depression because some people who take the so-called SSRI, selective serotonin reuptake inhibitors which as the name suggests increased serotonin suffer from serotonin related side effects. Things like decreased appetite, decreased libido, or sometimes increased appetite or other side effects that they don't want. And Wellbutrin seems to avoid the sexual side effects. It can blunt at appetite and these sorts of things because of the increase in norepinephrine and dopamine increases levels of motivation and craving, but also can create a state of elevated alertness that can sometimes get in the way of healthy eating and things of that sort. So one has to work with their clinician as psychiatrist. It is a prescription drug in order to find the dosage of Wellbutrin that's correct for them. In addition, things like Wellbutrin bupropion can increase anxiety because of the way that dopamine and norepinephrine are stimulating and tend to place people into heightened levels of alertness. Nonetheless, many people have gained terrific relief from depression from Wellbutrin bupropion, and many of those same people had serious trouble with some of the SSRI. So it does seem to be a very useful drug in certain contexts,

01:58:30 Tool 10 Mucuna Pruriens, Prolactin, Sperm, Crash Warning

both for depression and for the treatment of smoking for people desiring to quit smoking. And of course there are a lot of people out there who are seeking to increase their baseline levels of dopamine without taking any prescription pharmaceutical compounds. And nowadays there exist a lot of supplements to do that. The two most common ones that are directly within the dopamine pathway are Macuna Pruriens which is actually a velvety bean whose contents are L-DOPA. Believe it or not, the content of this being is the precursor to dopamine. So Macuna Pruriens is sold over the counter at least in the

United States. And it literally is the precursor to dopamine. Meaning if you take it, you will experience very large increases in dopamine. Those increases are transient and very, very intense. And in fact, if you look at the constellation of effects of Macuna Pruriens, what you find is that they're pretty striking and they look a lot like if not identical to L-DOPA. The most obvious of those is in the context of Parkinson's disease. There are at least five studies that have shown that Macuna Pruriens can reduce the symptoms of Parkinson's disease, much in the same way that L-DOPA can reduce the symptoms of Parkinson's disease. And that shouldn't come as any surprise given what I just told you that is essentially L-DOPA. It also can reduce a particular hormone called prolactin. Dopamine and prolactin tend to be in somewhat push pull fashion. When dopamine is up, prolactin is down and vice versa. Prolactin is involved in milk letdown in women. It's involved in setting the refractory period for sex after ejaculation in males. The reason mating can occur and then not occur after a ejaculation is because of an increase in prolactin. Macuna Pruriens is often used a blunt prolactin, and they're actually a couple of studies showing that it can indeed do that. Macuna Pruriens has a number of other effects that lie in the sex and reproduction pathway that are worth noting. Sperm concentration, sperm quality is actually greatly increased by Macuna Pruriens. These are kind of curious effects until you understand a little bit more about the biology of dopamine which I'll mention in a moment, but there are several studies, four in fact that describe how Macuna Pruriens can increase sperm count, sperm quality, and sperm motility. So for those of you seeking to conceive children, Macuna Pruriens might be an interesting choice if you're interested in exploring non-prescription compounds. However, I should mention that any time you consume a substance that increases dopamine by mimicking dopamine or acting as a direct precursor to dopamine, there's almost inevitably a crash or a reduction in the baseline in dopamine that we referred to previously. So many people who take Macuna Pruriens feel really elevated, really motivated, really alert, all the sorts of things that one would expect from a dopaminergic drug which Macuna Pruriens is. And then they feel a low or a reduction in drive and excitement and enthusiasm after the drug wears off. Just like they would with other dopamine

02:01:45 Tool 11 L-Tyrosine: Dosages, Duration of Effects & Specificity

increasing compound. For that reason, many people have turned to the use of L-

tyrosine. L-tyrosine is an amino acid precursor to L-DOPA. So it lies further up the dopamine synthesis pathway. And nowadays it's very common because all L-tyrosine is sold over the counter in the United States that people will take L-tyrosine as a way to get more energized, alert, and focused. Indeed, there are data that L-tyrosine will accomplish that. L-tyrosine is typically taken in capsule form or powder form anywhere from 500 to 750 to a 1000 milligrams. It is a potent stimulus for increasing dopamine. And the timescale for increasing dopamine is about 30 to 45 minutes after ingestion. Dopamine levels start to peak. The classic study that really nailed down the fact that tyrosine has this effect was published way back in 1983, *Journal of Clinical Endocrinology and Metabolism* that directly compared L-tyrosine supplementation with tryptophan ingestion on plasma dopamine and serotonin. Tryptophan being a precursor to serotonin. And indeed what they found is that ingestion of L-tyrosine can increase the amount of dopamine circulating in the blood and in the brain too, of course. The L-tyrosine ingestion induced dopamine increases within 45 minutes and they were short-lasting after about 30 minutes the effect had dissipated, meaning the levels of dopamine had dropped down to baseline. And even though they didn't look at levels of baseline dopamine past that time point, the expectation based on everything we know about dopamine biology is that it would then drop below baseline due to the depletion of the readily reservable pool of dopamine vesicles that we talked about way back at the beginning of this episode. The nice thing about this study is it does show specificity of effect because ingestion of tryptophan did not increase dopamine instead it increased serotonin. So there's really specificity of these pathways that rule out any placebo type effects. I'm not suggesting that anybody, everybody increase their dopamine levels by way of tyrosine or *Macuna Pruriens*. For those of you that are seeking to increase your dopamine levels without prescription drugs, those are the most direct route to that. Of course, if you have a pre-existing dopaminergic condition, so schizophrenia or psychosis of any kind, bipolar, anxiety, things like *Macuna Pruriens* and L-tyrosine will not be good for you. And if you don't, you should just understand and expect that it's going to lead to an increase in dopamine. You'll certainly feel an elevated state for some of you that might be agitating, for some of you that might be really pleasurable, and then you will feel a crash afterwards. How deep is that crash will really depend on your biology and where your dopamine baseline began. So I personally am not a fan of using things like *Macuna Pruriens* at all for myself for the reasons I mentioned earlier, just too intense and too much of a crash. I do use L-tyrosine from time to time for enhancing focus and

motivation, but I want to emphasize from time to time. So I might use it once a week, occasionally twice a week, but I've never been one to take L-tyrosine regularly in order to focus or train or do any kind of mental work. I just don't want to rely on any exogenous substance in order to get my dopamine circuits activated. And I don't want to experience the drop in dopamine

02:05:20 Tool 12 Avoiding Melatonin Supplementation, & Avoiding Light 10pm-4am

that inevitably occurs some period of time afterwards. I should also mention things that can reduce your levels of baseline dopamine. One that is rarely discussed is melatonin. I have talked before on this podcast about melatonin, why I am not a fan of using melatonin in order to enhance sleep. It can help one get to sleep, but not stay asleep. Dr. Matt Walker sleep expert from University of California, Berkeley. I think I don't want to put words in his mouth, but in our discussion about melatonin on this podcast when Matt was a guest in his book and on other podcasts, Matt has generally stated that the use of melatonin except for treatment of jet lag is generally not a good idea. And I agree. I think that melatonin is not often thought about as impacting the dopamine pathway, but there's at least one study published in 2001 first author is Nishiyama just as it sounds. It's spelled just as it sounds. Acute effects of melatonin administration on cardiovascular autonomic regulation in healthy men. So the study wasn't specifically about dopamine, but they looked at norepinephrine and dopamine levels, and they found a statistically significant decrease in dopamine 60 minutes after melatonin administration. I've talked before about how viewing bright lights between the hours of 10:00 p.m and 4:00 a.m has been shown in studies by Dr. Samer Hattar, David Bersin, excellent circadian scientists to reduce levels of dopamine for several days after that light exposure. So dim the lights at night, if you can avoid exogenous melatonin, meaning if you don't have to take melatonin

02:07:00 Tool 13 Phenylethylamine (with Alpha-GPC) For Dopamine Focus/Energy

and you can find a better alternative that would be a good idea if you want to maintain healthy levels of dopamine. Now, there is one compound that you are all familiar with, and you've probably actually taken without realizing it, that increases dopamine. And that's something called PEA for phenethylamine, technically beta phenethylamine. And

PEA is found in various foods. Chocolate just happens to be one in enriched in PEA and can increase synaptic levels of dopamine. I personally take PEA from time to time as a focus and work aid in order to do intense bouts of work. Again, I don't do that too often. This might be once a week or once every two weeks. I might use it for training, but typically I don't, it's usually for mental work. And I will take 500 milligrams of PEA and I'll take 300 milligrams of Alpha-GPC. That's something that I personally do. That's what's right for me, it's within my margins of safety for my health. Again, you have to check with your doctor and decide what's right for you. It leads to a sharp but very transient increase in dopamine that lasts about 30 to 45 minutes. And at least in my system I've found to be much more regulated and kind of even than something like L-tyrosine and certainly much more regulated and even

02:08:20 Tool 14 Huperzine A

and lower dopamine release than something like Macuna Pruriens. One of the lesser talked about compounds that's out there, but that's gaining popularity for increasing dopamine and as a so-called nootropic is something called huperzine A. Huperzine A is a compound sold over the counter at least in the United States that can increase acetylcholine transmission, a different neuromodulator entirely. But what's interesting is that huperzine A somehow by way of interactions between the cholinergic system and the dopaminergic system leads to increases in dopamine in the medial prefrontal cortex and hippocampus. Hippocampus, of course, being an area of the brain associated with learning and memory. And prefrontal cortex being associated with the mesolimbic pathway, decision-making focus, et cetera. And so I think the reason why we're seeing an increase in popularity of companies including huperzine A and nootropic compounds is both for the cholinergic stimulating properties, but also for stimulating dopamine release. I personally have never tried huperzine A. You can go to www.examine.com or put huperzine A into PubMed if you'd like to search around and see some of the science behind it. Again, I'm not recommending anyone take these things. In fact, I recommend against anyone just diving in, and starting to consume things without gaining knowledge about how they function, whether or not they're right for you. But nonetheless, I think in the years to come, we are going to see a lot more of L-tyrosine, PEA phenethylamine and huperzine as a way of tapping into the dopaminergic and cholinergic circuits certainly along with things like Alpha-GPC as non-prescription, short-lived somewhat

milder alternatives to things that really spike dopamine, things like Adderall, Ritalin, modafinil, armodafinil

02:10:02 Social Connections, Oxytocin & Dopamine Release

and similar. And I can't help but share with you one more result. It's not related to pharmacology. It's related to behaviors and social interactions. And that's the very interesting and I would say important finding that was made a few years ago by my colleague, Rob Malenka, who's in our department of psychiatry at Stanford, showing that oxytocin and social connection is actually directly stimulating the dopamine pathway. I think for many years, all of us including me would hear and thought that oxytocin was in the serotonergic pathway that it was about pair bonding, and it was about some of these neuromodulators that were more associated with things related to feeling good with what we have in the present moment. That's typically what we think of when we think of the opioid system or the serotonergic system. The dopamine system is really about seeking and reward, but in a paper published in 2017 in the journal Science, excellent journal. The papers titled gaining of social reward by oxytocin, excuse me, in the ventral tegmental area. You now know what the ventral tegmental area, it's that area of the mesolimbic pathway. What this paper essentially showed is that, oxytocin social connection and pair bonding itself triggers dopamine release. And as everyone read this result, we all realized, ah, this makes total sense that for the evolution of our species, indeed for any species where social connections are important, it's also important to go seek social connections. And so, while it's fun to think about pharmacology and underlying neurocircuitry and cold water baths and all these different things related to dopamine schedules and reward mechanisms and attaching reward to effort and all the various things that we've talked about today in terms of science and tools and protocols, I'd be remiss if I didn't include description of this result and just emphasize that social connections, close social connections in particular that evoke oxytocin release. So those are romantic type, those are parent-child type, those are friendship related, and those can even be just friends at a distance related, right? It doesn't actually require skin contact to get oxytocin release, but oxytocin release is central to stimulating

02:12:20 Direct & Indirect Effects: e.g., Maca; Synthesis & Application

the dopamine pathways. So the take home message there is quite simple, engage in pursue quality, healthy social interactions. I know I've covered a lot of material today. I've really tried hard to focus on things that lie directly within the dopamine pathway and circuitries, as well as things that directly stimulate those pathways and circuitries. What I haven't talked about are all the things that indirectly serve the dopamine pathways. And out there on the internet and indeed in the scientific literature, you will find for instance, that things like Maca root can increase dopamine. Things like the gut microbiome can influence dopamine. And indeed they can, but they do that through indirect mechanisms. By creating a environment, a milieu in which dopamine and dopamine circuits can flourish. Maca is a good example of that. It will reduce cortisol and through some indirect pathways related to cortisol can increase dopamine. But it's not a direct increase in dopamine. And so as a consequence, it's rather subtle compared to the various compounds and behaviors that I talked about today. Indeed cold water exposure leads to huge increases in dopamine as we talked about before, and very sustained ones at that. I realize in giving you a lot of information about science and mechanism all the way from psychological biological to circuitry and synaptic transmission, volumetric transmission and so forth, that it might seem overwhelming. The most important thing is to understand, or that these dopamine pathways really are under your control. And the locus of control resides in the fact that your previous levels of dopamine are influencing your levels of dopamine right now. And your current levels of dopamine and where you take them next, will influence your dopamine levels in the next days and weeks to come. So I hope both with the mechanisms that you now have in hand plus some of the tools to tap into the dopaminergic system, both behavioral, pharmacologic prescription, and non-prescription, et cetera, that you'll feel that you have more control over your dopamine system. And certainly that you have a better understanding of your dopamine system so that you can modulate

02:14:22 Zero-Cost & Other Ways To Support Podcast & Research

and adjust your levels of dopamine in the ways that serve you best. If you're learning from and or enjoying this podcast, please subscribe to our YouTube channel. That's a terrific way to support us. In addition, please leave us a comment or a suggestion for a guest you'd like us to interview or a topic you'd like us to cover. In addition, please subscribe to us on Apple and Spotify. And on Apple, you have the opportunity to leave

us up to a five-star review and to leave us a comment there as well. Please also check out the sponsors mentioned at the beginning of today's podcast. That's a terrific way to support us. In addition, if you'd like to support the Huberman Lab and research at Stanford on stress, stress mitigation and human performance, you can do that by going to, www.hubermanlab.stanford.edu/giving. And there you can make a tax deductible donation to the research in my laboratory. In addition, we have a Patreon. It's www.patreon.com/andrewhuberman. And there you can support the podcast at any level that you like. Today and on previous podcast episodes we talked a bit about supplements. Supplements certainly aren't necessary, but many people find them beneficial for things like adjusting their levels of dopamine or for other purposes. If you're going to use supplements, it's very important that the supplements you use be of very high quality, and that the quantity of ingredients that are on the label match what's actually in those bottles. For that reason, we've partnered with Thorne. T-H-O-R-N-E because Thorne has the highest levels of stringency with respect to quality and how much of each supplement they put in the products that they sell. If you'd like to see the supplements that I take, you can go to Thorne, www.T-H-O-R-N-E.com/u/huberman. And there, you can see what I take. You can get 20% off any of those supplements. And if you navigate into the Thorne site through that portal, then you can get 20% off any of the supplements that Thorne makes. If you're not already following us on Instagram at Huberman Lab, please do so. There I teach neuroscience tools and information. Oftentimes, it's tools and information that I don't cover on the podcast. We're also on Twitter, also at Huberman Lab. And last but certainly not least, thank you for your interest in science. [energetic music]