Welcome to the Huberman Lab Podcast, where we discuss science and science-based tools for everyday life.
I'm Andrew Huberman, and I'm a professor of neurobiology and ophthalmology at Stanford School of Medicine.
Today we are discussing how to build tenacity and willpower.
Previous episodes of the Huberman Lab Podcast have focused on the topic of motivation.
And while motivation and willpower are linked thematically and mechanistically, today we are going to discuss tenacity, that is, the willingness to persist under pressure and resistance of different kinds, and willpower, which has to do with both the motivation to do things and the motivation to resist certain things.
Today you will learn about the psychology and neuroscience of tenacity and willpower.
And I must tell you, this is a fascinating literature.
In fact, you will learn about a brain structure that, at least to my knowledge, most neuroscientists are not even aware of.
And yet, in researching this episode, I absolutely fell in love with this brain structure because of its incredible ability to integrate the very sorts of information from within and from outside of you to harness and build tenacity and willpower.
And indeed, today you will learn research-supported tools for how to enhance your level of tenacity and willpower in any circumstance.
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 Maui Nui Venison.
Maui Nui Venison is the most nutrient-dense and delicious red meat available.
I've spoken before on this podcast in solo episodes and with guests about the need to get approximately one gram of high-quality protein per pound of body weight each day for optimal nutrition.
Now, there are many different ways that one can do that, but a key thing is to make sure that you're not doing that by ingesting excessive calories.
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I particularly like the ground venison.
I make those into venison burgers probably five times a week or more.
I also like the jerky for its convenience, especially when I'm traveling or especially busy with work, and know that I'm getting an extremely nutrient-dense, high-quality source of protein.
If you'd like to try Maui Nui Venison, you can go to MauiNuiVenison.com slash Huberman and get 20% off your first order.
Again, that's MauiNuiVenison.com slash Huberman to get 20% off.
Today's episode is also brought to us by Helix Sleep.
Helix Sleep makes mattresses and pillows that are tailored to your unique sleep needs.
Sleep is the foundation of mental health, physical health, and performance.

When we are sleeping well and enough, mental health, physical health, and performance all stand to be at their best.
One of the key things to getting a great night's sleep is to make sure that your mattress is tailored to your unique sleep needs.
Helix Sleep has a brief two-minute quiz that if you go to their website, you take that quiz and answer questions such as, do you tend to sleep on your back, your side of your stomach, do you tend to run hot or cold in the middle of the night?
Maybe you don't know the answers to those questions and that's fine.
At the end of that two-minute quiz, they will match you to a mattress that's ideal for your sleep needs.
I sleep on the Dusk DUSK mattress and when I started sleeping on a Dusk mattress about two years ago, my sleep immediately improved.
So if you're interested in upgrading your mattress, go to helixsleep.com slash Huberman.
Take their two-minute sleep quiz and they'll match you to a customized mattress for you and you'll get up to $350 off any mattress order and two free pillows.
Again, if interested, go to helixsleep.com slash Huberman for up to $350 off and two free pillows.
Okay, let's talk about tenacity and willpower and how to enhance your level of tenacity and willpower.
I will also mention certain cases where having too much tenacity and willpower can be problematic for mental health and physical health.
But for most people, I believe that enhancing one's level of tenacity and willpower would be advantageous.
Now you'll be relieved to know that while there are a near infinite number of different circumstances where one would need to draw on tenacity and willpower in order to succeed, there is one major mechanism within the brain, indeed one major mechanism by which tenacity and willpower are generated.
And it arrives through the activation of a particular brain center that is a hub.
That is, it lies at the interface of many other neural circuits and has input from all the critical neural circuits that one would need in order to generate tenacity and willpower.
We are going to return to that particular neural circuit a little bit later after we talk about the psychology of willpower.
Because in talking about the psychology of willpower, it will frame up as to why understanding this one particular brain center or hub of inputs and outputs from different neural structures in the brain and body will indeed allow you to get the most out of the tools that have been shown in scientific research to enhance your level of tenacity and willpower.
In other words, understanding the psychology of tenacity and willpower while valuable.
If it's coupled with an understanding of the underlying neural mechanism, and notice I use the singular neural mechanism, not mechanisms for generating tenacity and willpower, will allow you to use and to tailor the specific protocols for enhancing tenacity and willpower to your unique circumstances.
So this is yet another case where certainly life circumstances vary from one person to the next.
The need for tenacity and willpower varies tremendously.

For instance, some people may need more tenacity and willpower in order to engage in certain behaviors.
Others of us might need more tenacity and willpower in order to resist certain types of behaviors.
Today, you will learn about the brain center that governs all of that.
And then you can frame it within the psychological understanding of tenacity and willpower so that you can get the most out of the protocols that we will discuss.
Let's start by talking about what tenacity and willpower clearly are, and separating tenacity and willpower from some other psychological constructs that they often get confused with.
Because this will be important in understanding exactly what we are trying to build when we say we want to build tenacity and willpower.
So tenacity and willpower can be distinguished from habit execution.
Habit execution is what you do anytime you wake up in the morning, maybe you lie there for a bit, maybe you get out of bed immediately, hopefully you get outside and get some sunlight in your eyes, especially on cloudy days, go brush your teeth, use the restroom, engage with others in your home if you live with others, etc.
All of those sorts of behaviors, while on some days can be a bit more challenging, especially the get out of bed part, maybe you didn't get a great night's sleep the night before, for instance.
But all of those sorts of behaviors are behaviors that you have the neural circuits to generate and that typically you can generate without a lot of willpower required.
Now willpower, sometimes also referred to as tenacity, grit, or persistence, is a distinctly different phenomenon than habit execution.
Because willpower and tenacity require that we intervene in our own default neural processes, such as habits or particular patterns of thinking, and essentially govern ourselves to do or not do some particular thing.
And that process requires effort.
It requires energy.
And I think all of us are familiar with that feeling of effort or energy that's required in order to engage in a behavior that we really don't feel like engaging in, or avoiding a behavior or a thought that by default we would naturally just engage in.
And when I talk about energy in this context, I'm mainly talking about neural energy.
Remember that neurons, nerve cells in your brain and body use chemical and electrical signaling to communicate with one another.
That's what allows you and all of us to do all the things that we do, think, feel, move, et cetera.
Now, of course, that chemical and electrical communication requires fuel sources that indeed come from things like glucose, ketones, the creatine phosphate system, multiple fuel systems feed the energetics of the brain.
But ultimately, when I talk about energy in today's discussion, I'm talking about the energy required to engage in or to resist in a particular behavior.
And that level of energy can be quite high, depending on how much resistance we are feeling internally or externally, right?
Somebody can be telling us, you're not going to be able to do this.

You can't do it and you can say, no, I have a ton of resolve.
I have a ton of tenacity, willpower, and I'm going to push past all the barriers that you are setting up for me on the outside, oftentimes, all too often, I should say, we experience resistance from the inside, where we are feeling like we don't want to do something or we really want to do something and we are having trouble either engaging in the thing that we don't want to do or that we know we should do, but we just don't feel that level of motivation for or we are having a hard time resisting the thing that's pulling us toward it.
So in that context, it's important for us not to just distinguish tenacity and willpower from habit execution, but also draw out a continuum with tenacity and willpower at their most extreme on one end of that continuum and apathy and, yes, depression on the other end of that continuum.
And we will return to the topic of depression a little bit later, but I can just cue it up right now by saying that one of the hallmark features of major depression is a lack of positive anticipation about the future that leads to, this is important, there's a verb tense here, that leads to a much lower tendency to engage in the specific types of behavior that would allow one to arrive at a particular new, different and positive future.
So I'm deliberately putting apathy and depression next to one another at one end of the continuum and I'm putting grit, persistence, tenacity and willpower at the other end of the continuum.
And a little bit later, it will become very clear to you why I put those particular items on the continuum as opposed to other psychological constructs such as motivation, because it turns out that motivation is what allows you to move up and down that continuum, but motivation itself as a verb is distinct from what we call tenacity and willpower.
And motivation itself is distinct from what we call apathy and depression.
But motivation is the engine or the motor, the verb that allows you to move up and down that continuum.
And today you will learn multiple tools that will allow you to move toward the tenacity and willpower end of that continuum by engaging a very specific neural circuit.
Before we get into the discussion of neural circuits, I'd like to talk about the psychology of willpower.
And this is something that really has been considered by psychologists for well over a hundred years.
William James wrote about this, the ancient Greeks wrote about this.
The topic of willpower is certainly not a new one.
And yet the formal study of willpower in the laboratory context, that is bringing human subjects into the laboratory and examining what sorts of conditions allow them to engage their willpower and tenacity.
What sorts of conditions really sap or drain their willpower and tenacity.
And of course, parallel experiments done in what we call preclinical models, which are animal studies, have revealed to us a lot about the sorts of conditions that allow us to generate willpower and the sorts of conditions that drain our willpower.
Now, if we are to throw our arms around that entire literature, there is a big batch of that literature, not the whole batch, but there's a big batch of that literature that believed and still believes that willpower is a limited resource, much like fuel in the body or fuel in a car.

Now the idea of willpower as a limited resource is certainly not a new idea.
But again, the formal study of willpower and willpower as a limited resource really dates back a little over 20, 25 years when Roy Baumeister and colleagues started to explore the idea that, of course, had been kicked around for years, that with each additional decision that we have to engage across the day and with each additional bout of willpower that we have to draw on as a resource, that we would drain this reservoir of willpower that we all have within us.
Now Baumeister and colleagues referred to that process as ego depletion.
Now when people hear the word ego, some people think Freud, ego, super ego, it and so forth.
Most people think ego, like somebody having a big personality where they think a lot of themselves.
When Baumeister referred to ego depletion, he was defining ego depletion as a concept of oneself and a concept of outside challenges and the degree of effort required to bridge one's concept of self and those challenges.
And so ego depletion is really a operational construct within the field of psychology.
So we don't want to get too distracted by that word ego.
There's a tendency anytime people hear ego, they hear narcissism or if they hear gaslighting to immediately assume that they know what that means when in fact the formal definitions of those quite often differ from the way that they're kicked around on social media, the internet, and even in a lot of popular writing about psychology.
So let's just note that ego depletion is the term that Baumeister used to describe the ability for our willpower to be depleted with each successive attempt to engage willpower and by extension, our ability to replenish our degree of willpower if we take a break from making decisions and engaging our willpower.
But ego depletion itself isn't the focus right now.
The focus right now is whether or not indeed willpower is a limited resource and whether or not with each decision that we make and each effort to either engage in an activity that we prefer not to at least in that moment and with each attempt to resist a behavior, thought, etc. that is pulling on us or that we feel that we want to engage in by default either eating the cookie or thinking the thought or engaging in a particular type of behavior of any kind and we need to resist that, that it is draining that willpower resource.
Now before I go any further, I know that some of you out there are probably aware that ego depletion and the Baumeister theory of willpower as a limited resource has been very contentious, especially in recent years.
And so today what I'm going to do is I'm going to first present the Baumeister and colleagues work about willpower as a limited resource.
And then I'm going to present some of the conflicting evidence that Carol Dweck, my colleague at Stanford School of Medicine and researchers elsewhere have carried out meta-analyses and entirely new experiments, which indeed in some cases contradict the findings of Baumeister, but more often than not contradict the conclusions that Baumeister drew about willpower.
So if we are to understand the psychology of willpower and tenacity, it's important that we understand the concepts of ego depletion and willpower as a limited resource, even if after hearing all the evidence, you decide that willpower is not a limited resource.

And in fact, I'm quite confident that once you hear about the Baumeister work and then you hear about the work of Dweck and others, which in some ways counters the conclusions of Baumeister, that you'll have a much firmer and certainly a much more complete understanding about what tenacity and willpower are.
And perhaps, and here I'm revealing my own leanings when having examined the totality of the data, that tenacity and willpower in some cases is a limited resource that can be replenished by engaging particular processes within the body.
That's right, within the body, but that willpower and tenacity, and most importantly, how to engage tenacity and willpower, especially when you have a lot of challenges in front of you, not just one challenge, but multiple challenges that need to be carried out throughout the day, over weeks, over months, et cetera, that tenacity and willpower can be drawn upon repeatedly without them being depleted.
If you are clear on your beliefs about tenacity and willpower, so I realized that what I just brought up was a controversy about something that I haven't even discussed yet, so it might seem like a bit of a swirl of information for which there's really no context.
But the reason I bring up the controversy at this stage of our conversation is that the moment that the words ego depletion or willpower is a limited resource falls out of my mouth, I can hear those voices out there saying, wait a second, I thought that was all debunked.
And I want to make very clear.
Willpower is a limited resource, and ego depletion have not been debunked.
It's simply a controversial area of psychological research.
And more importantly, for today's discussion, we have to understand the theory of willpower as a limited resource.
If we are to understand the controversy, that is the counter argument of what willpower really is that comes from other groups.
So I really want to give you both sides of the story so that when we get to the underlying neural mechanisms for tenacity and willpower, and we get to the tools and protocols for increasing your level of tenacity and willpower, and your flexibility of willpower in different contexts, that you'll be able to get the most out of those tools and protocols.
Okay, so let's take a look at the evidence that willpower is a limited resource.
I think most of us are familiar with what willpower feels like, that is, what it feels like to be tenacious.
And again, there are two sides to this coin.
There's willpower and tenacity of the sort of trying to engage in a behavior when we really don't want to, or when our impulse is not to engage in that behavior.
And I say when our impulse is not to engage in that behavior, because oftentimes we want to engage in the behavior, we want to study, we want to learn the instrument, we want to perform well, we want to exercise, we want the benefits of all those things.
So it's not that we don't want the outcomes or the rewards of those things.
And in many cases, it's not that we don't enjoy those activities, but that for whatever reason, we are feeling a lack of motivation.
We're drifting down that continuum toward the more apathetic end of things, hopefully not all the way to deep depression and apathy, but we're drifting that way or we're not far

enough up the continuum, and we're not engaging enough motivation to feel like the desire to do something, either for its own sake or for the rewards and outcomes of that thing are sufficient to allow us to just do that thing, hence the Nike slogan, just do it, which is a wonderful slogan, except that in the absence of any understanding about the mechanisms of how we can get ourselves to just do something, oftentimes it falls short.
And to be honest, anytime I hear about people saying, well, just eliminate the thinking and just do it, that is valuable advice until it doesn't work.
Because when it doesn't work, it simply doesn't work.
And then you need to rely on other tools and mechanisms, which are the sort that we will talk about today.
So while I have great respect for the just do it mantra, when it doesn't work, it doesn't offer any alternative solutions to engage tenacity and willpower.
And I do not know anyone on this planet.
I don't care if you're David Goggins or Courtney Dewalter, there will be days when telling yourself, just do this or just don't do that is not going to be sufficient for you to engage in the behaviors or resist the behaviors or thoughts that you need to engage in or resist.
And we should ask ourselves, why is that reality?
And this is a very important point and in fact, really illustrates the first bucket of tools and protocols for increasing tenacity and willpower.
And these are the tools and protocols that I would categorize under the rubric of modulators.
I've talked before on this podcast about the important distinction between mediators and modulators.
Mediators are things either psychological or biological, etc. that are directly in the mechanisms that generate some sort of action or emotion.
This could be neurochemicals like dopamine or serotonin and so on.
Modulators are things that can modulate that is can change our probability of doing something or not doing something, but they do so indirectly.
And in the context of tools and protocols to increase our level of tenacity and willpower, I will be completely remiss if one of the sets of tools that is the protocols for increasing the probability that we can access high levels of tenacity and willpower didn't include at least some of these modulators.
So I'm just going to spend about three minutes on these modulators because what we know for certain is that the regions of the brain that generate tenacity and again, there is literally a brain hub for generating willpower and tenacity gets strong input from the so-called autonomic nervous system.
The autonomic nervous system has two major components they are referred to as the sympathetic nervous system and the parasympathetic nervous system.
Keep in mind because when most people hear the word sympathetic, they think sympathy, they think emotion.
It has nothing to do with that simple means together and the sympathetic arm of the autonomic nervous system.
I know that's a mouthful is responsible for generating states of alertness in our brain and body.
Everything from panic to being alert and calm, our tendency to move or our likelihood of

moving under pressure.
It is also responsible for our ability to resist movement when we need to resist movement and therefore it's an active process.
So the sympathetic nervous system is all the things of action and when it is involved in generating inaction, those are cases where inaction requires energy.
Okay.
I want to be very clear about this.
The sympathetic nervous system isn't just about moving our body, although it has a lot to do with that.
It is also responsible for our ability to resist movement or thought or emotion when we need to do that clamp down on ourselves.
The parasympathetic aspect of our autonomic nervous system is the one that sometimes referred to as the rest and digest neural circuits and chemicals.
And that's true, but there's a lot more to the parasympathetic component of the autonomic nervous system.
It's also responsible for falling asleep.
It's responsible for us feeling relaxed.
It is responsible for most of the states of mind and body in which we are quiescent, where we don't feel an impulse to move or when we have a difficult time getting into action.
So the sympathetic and the parasympathetic aspect of the autonomic nervous system are always in a push pull with one another.
Think of them more or less on a teeter totter when one end goes up, the other end goes down.
They're really in competition with one another and it's their balance that reflects how alert or how sleepy we happen to be.
Now the reason I'm giving you this rather geeky nerd speak nomenclature filled discussion about the autonomic nervous system in the context of willpower is that regardless of whether or not you believe willpower is a limited or an unlimited resource, we know one thing for sure.
And that's that willpower and tenacity ride on our current autonomic function.
We can translate that to everyday language by saying that when we are well rested, for instance when we've been getting great sleep of sufficient duration, the previous night and the night before that, our level of tenacity and willpower to engage in things that we would not ordinarily engage in by default and our ability to resist behaviors and thought patterns that would otherwise be our default behaviors and thought patterns is much higher.
Conversely, when we are not getting enough quality sleep on a regular basis, our ability to call on tenacity and willpower is diminished.
Now that series of statements I just made is clearly going to be a duh for most people, but it is very important to understand that when we are sleep deprived, when we are in physical pain, when we are in emotional pain and or when we are distracted, when we are thinking about something else, aside from what we are trying to engage tenacity and willpower in order to do or not do, tenacity and willpower will be diminished.
Now all of those things together are just a bigger duh.
We all know this.

If you've got a splinter in your foot, it's really hard to think about not thinking about something else.
If you are extremely hungry or if you had an argument with somebody that you really care about and they said something that was particularly vexing to you and it's looping around in your head, it's going to be very hard to engage in something else that you need to do because you're going to be distracted.
Likewise, if you're sleep deprived, likewise, if you are a bit sick or run down or if you're in any kind of physical or emotional pain, your ability to draw on tenacity and willpower will be diminished.
So it's an absolute truth that your ability to generate tenacity and willpower rides on a reservoir of autonomic function.
And today we don't really have a way of quantifying the level of autonomic function or dysfunction in a very simple way.
It's not like resting heart rate, although resting heart rate is involved.
For instance, if you haven't slept well for a few nights or if you're particularly stressed over trained, you'll wake up in the morning with a significantly elevated heart rate.
However, there is no simple metric like heart rate or blood pressure or even cortisol level that can tell you whether or not your autonomic function is imbalanced.
That is the sympathetic and parasympathetic systems of your autonomic nervous system are in the best possible balance to generate tenacity and willpower.
We don't yet have such a metric, although there are companies that are starting to develop devices that hopefully will give us indices of autonomic function or dysfunction.
But it is important that we acknowledge that if you're not taking care of the foundational modulators of tenacity and willpower, none of the subsequent tools and protocols that we will discuss are going to help you that much over time.
You might get tenacity and willpower to engage one day when you're very sleep deprived, but it's going to be very difficult to consistently engage tenacity and willpower.
For that reason, if you have any struggles with sleep that is getting enough quality sleep on a regular basis, please see the zero cost toolkit for sleep that we've put at hubermanlab.com.
Please also see the perfect your sleep, master your sleep episodes also at hubermanlab.com.
Please also see the episode with expert guest Dr. Matthew Walker, professor of sleep neuroscience and psychology at University of California, Berkeley.
We just revamped the hubermanlab website.
So if you go to hubermanlab.com and you put something like sleep into the search function, it will take you not just to the toolkit for sleep, but to the exact timestamps that will queue up particular topics and protocols around sleep.
So if you were to put sleep and light, it would take you to those particular protocols.
If you were to put sleep and magnesium three and eight, it would take you to those particular protocols and so on and so forth.
Yeah, I don't want to get too far off topic here during today's discussion, but if you're not sleeping well, and if you're not managing your stress levels well, it's going to be much harder for you to engage tenacity and willpower regardless of the tools you happen to use.

And those tools could be everything from behavioral tools to supplements to prescription drugs. You need to get those foundational modulators in check and there are a lot of zero cost ways to do that that are all spelled out very clearly at the resources I just described.
Likewise for stress, if you're experiencing challenges with stress, both short term, medium term or long term stress, if you think you have elevated cortisol levels, which by the way may not be the case.
There are a lot of tools for modulating stress in real time, increasing your stress threshold etc.
Simply go to the hubermanlab.com website and put in stress threshold tools or stress real time tools and you'll get a bunch of zero cost tools that will allow you to do that.
It's also worth mentioning that when we get to our discussion about the neuroscience of tenacity and willpower, that you will understand why autonomic health and autonomic function is so important for our ability to engage tenacity and willpower.
I'll just tell you right now, it's because the neural circuits of the autonomic nervous system provide direct and robust input to this hub in the brain, this brain location that governs our ability to allocate our mind and body toward particular activities or to resist particular activities.
As many of you know, I've been taking AG1 daily since 2012, so I'm delighted that they're sponsoring the podcast.
AG1 is a vitamin mineral probiotic drink that's designed to meet all of your foundational nutrition needs.
Now of course, I try to get enough servings of vitamins and minerals through whole food sources that include vegetables and fruits every day, but oftentimes I simply can't get enough servings.
But with AG1, I'm sure to get enough vitamins and minerals and the probiotics that I need, and it also contains adaptogens to help buffer stress.
Simply put, I always feel better when I take AG1.
I have more focus and energy and I sleep better and it also happens to taste great.
For all these reasons, whenever I'm asked if you could take just one supplement, what would it be, I answer AG1.
If you'd like to try AG1, go to drinkag1.com slash huberman to claim a special offer.
They'll give you five free travel packs plus a year supply of vitamin D3K2.
Again, that's drinkag1.com slash huberman.
Okay, so let's think about the Baumeister data on willpower as a limited resource.
I'm going to briefly describe one of the first studies that really said to the field willpower is a limited resource, but I want to be clear that there are other studies like it and they all generally follow the same contour and that general contour is as follows.
Baumeister and colleagues and now many other laboratories have done experiments where they bring human subjects into the laboratory and those human subjects have to do something that requires mental effort or energy, aka willpower.
The classic example of this is you bring people into the laboratory, some of them might actually be dieting or fasted, although not always, and there are two platters set out for them.
One platter contains radishes, just plain radishes, by the way, I hate radishes unless they're pickled radishes.

I don't know why that is.
So these experiments picked my least favorite vegetable.
I love many other vegetables.
I disdain the radish.
That was just a personal editorial.
In any case, the radishes are set out and next to them are freshly baked cookies.
And in the room is the wafting aromas of freshly baked cookies.
So I think it's fair to say that most people, because of a hardwired tendency to like sugar and fat, especially when they are combined, would prefer to eat the cookies versus the radishes.
I know that there are some mutants out there.
They're saying I like radishes more than cookies.
But look, most people like cookies more than radishes.
The subjects in these studies are divided into two groups.
One group is told you have to resist eating the radishes.
The other group is told you have to resist eating the cookies.
And then the subjects are observed during this time, typically.
But this is really not what the experiment is about, per se.
This stage of the experiment is really designed to get people to resist a certain kind of behavior and the assumption, again, this is an assumption because there's no brain recordings here.
No one's in an MRI machine looking at what brain areas are activated or not activated.
There's no cortisol being measured, at least not in these early experiments.
These people are either resisting something that's pretty easy to resist, radishes.
Or they are being asked to resist something that, for most people, is going to be harder to resist than resisting radishes, which is resisting freshly baked cookies.
And that challenge has been made even more difficult by the wafting aromas of freshly baked cookies in the room.
And in some cases has been made even more difficult because these people are dieting.
And keep in mind that when you calorie restrict or when you put yourself on a diet of any kind, there is a well-established mechanism in the brain by which the neurons that engage hunger, especially hunger for fat and sugar, and that respond to things like aromas and taste are heightened, that is, their activity levels are heightened, which means that things that smell really good smell really, really good when you're hungry.
Things that ordinarily would taste really good, taste really, really, really good when you finally eat them.
So the key component of this stage of the experiment is to engage people's willpower.
The second part of the experiment has all of the subjects separately engage in another challenging task.
And the challenging task that they are asked to engage in is to solve a particular puzzle.
And again, different experiments use different puzzles, different experiments use different contexts, but the original experiments that Balmeister and colleagues did had people try and solve a puzzle that could not be solved.
So it's very, very difficult.

In fact, it's impossible, but the subjects weren't aware of that.
And then what was measured was how long subjects persisted in trying to solve this impossible to solve puzzle, depending on whether or not previously they had to resist the radishes, which is pretty easy to resist, or resist the cookies, which is at least harder to resist.
And for some people would be very, very hard to resist.
Now you can probably already guess what the outcome of this and similar studies was, because it birthed this entire belief camp within the field of psychology, that willpower is a limited resource.
The outcome was that if people had to resist the cookies, which is harder to do than resisting the radishes, that they would persist for less time when they had to try and solve a puzzle that unbeknownst to them could not be solved.
Conversely, if people had to resist something that was pretty easy to resist, such as resisting eating radishes, something that for me would be very, very easy to resist.
Well, when they were subsequently faced with trying to solve a very difficult, indeed impossible to solve puzzle, they persisted much longer.
Okay.
So put very simply, the study concluded that if you have to resist one thing and it's a hard thing to resist, well, then you have less air quotes here, resistance in you willpower to engage in another difficult task subsequently.
Whereas if you had an easy challenge just prior or no challenge just prior to being faced with a challenge such as a very difficult puzzle, well, then you had more resource, more willpower to apply to the solving of that puzzle.
So the conclusion that Baumeister and colleagues drew from those results was that willpower is a limited resource, but it didn't specify nor did they specify exactly what that limited resource is.
And this was quite an attractive theory because it jived well with most people's perception of what willpower and tenacity was for them.
This idea that, yes, there are things that challenge us both to do and to resist, but that we can do that.
But when we are asked to do that again and again and again, while we may build up some capacity to engage our willpower and tenacity, and of course, there are those rare individuals that we've heard about and some of us know that seem to have just a kind of bottomless reservoir of willpower and tenacity.
Most of us have an intuitive understanding of how hard it is to constantly be in friction with life, to constantly have to push ourselves to do things and to resist things.
And that while that capacity can expand and grow and we can get better at it, that there does seem to be something here, just subjectively speaking, there does seem to be something about engaging tenacity and willpower that, yeah, it can feel good, but it also requires effort, this neural energy that we were talking about.
So that raised the question of, okay, if willpower is a limited resource, what exactly is that resource at a physiological level?
So Balmeister and colleagues subsequently went on to explore what I think is a really interesting and clever idea.
Frankly, I can't confess that I would have thought of this, but they did.

We said, okay, you know, in some cases, people are eating the cookie and then they're engaging in this very difficult puzzle.
In other cases, they're eating the radish and engaging in this difficult puzzle.
And of course, other experiments used non-food challenging choices, but they came up with an idea, which was the brain as one of the most metabolically active organs in our entire body, if not the most metabolically active organ in our entire body, requires a lot of fuel.
It requires a lot of glucose.
Now, of course the brain mainly runs on glucose, but if you're following a ketogenic diet, your brain will mainly run on ketones.
But for most people who are omnivores or eating carbohydrates, glucose is the main and preferred fuel source for neurons, for nerve cells in your brain and body for that matter.
Balmeister and colleagues raised the hypothesis that perhaps glucose availability itself is the resource that's limiting willpower.
And in a whole set of experiments, they really showed that if people are asked to do a difficult task to engage their willpower, and this could be done by resisting a particular behavior or by engaging in a particular behavior, I'll just give you an example of engaging in a particular behavior that requires willpower or at least focus and mental energy to contrast it with the resisting radishes versus resisting cookies example that I gave earlier.
One common practice within experiments like this is to give people a very long passage of words.
So it's a story.
And then to give them some sort of rule about how to edit that passage, maybe they have to cross out every third E or the E's that arrive in the middle of sentences next to consonants, but not other vowels, you know, stuff that takes a lot of energy.
So these are dues as opposed to resisting behaviors, like we were talking about earlier, resisting the radish, resisting the cookies, although in many of these experiments, there's a command to do something, you know, cross out certain letter E's in this passage, but also to resist the reflex to cross out other E's.
And of course, all this is under time pressure.
And oftentimes it's being rewarded or scored.
This is the way that psychology researchers get people to engage in particular experiments and behaviors and resist certain things in the context of a laboratory environment when those things, frankly, are kind of boring and meaningless, they'll pay you more if you do well at the task, they'll give you money and then subtract the money that you're going to get at the end of the experiment.
If you make errors and things like that, and they'll do it under time constraint, as I mentioned earlier.
So there were lots of different conditions for, again, here air quotes, draining people's willpower and tenacity and certainly draining their mental attention.
And then they would have them do another subsequent task.
So in many ways, this just mirrors the first cookie radish experiment done by Bowmeister and colleagues.
But there was an important intervention put between the first and the second hard task.

And that intervention was to give one group a glucose beverage of about 150 calories or so.
So they would drink a glucose beverage to increase levels of blood glucose, the preferred fuel source for the brain, versus giving them an artificially flavored drink or just water or something that was, of course, matched for flavor, but that did not contain any glucose or calories.
Now, this is a clever experimental design, if you think about it, because at least at a first glance, the only thing that really seems to be different is the availability of glucose for the brain.
And you can probably guess what the outcome of these studies was.
The outcome of these studies was that when subjects are given glucose in between a first hard task that required willpower and a second hard task that required willpower.
And in some experiments, a third hard task that required willpower, that their levels of willpower were maintained consistently from one task to the next.
And in some cases, increased from one task to the next if they had more glucose available because they drank this glucose drink.
So what's really interesting and frankly, really nice about these studies is that they attempted to bridge a psychological construct like tenacity and willpower.
And to test the argument that willpower is an expendable resource.
And yet it's an expendable resource that is replenishable by linking that to a physiological variable.
And the physiological variable they linked it to was glucose availability in the brain.
Now, this set the field of psychology and in fact, the field of pop psychology, that is the discussion about formal findings in the field of formal psychological research ablaze. People were so excited about this.
I mean, this set of findings really pointed to the argument that if you could just keep levels of brain glucose elevated across your day, or at least stable across the day, that you would have more willpower and tenacity, this thing that humans have been seeking more of since the beginning of time.
Now, all of that seemed fine and good.
And in fact, a lot of products and courses were born out of that literature.
People were arguing that you should sip on a glucose drink while doing any kind of hard task, that you should sip on glucose drinks between tasks, that you should be thinking about literally fuel that you ingest into your body as fuel for psychological processes within your brain that would allow you to perform better in work and school and athletics and relationships and all of the domains of life.
But of course, any time there is a prominence or a real excitement about a particular finding in any field of science, but in particular in psychology, where it feels so applicable, as did the Balmeister results, you are going to get other groups that are going to try and replicate those findings and that are going to dig into the findings themselves and look at the statistics, look at how well or poorly powered those studies were.
We don't want to get into a full discussion about powering studies right now, but powering studies has a lot to do with addressing the question of whether or not there were enough subjects in the study to really draw the conclusion that one drew or whether or

not the statistics fell out as, yes, there was a significant effect of glucose ingestion on willpower and tenacity.
But if there weren't enough subjects, well, then there are other variables that could potentially explain those results.
So there were a lot of meta-analyses and other studies trying to replicate the work of Balmeister, and that's where things got controversial.
Now, we can take a step back from all of that controversy.
After all, we don't want to spend too much time on the controversy itself.
Rather, we want to know what the counter interpretation of the Balmeister results was.
And I want to be very clear, there was no real dispute as to whether or not Balmeister got the results that he and his colleague claimed to have obtained.
They did get those results.
The question really was about the interpretation.
Is willpower a limited resource?
And if it is, is the physiological resource itself glucose availability to the brain?
So in 2013, a colleague of mine at Stanford, Dr.
Carol Dweck, our Department of Psychology, did a study in which she examined this idea that willpower is a limited resource.
And the idea that the resource that's limited is glucose availability for the brain.
So Dweck and colleagues did an experiment that in many ways mirrored the overall organization of the experiments done by Balmeister and colleagues.
There was a difficult task, in some cases, the difficult task was that crossing out a particular ease within a passage task, followed by another difficult task.
And the difficult task that came second was the Stroop task.
This is a task I've talked about before on this podcast, although some episodes ago.
So for those of you that are not familiar with the Stroop task,
the Stroop task is where subjects are presented with words in different colors.
And they are instructed to either read the word.
So to pay attention to the content of the word or to the color in which the font of the word is written, this might seem pretty easy to most of you.
Right.
If I put up a card that says Apple on it and Apple is written in green,
you probably wouldn't have a hard time if you had been instructed to tell me what color is the word written in for you to just say green.
Okay.
But if I were to hold up a card that said red, but the font is actually in the color green, it's a little bit harder.
And if I were to then do that for a hundred cards or 300 cards and put you under time pressure where you're losing money that you're sure to get, if you make mistakes or you will earn money at the end of the experiment, if you get answers correctly,
well, then you start making more mistakes.
That's just the way these experiments work.
So they did a variation on the Stroop task that isn't exactly the way I just described it.
And the Stroop task, by the way, is one that's used to probe prefrontal cortex function.

This area of our brain, right behind our foreheads, that is responsible for many things, but in part is responsible for context and strategy setting, given a particular set of rules.
So if you get onto the bus or get onto the subway versus walk into a black tie dinner, the context and rules are very, very different as to what you would say or not say, how you behave, how you address your prefrontal cortex is largely, although not entirely, is largely responsible for a lot of the context setting and rule setting from one situation to the next.
And if you think about the Stroop task, it's really just a context dependent strategy task.
You either have to pay attention to the meaning of the words or the colors in which those words are written.
And the number of mistakes that you'll make depends on how much time pressure you're under, what sorts of neurologic or psychiatric challenges you might be facing or not facing, so on and so forth.
But it's a very robust task that's existed in the scientific literature for a long period of time.
So the Dweck experiment.
And by the way, there were actually three experiments in this paper.
I won't go through all of them in detail for sake of time, but I will provide a link to the paper in the show note captions.
But the major focus of the study was to have people engage in one hard task and then in another hard task, both of which drawn willpower testing the idea that willpower is a limited resource and then providing some of those subjects with a glucose rich drink or other subjects with a drink that was artificially sweetened.
So it had no glucose, no calories, but tasted.
Yes, they match them for taste.
I know some of you who don't like artificial sweeteners are saying those don't taste exactly like real sugar, but they manage to match these drinks for taste.
But in one case, the drink would clearly increase blood glucose.
In the other case, the drink would not raise blood glucose.
So the results of this study are really spectacular in my mind, because what the study found was that, yes, indeed ingesting glucose can improve performance on these multiple challenging willpower requiring tasks.
However, the degree to which the glucose containing drink could improve performance depended on whether or not you believed that willpower was a limited resource and whether or not you believe that resource was glucose.
In other words, if you hear and believe that willpower is a limited resource, well, then indeed with each subsequent task that you engage in or life event of any kind that you engage in that requires willpower and tenacity, you will have less willpower and tenacity to draw on.
Whereas if you believe that willpower and tenacity are unlimited and in fact are divorced from blood glucose as the physiological source of willpower and

tenacity, well, then you can engage in one challenging task and another challenging task and another challenging task without any diminishment in performance.
Now that, of course, leaves us all in a very tough position because how are we to decide what to believe if we know that willpower can be a limited resource or willpower cannot be a limited resource?
Ah, well, the results of the Dweck study.
And by the way, I should share with you the title of the study.
The title of the study, not surprisingly, is beliefs about willpower determine the impact of glucose on self control.
And this was a study published in the proscenes of the National Academy of Sciences.
Again, I'll provide a link to this study in the show note captions.
There are three major experiments in this study.
As I mentioned before, I just gave you the major conclusion of all of them sort of woven together.
And if it wasn't clear already, the major conclusions are that, yes, ingesting glucose can improve your ability to engage tenacity and willpower, AKA self control from one task to the next, provided that you believe that glucose is the limiting resource for engaging tenacity and willpower.
If you don't believe that, well, then you can engage tenacity and willpower without ingesting glucose.
And that's where the artificially flavored drink comes in.
I'll leave it to you to kind of unpack what that means experimentally.
But it's a very clever experimental design that Dweck and colleagues came up with because it argues that, yes, indeed, it's hard to do a challenging thing right after another challenging thing.
But there's no reason to think that you can't do both of those things while engaging the utmost tenacity and willpower.
If you believe that tenacity and willpower exist within you as a single mechanism that can be harnessed and that it's not a single mechanism that has a reservoir that runs down as you engage in one hard thing to the next.
Now, this is very important because we are about to transition into our discussion of the physiological.
That is the neural underpinnings of tenacity and willpower, which as it turns out is one major set of brain circuits.
There could be others that are yet to be discovered, but we know that there is one major set of brain circuits in particular one brain area, believe it or not, that an entire collection of more than two dozen studies really points to as the seat, the origin of what we call tenacity and willpower.
But before we transition to that and the tools and protocols that that physiological neural understanding set forth for us to all use and apply, I'd be remiss if I didn't mention that Baumeister wasn't about to hear these results from Dweck and colleagues and just say, OK, willpower

is not a limited resource.
It's not blood glucose.
It's all what you believe about willpower.
It's all what you believe about blood glucose.
Rather, Baumeister himself went back to the lab and did subsequent experiments that in some ways not all counter the Dweck results.
So I'm not trying to confuse anybody, but I wouldn't be doing my job if I didn't give you both sides of the story.
Now, the good news is that the tools and protocols that we are going to arrive at work regardless of which psychological camp you happen to be in the Baumeister camp or the Dweck camp.
Now, I don't want to give the impression that these are warring camps.
And I also don't want to give the impression that these are the only two camps of thought and experimentation within the field of tenacity and willpower.
There are many groups working on these subjects.
Indeed, there have been meta-analyses that have confirmed the major theories of Baumeister and there are meta-analyses that have refuted the major findings of Baumeister.
I will provide links in the show note captions to a couple examples of each so that you have those to peruse if you like.
But let's discuss for a moment what Baumeister found when they went back and re-researched, I think that's a word, re-researched the idea that willpower is a limited resource and that glucose is that limiting resource.
Baumeister and colleagues looked at the Dweck data and said, OK, fine, the data looked great, except for the fact that in real life and in many previous experiments that they and others had done, it wasn't just two hard challenges back to back, but often two or three or four.
And what Baumeister and others found was that when subjects are presented, not with just two challenges back to back, but three or more challenges.
So back to back to back to back.
Challenges that have to engage a lot of neural energy, a lot of willpower, tenacity, resistance to do certain things and effort to engage in certain kinds of behaviors and cognitive processes that when subjects had glucose available to them in the brain by way of ingesting these glucose drinks, sipping those in between the tasks or sometimes even during the tasks, that their performance, that is their willpower and tenacity to engage in challenges was maintained across those multiple challenges.
And they conceded that one's belief about willpower could indeed dictate whether or not willpower was or was not a limited resource and whether glucose would or would not enhance one's ability to engage willpower.
But they argued that if one confronts multiple challenging circumstances, as is very naturalistic, as we say, it's very typical of every day real life, then the availability of glucose during and between tasks, the ability for the brain to engage in its external environment and take

reads of its internal environment, how we feel inside relative to what's expected of us was very valuable in allowing people to engage this thing that psychologically we describe as tenacity and willpower.
I'd like to just take a brief break and thank one of our sponsors, which is element element is an electrolyte drink that has everything you need and nothing you don't.
That means plenty of salt, sodium, magnesium and potassium, the so-called electrolytes and no sugar.
Now, salt, magnesium and potassium are critical to the function of all the cells in your body, in particular to the function of your nerve cells, also called neurons.
Now, people, of course, have varying levels of requirements for sodium.
So people with hypertension or prehypertension probably shouldn't increase their sodium.
However, many people are surprised to find that by increasing their sodium intake, they are able to function better cognitively and physically.
And that's because a lot of people, especially people who are following low carbohydrate or even moderate carbohydrate and really clean diets, oftentimes are excreting a lot of water and electrolytes along with it and simply by increasing their electrolyte intake using element, they just feel better and function better.
I typically drink element first thing in the morning when I wake up in order to hydrate my body and make sure I have enough electrolytes.
And while I do any kind of physical training and certainly I drink element in my water when I'm in the sauna and after going in the sauna because that causes quite a lot of sweating.
If you'd like to try element, you can go to drink element.
That's lmnt.com slash huberman to claim a free element sample pack with your purchase. Again, that's drink element lmnt.com slash huberman.
Let's talk about the physiology of tenacity and willpower.
And I assure you that the conversation where you are about to have is not going to be just a bunch of nomenclature and mechanistic understanding of the origins of tenacity and willpower.
Rather, it argues that tenacity and willpower have a unified source.
That is a specific set of brain areas that when active, engage that feeling of tenacity and willpower, regardless of what we are confronted with, regardless of whether or not we are trying to engage in something that reflexively we wouldn't otherwise want to engage in.
And regardless of whether or not we are confronted with something that we have to resist. And to me, that's extremely reassuring.
Because whether or not you believe that blood glucose is the limiting resource for willpower, whether or not you believe that your beliefs about willpower and blood glucose impact your level of willpower.
What we know for sure is that there's a single set of brain circuits.

Indeed, there's a single brain area that seems to be able to largely,
if not entirely, explain this phenomenon that we call tenacity and willpower.
And that should be reassuring because what it means is that tenacity and willpower
is the reflection of a neural circuit function that is a skill.
It's an expression of something that we all have within us.
We all have this particular brain area.
And quite excitingly, this is the third point,
this brain area is highly subject to plasticity.
There are specific things that we can do and there are specific mindsets
that we can adopt that allow us to increase the activity of this particular brain area.
Indeed, to increase the size of this particular brain area
so that we can call on tenacity and willpower,
not just in one circumstance like school or musical learning
or athletic endeavors or relationship endeavors,
but rather that we can call on this brain area in the context of any and all circumstances
where willpower and tenacity are required.
Now, we talk about neuroscience a lot on this podcast,
but it's not often that I point to a particular brain area
and can confidently say this particular brain area
has an absolutely integral role in something as kind of high level,
psychological as tenacity and willpower.
But today we can do that.
And that's because there's a collection of more than two dozen studies
that point to one particular brain area.
And of course, it's connections with other brain areas
because no single brain area operates in isolation.
Every brain area is operating in the context of neural circuits,
other brain areas that it receives inputs from and gives inputs to and so on.
But this one particular brain area really does seem
to underlie what we call tenacity and willpower.
And we know that through several lines of evidence.
First of all, I'll tell you the name of the brain area,
although the name itself isn't going to tell you much
unless you're a neuroscientist or anatomist.
So I'll give a little bit of background about it.
The name of the brain area is the anterior mid-singulate cortex.
The anterior mid-singulate cortex is part of a larger brain area
called the singulate cortex.
And in humans versus animals, it goes by slightly different names.
Unfortunately, it's just one of the consequences of different researchers
in different labs, calling the same thing different things.
It'd be really frustrating, but we'll make it very simple
because today we were referred to this area as the anterior mid-singulate cortex,
which is a subdivision of a larger brain area simply called the singulate cortex.

The anterior mid-singulate cortex resides in the frontal lobes.
So it's behind your forehead, although that doesn't tell you anything
because all of your brain is behind your forehead if you think about it.
And it's about a third of the way back toward the back of your head.
And you actually have two of these structures, two anterior mid-singulate cortices,
one on each side of the brain, and they receive a lot of inputs
from a lot of different areas.
And we'll talk about what those areas are because this is extremely important
when thinking about the different psychological and physiological resources
that you can draw upon to engage tenacity and willpower.
But for the time being, let me just go through the evidence
and kind of list format of why we feel so confident
that the anterior mid-singulate cortex is such a vital hub
for engaging tenacity and willpower.
For each of these points that I'm about to make,
there is indeed at least one, if not several, quality peer-reviewed studies in humans.
So there's a lot of data from animals,
both rodents and primate models, et cetera,
that we're not talking about today,
but I should mention all of which supports the human data and vice versa.
The data I'm going to describe now come from humans
and from a variety of different types of studies.
So there are a lot of different ways that one can consider
if a brain area is implicated in a given psychological or physiological phenomenon
like motivation or sadness or visual perception.
And those include, for instance,
if a brain area is active during a given phenomenon.
So one way to explore this is to put literally wire electrodes down below the skull,
record the electric activity of neurons,
and assess whether or not the electrical activity of those neurons changes
when a person is, say, viewing faces or feeling a particular way,
like feeling tenacious or feeling bored or feeling aggressive and so on.
Another way of assessing a particular brain area's role
in a given physiological or psychological phenomenon
is in individuals where that particular brain area is injured.
You might expect that a particular phenomenon like willpower,
like the ability to perceive faces,
is present or absent, whether or not it's exacerbated
or whether or not it's diminished.
Other ways of assessing whether or not a given brain area
is involved in a given phenomenon
is whether or not that brain area literally changes size,
whether or not it changes in volume over the course of some sort of training.
So for instance, if somebody is not able to play a musical instrument,

such as myself, and then I or a subject in one of these experiments
learns a musical instrument and the volume, the size of that particular brain area
is assessed across the learning or simply before and after that musical learning
and it grows, or perhaps even if it shrinks or changes shape,
one might determine that it is somehow, somehow involved
in the process of learning a musical instrument.
You couldn't unequivocally conclude that,
but along with other types of evidence, one could perhaps conclude that.
So that's just a partial list of ways to assess brain area function,
other ways include assessing what other areas a given brain area gets input from.
So for instance, in the case of the anterior mid-singulate cortex,
we will soon discuss the fact that it gets robust input
from the autonomic nervous system, which you already learned about.
It gets robust input from reward systems of the brain,
such as the dopamine and serotonin based reward systems of the brain,
and it gets robust input from the context and strategy setting areas of the brain as well,
and many other different brain areas.
So there's a structural logic as to why the anterior mid-singulate cortex
would be involved in tenacity and willpower,
but no single anatomical or physiological or lesion based finding
is as compelling as when we consider all of the results
about the anterior mid-singulate cortex together and side by side.
So for instance, recordings by neural imaging of the anterior mid-singulate cortex
in an unbiased way, meaning people are put into a brain scanner
and brain activity is examined en masse, all of the brain areas are looked at,
and people are presented with either a hard task or an easy task,
revealed that the anterior mid-singulate cortex shows elevated levels of activity
in the hard versus the easy task.
And again, I want to point out that the researchers were not looking for that result,
they simply observed that result.
In addition, if people who exhibit high levels of academic performance
across many different subjects are put into a brain scanner
that evaluates so-called resting state connectivity, so no task,
but simply levels of activity in different brain areas that occur spontaneously,
so they're just sitting in the scanner looking at a blank screen,
the resting or spontaneous levels of activity in the anterior mid-singulate cortex
of high achieving individuals is higher relative to those of lower achieving individuals.
In addition, people that have lesions or disruptions
of anterior mid-singulate cortical function show increased apathy and depression
and reduced levels of tenacity and motivation across the board,
regardless of what domain of life one is asking about,
whether or not it's athletic or academic, etc.
Indeed, successful dieters show elevated spontaneous
and what's called evoked levels of activity in the anterior mid-singulate cortex.

So spontaneous, again, just at rest, they have higher levels of activity
in the anterior mid-singulate cortex and for those that are presented with food
and they have to resist that food and they have to resist the smell of that food
and the potential taste of that food,
the activity of the anterior mid-singulate cortex goes up even further,
especially in those individuals who can resist,
that is, who can engage willpower to not eat the delicious food item.
Conversely, individuals that have failed to exert sufficient willpower
to lose their desired weight, and this was for medical reasons
related to trying to achieve medical health,
as well as people who are obese seem to have diminished levels of activity
in the anterior mid-singulate cortex.
In addition, people who are depressed, who express a lot of apathy,
and here we're talking about clinically diagnosed major depression,
show reduced levels of activity in the anterior mid-singulate cortex.
Humans that express a lot of what's called learned helplessness,
that is, they've adopted the belief and the actions associated with the belief
that no matter what they do, the outcomes are not going to be what they desire,
express lower levels of neural activity in the anterior mid-singulate cortex.
So you can see this list goes on and on, but it in fact gets even more interesting.
Remember earlier, I mentioned that successful dieters
have elevated levels of neural activity in the anterior mid-singulate cortex.
Now that might seem like a good thing, and indeed it can be a good thing,
but there's a pathologic condition associated with dieting and one's ability
to engage willpower and resist food, and that's in the case of eating disorders
such as anorexia nervosa.
Now I've done a Huberman Lab podcast solo episode about anorexia nervosa,
and on that podcast I made the point that I'll make again now,
which is that anorexia nervosa is the most deadly of all the psychiatric conditions,
leading to death in a very large percentage of people that have it.
Now fortunately there are treatments and more emerging all the time,
but it's a very serious psychological and physiological condition that is extremely deadly.
Individuals with anorexia nervosa exhibit heightened levels of activity
in their anterior mid-singulate cortex, both at rest and when presented with food.
And I don't want to go on a full tangent about anorexia because we covered
anorexia on the previous podcast episode about anorexia,
which by the way you can find at Huberman Lab.com, simply search anorexia
or eating disorders within the search function.
But one of the clear symptoms of anorexia nervosa is that the reward pathways of the brain,
which we know feed into, that is send direct connections to the anterior mid-singulate cortex,
seem to be activated under conditions in which people with anorexia
avoid food as opposed to eat food.
And then there's a very interesting and positive literature about so-called super-agers.
So what we know for sure is that as people age, in particular between the ages of 60 and 90,

there's a reduction in the size of many brain areas,
but the anterior mid-singulate cortex in particular,
unless certain things are done to offset that,
we are going to talk about what those particular things are in just a few minutes.
But there's a particular category of humans that's alive now and that live a very long time.
These are the people that stand the greatest chance of becoming centenarians,
and many of them are centenarians, so-called super-agers.
But also within the category of super-agers are people who are 60 years old or more,
because not all of them have reached 80, 90 yet,
and have the cognition of 40-year-olds, 30-year-olds,
and often even of people in their mid-20s.
Now, there are a lot of things that are different about these super-agers,
super-agers in the sense that they are maintaining very youthful levels of cognition.
But one of the things that's become very apparent from the neuroimaging data
is that super-agers maintain a volume, a size,
of the anterior mid-singulate cortex that is significantly greater than their age-matched cohorts.
So the exciting thing is that there are many, many lines of evidence
pointing to the fact that the anterior mid-singulate cortex
at least has something to do with our ability to generate tenacity and willpower,
and that it, when active, moves us up that continuum away from apathy and depression
toward states of being able to engage in or resist particular types of behaviors.
So what I just described is a bunch of neuroimaging, structural volume data,
blood uptake data, lesion studies, and so on and so forth.
But we can simplify all of that and, in fact, address something that perhaps I should have said earlier,
which is that when we're talking about tenacity and willpower,
we're really talking about one of two things.
We are either talking about that sense within us that has us saying, I will.
No matter what you tell me, no matter what you put in front of me,
no matter what is rolled my way, I will blank.
Now, the other expression of tenacity and willpower is that within us, within you, within me,
when tenacity and willpower are active, we have that sense within us,
that feeling in our body and that thought pattern, aka feeling in our brain,
that no matter what you say, no matter what you do, no matter what you put in front of me,
I won't. So really willpower is either an expression of I will or I absolutely will,
is perhaps a better way to state it, or I absolutely won't.
Now, that might seem like just a simple subjective reordering of a bunch of
physiological data and psychology studies, but it's not.
It's actually far more important for us to understand this I absolutely will and I absolutely won't
aspect of willpower, because if indeed there is a single brain area that can govern willpower,
and willpower is not one, but is at least two things, the sense of I absolutely will,
no matter what you say, do, et cetera, or I absolutely won't, no matter what you say, do,
et cetera. Well, then this brain area can't be a simple switch. It can't be willpower on,
willpower off, willpower on, willpower off. It can't be absolute, as we say. It must be

graded. It must have levels. So it's more like a slider on a light switch than an on versus off light switch. In addition to that, if there is truly one brain area that plays a critical role in generating tenacity and willpower, and tenacity and willpower is something that's required from us in a lot of different contexts where we have to say, I absolutely will. Yes, this. I absolutely won't know that. I absolutely will. Also, yes, this, et cetera, et cetera, because life is complex, even just the simple thing of, say, dieting or trying to get a particular degree or trying to navigate even a simple illness, like I'm going to get through this week, despite feeling lousy, I'm going to take good care of myself. All of these things in some sense require tenacity and willpower and the behaviors we need to engage in and avoid engaging in is very dynamic, depending not just on who we are and what we're trying to do or not do, but also where we are that day, that moment. Well, that means that the anterior mid-singulate cortex also needs access to information about context. It needs to understand what's rewarding or non-rewarding in the context
of what we're trying to accomplish, not just what feels good in the moment. Now, fortunately, there have been a number of studies exploring not just the activity levels of the anterior mid-singulate cortex or the size of the anterior mid-singulate cortex in the various conditions we talked about before, depression, obesity, successful dieters, successful students, successful athletes, et cetera, but a lot of anatomical tracing studies, both from fixed, that is from dead brain tissue, so postmortem brain tissue in humans, but also nowadays there are certain types of neuroimaging, particularly something called diffusion tensor imaging that allows one to examine the flow of information in and out of different brain areas through so-called white matter tracks, tracks meaning T-R-A-C-T-S tracks. So these are the wires that connect neurons are called axons and those axons are in sheaths with a fatty substance called myelin and that in sheathment with myelin allows them to transmit information very quickly. You'll see where I'm going with all this in just a moment and what we know is that the anterior mid-singulate cortex, again of which you have one on each side of the brain, about a third of the way back from your forehead to the back of your brain approximately, right above the so-called corpus callosum, this very robust collection of white matter tracks that connects the two sides of the brain, well it gets input and sends input to a number of different brain areas, including but not limited to the following, autonomic centers that control for instance, cardiovascular function, increases or decreases in heart rate, respiration, how fast and how deeply you breathe or how shallowly and slowly you breathe, immune system, inputs and outputs with the spleen, not directly but through a couple of different stations with the very organs in your body that can release B cells and T cells and immune molecules that can combat bacterial viral and fungal infections and that can repair physical wounds and it communicates with the endocrine system with the systems of the brain and body
that release for instance estrogen and testosterone which by the way are present in both males and females and on a previous episode of the Huberman Lab podcast with Robert Sapolsky as my guest, we talked about for instance the role of testosterone and many people think oh testosterone is all about aggression, testosterone is all about attack, testosterone is all about mating, that is completely false, well it can be involved in those different processes.
What Dr. Sapolsky and I discussed is that one of the major functions of testosterone in the brain is to make effort feel good and you can see and we'll talk a little bit more about how that links up very directly with this concept of tenacity and willpower. So the first point is that the

anterior mid-singulate cortex is in direct communication with all of the areas of the brain and through a couple of other stations the body that modulate our sense of tenacity and willpower which we talked about earlier, the need for sleep, the need for pain or lack of pain or emotional comfort or discomfort to modulate our level of tenacity and willpower. The anterior mid-singulate cortex is also directly linked up with premotor centers, these are the centers of the brain that organize particular patterns of behavior and indeed that can suppress particular patterns of behavior. As I tell you that you're probably feeling in the blanks, this is engaging in a behavior or resisting a behavior. The anterior mid-singulate cortex is also directly wired in with the reward pathways of the brain, it can trigger the release of dopamine, it can also respond to the release of dopamine and that dopamine release could be generated behaviorally, it could be generated through some sort of food reward, it could be pharmacologic, there are a number of different ways that the dopamine system can communicate with the anterior mid-singulate cortex. The point here is that it is in direct communication with the anterior mid-singulate cortex and the anterior mid-singulate cortex is in direct communication with the dopamine system and what I just gave you is frankly just a partial list of the different areas of the brain that are communicating robustly with the anterior mid-singulate cortex. It gets information about interoception, our readout of how we feel in our body, it also has robust inputs and outputs with the areas of the brain that are associated with exteroception, our perception of what is out around us. So all of that provides a logical basis for the neuroimaging data, the lesion data, the volumetric data that we talked about a few minutes ago in the context of depression, anxiety, high performance, anorexia and so on. But one of the most important arguments that's ever been made in favor of the anterior mid-singulate cortex being a major seat for tenacity and willpower comes from Dr. Lisa Feldman Barrett, who is soon to be a guest on the Huberman Lab podcast. We've actually recorded that episode already and it should be out very soon. Lisa's laboratory is well known for pioneering research on emotion and affect. I strongly encourage you to listen to that episode once it comes out. And it was actually Lisa herself that cued me to the importance of the anterior mid-singulate cortex. And Lisa and colleagues have written several spectacular reviews about the anterior mid-singulate cortex and its role in tenacity and motivation. I will provide links to a few of those in the show note captions. The one that I'm particularly excited about, the one that I've spent now an immense amount of time with is entitled the tenacious brain, how the anterior mid-singulate cortex contributes to achieving goals. So if you have a background in biology, even if you don't, I think you'll find that review to be very interesting. And it further substantiates a lot of the points that I made a few moments ago about the different scenarios and types of individuals that seem to be able to engage their anterior mid-singulate cortex under different conditions and to a greater or lesser extent than others. So hats off to Lisa for cuing me to this incredibly interesting brain structure. I had known that it existed, after all I teach neuro anatomy to medical students at Stanford and I taught neuro anatomy for many, many years, but I don't think enough people and indeed very few professional neuroscientists could tell you what the anterior mid-singulate cortex does, but it has this apparently incredible function in generating tenacity and motivation. Along those lines, one of the most incredible and important studies about the anterior mid-singulate cortex and its capacity to generate feelings

of
tenacity and willpower comes from one of my colleagues at Stanford, Joe Parvizi, who essentially went into human beings who needed brain surgery for other reasons and stimulated particular brain areas with a very high degree of precision. The title of the paper that I'm referring to was published in 2013 in the journal Neuron Cell Press Journal, excellent journal and it's entitled the will to persevere induced by electrical stimulation of the human cingulate gyrus. Now you'll notice the title said human cingulate gyrus, not anterior mid-singulate gyrus, but because they had electrodes and a stimulation technique that would allow them to stimulate in very small regions, extending as little as five millimeters, but no more away from the stimulation site. They were able to march the stimulation around different sub regions of the cingulate gyrus of humans while those people were awake and then ask those people, how do you feel? What are you experiencing in this
moment? In addition to that, they were recording various autonomic parameters from those people, so heart rate, breathing, in addition to brain wave activity. So what the subjects report when their anterior mid-singulate cortex was stimulated is that in their words, something was about to happen. They felt as if there was some sort of pressure upon them from the outside, not physical pressure, but that something was about to happen. In fact, one of the subjects described the sensation
as it's as if there's a storm off in the distance, but I know I need to go into the storm and I know I can make it through the storm. Another subject described the experience of having their anterior mid-singulate cortex stimulated as something not necessarily good is going to happen, but I know that I need to marshal resources and resist, and I'm confident that I can push through. Now, because Parvizian colleagues are excellent scientists, they of course did control experiments where they would tell the person, okay, we're stimulating that same brain area that a moment ago you told me created this feeling of some pressure upon you that you have to resist some sense of fight or urgency to push back. But in reality, during certain control conditions, they were not stimulating those brain areas. And the subjects then reported, I don't feel like anything's about to happen. Yeah, I don't feel anything at all. In other words, it was the stimulation of the anterior mid-singulate cortex and only the anterior mid-singulate cortex that created the sensation within people that there was something to resist, that there was something putting pressure on them, again, not physical pressure, but psychological pressure, and that they were going to have to marshal resources in order to push back upon. In fact, they reported feeling as if their body was getting ready to do something. One subject said something along the lines of, yeah, I feel like I'm about to do something. I'm about to go someplace or do something to resist this foreboding sense that's now coming over me. So this is very interesting and of course is in line with all of the data that we discussed before about neural activity patterns, both spontaneous and evoked, about brain volume changes in the anterior mid-singulate cortex, so on and so forth. And it really points to the idea that the anterior mid-singulate cortex is a hub, a hub that receives information from a diversity of brain areas that we talked about a few minutes ago, and that generates a particular sense within us that we are going to be forward center of mass, that we are going to resist something, and that perhaps we are going to move or act in some particular way, or as we've been discussing all along, resist action in some particular way, but that it requires that we marshal resources, which takes us back, of course, to the studies of Baumeister and indeed of Dweck, where they explored willpower as a limited

resource,
perhaps glucose, perhaps as that limited resource, beliefs about willpower and glucose,
probably with a high degree of certainty, are going to be involved there too.
But regardless of that controversy, it's clear that there's an energy required,
there's an activation state of engagement or resistance to a particular behavior or thought
pattern that we all associate with this phenomenon of tenacity and willpower. And in a kind of
miraculous way, as a neuroscientist, we're generally taught nowadays that individual
brain areas don't really trigger individual functions and perceptions of the brain. There
are a few exceptions to that. You have a fusiform face area that really does seem to be involved
in the perception of faces and when lesion, you can't recognize faces. But outside of just a few
limited contexts, it's very rare that one comes across a literature that across all of the studies
involved point to a single brain structure and its networks as giving rise to something as complex
and flexible as tenacity and willpower. But in the case of the inter mid-singulate cortex,
it really does seem to meet those criteria as the brain hub responsible for tenacity and willpower.
Now a key idea that Dr. Feldman Barrett has contributed to studies of the inter mid-singulate
cortex as a structure that helps us generate what we call tenacity and willpower to help
us achieve different types of goals is this idea of allostasis. Most of you have perhaps heard of
homeostasis, which is the idea that all of our cells, all of our organs, indeed our entire body
and psychology are always seeking homeostasis, the perfect balance of sleep and activity,
of food and burning fuels, of oxygen and carbon dioxide and so on and so forth. And while
homeostasis
certainly exists and is a valid phenomenon, there's also a concept that we hear far less about,
but that is equally important, which is the concept of allostasis. Allostasis is the idea that much
of what our brain and body need to do, but especially our brain, is to allocate allostasis,
to allocate resources to particular functions depending on our motivational goals and the
challenges upon us. And in every way, what we understand about the structure and function
of the inter mid-singulate cortex is that it is doing just that. It is deciding how much glucose
should a given brain area consume, perhaps a brain area that's involved in visual perception,
because you're involved in a motivational task where in order to succeed, you need to pay careful
visual attention to particular things, or you're involved in a task, we have to listen to particular
things, or perhaps you are involved in a physical foot race where you don't want to allocate a lot
of energy towards thinking about your stride or your step unless that's necessary, and you actually
want to shut down your brain activity as much as possible, except for the brain areas that are
required to get you to continued run. In that sense, the inter mid-singulate cortex, as a
sort of a dial on how much fuel is consumed, not by the brain and body as a whole, but by
individual brain and body parts, meets all the criteria of what you would want for a brain area
that controls things like tenacity and willpower, because even for those individuals who seem to
just have an endless supply of tenacity and willpower, they too have to go into habitual behavior.
They can't simply lean into every aspect of life with the kind of resistance from outside and the
resistance against those outside forces or even resistance to internal forces, voices in their
head, et cetera, on a constant basis. They still need to sleep. They still need to be functional
in that expression of tenacity and willpower. They need to be able to strategy switch,
and they need to be able to come off the gas, as we say, not because tenacity and willpower are
necessarily a limited resource, but because for so many aspects of life, engaging tenacity and

willpower is not advantageous. Hence the example I gave earlier about eating disorders, where an apparently hardwired function of our brain to be able to generate some sort of reward for resisting a given behavior goes too far and then can actually threaten one's own health or even life. Concept of allostatic load, allostatic balance, and allostatic function is something that we get into in a fair amount of detail in the discussion with Dr. Feldman Barrett in that episode, which is coming out soon. In the meantime, if you were to think about the anterior mid-singulate cortex as having a single function, the function that Dr. Feldman Barrett has ascribed to it as controlling how much energy different brain and body areas should get in a given context, well, that makes a lot of sense to me. I think it's the one that best describes all of the functional data indeed includes or jibes with all the anatomical data about the anterior mid-singulate cortex as well. One of the really important twists in all of this is that the anterior mid-singulate cortex is not just sitting there to allocate and dole out different amounts of energy and activation to different brain areas. It is also receiving input from both the brain and body and in sort of a beautiful twist on the whole story of what the anterior mid-singulate cortex does. We know that when we move our body, we are activating the anterior mid-singulate cortex and we know that when we move our body, because we in some way forced ourselves or encouraged ourselves to do it, we activate the anterior mid-singulate cortex more. Similarly, and because the anterior mid-singulate cortex is so flexible in the different contexts in which it can be activated, if we are simply reading or we are listening to something that we are supposed to learn or trying to learn a piece of music or trying to do anything for that matter, the anterior mid-singulate cortex, yes, will be activated, but that its levels of activation are far greater when we experience a lot of resistance that we have to overcome. Remember the earlier result, and by the way, I'll provide a link in the show note captions to this particular study or set of studies. There are about two, one really spectacular one and a couple of others that tangentially point to the same finding that when people engage in a hard task, not an easy task, but a hard task that the anterior mid-singulate cortex activity is elevated. So the way to think about the anterior mid-singulate cortex is that it's not just sitting there as a hub that you reach into and activate, it's also receiving inputs that can activate it. And that's what allows us to now talk about the tools and protocols that don't just allow us to engage our anterior mid-singulate cortex and access more tenacity and willpower, but that allow us to exercise, not necessarily in the context of physical exercise, although it could be that too, but to exercise our anterior mid-singulate cortices ability to engage not just in that challenging context, but in other challenging contexts as well. In fact, I'll just tell you right now that studies in non-human primates and to a limited extent in humans, but here we think there's a strong analog between the non-human primate data and the human data. The anterior mid-singulate cortex is chock-a-block full of the expression of molecules such as chem kinase 2, receptors to various neurotrophins, particular types of NMDA and methyl deaspartate receptors, all of which, if none of those names mean anything to you, just know that all of them refer to different aspects of and a capacity for synaptic plasticity, which is the ability for connections in the brain to change. They can get stronger, you can actually grow new connections. In other words, the anterior mid-singulate cortex can be built up as a structure to engage tenacity and willpower by activating it through one or a limited number of different types of behaviors, meaning engagement in behaviors that frankly, we would rather not engage in, as well as not engaging in behaviors that reflexively we really want to, that were sort of drawn to engage in.

Both of those contexts, I absolutely will, even though frankly, I don't want to or you're telling me I can't, as well as that I absolutely won't, even though you're tempting me to do that or that's tempting me to do that or even I'm tempted to do that. That buildup of the anterior mid-singulate
cortex has extensive carryover into other domains of life because it's the same structure that is then used for other types of behaviors and learning that require tenacity and willpower.
So that's incredibly reassuring. In fact, it's downright exciting because,
as I mentioned earlier, while there are a near infinite number of different circumstances where we each and all need tenacity and willpower, it seems that there's a very generic mechanism for generating tenacity and willpower. And that means that if we can build up our capacity for tenacity and willpower by engaging in particular types of behaviors and resisting particular types of behaviors, well, then it's going to carry over in a very functional way to the other aspects of life that we find challenging and that we may find challenging in the future.
Okay, so by now, I like to think that I've convinced you because, frankly, the data are very convincing that the anterior mid-singulate cortex is a vital hub within your brain for allocating energy and resources to generating tenacity and willpower. And perhaps it's taken you a lot of tenacity and willpower to get this far through the episode, waiting with bated breath, presumably, to learn how exactly you can improve the functioning of your anterior mid-singulate cortex.
Now, fortunately, there are published peer-reviewed data that explain how to do that. In fact, there's a study that was published in 2006 by Colom and colleagues entitled,
Aerobic Exercise Training Increases Brain Volume in Aging Humans. And before you go run off, literally, and engage in cardiovascular exercise, I'm just going to describe to you the contour of this study and what specifically was done so that you can best implement the best protocols for your particular circumstances. This was a study exploring why and how certain brain areas and brain volume
generally decreases as we age. It's well known, as I mentioned earlier, that individuals aged really 50 and older, and maybe as early as 30 and older, experience a decrease in brain volume with particular brain areas shrinking faster than others. But of course, there are other people that include the superagers that we talked about earlier and many, many other people who are not superagers who don't experience the same decrease in brain volume. So why is it that they maintain the same brain size that they did when they were younger or undergo less decrease in brain size? That's what the researchers for this study were initially interested in understanding.
And they did come to some really interesting conclusions about that, but they also came to some interesting conclusions that relate to today's discussion on tenacity and willpower.
This study involved having individuals who were 60 to 79 years old divided into one of two groups. One group did cardiovascular exercise, the other group did more calisthenics slash stretching type exercise. Both groups did one hour of exercise three times per week. The group that did cardiovascular
training initially started off by doing, and by the way, they just simply called it aerobic training, but this could be rowing on the rower. This could be running. This could be cycling. I think for sake of understanding application of tools and protocols, you would want to pick any kind of activity that you could do consistently without injuring yourself. That's what's really important. And that gets your heart rate elevated. They started off these individuals with relatively low intensity cardiovascular exercise for that hour, getting their heart rate up to about 50%

of their maximum heart rate, but very quickly had those individuals increase the intensity of those cardiovascular training sessions. So they were doing again, three one hour sessions per week, getting their heart rate up to about 75% of their maximum heart rate, sometimes a little less 60%, sometimes a little bit more, but in that general range. So for those of you that think about different zones of cardio, this is probably in the area of zone three, not quite zone two cardio, maybe zone three cardio, so where one can not carry out a conversation very easily, but where one is not completely gasping for air as one would if they went to their maximum heart rate
or near maximum heart rate. Okay, so three one hour episodes of cardiovascular training per week at a moderately high intensity. The other group simply doing calisthenics and stretching for the equivalent amount of time. And they had another group within the study that were much younger that did similar activities or no activity, simply as a control for the brain imaging data.
Now I'm summarizing the study with a fairly broad brush, both for sake of time. And of course, I'll provide a link to the study in the show note caption so you can access it and proves in more detail if you like. But I wouldn't be talking about this study if it were simply a study about cardiovascular training and brain volume. I'm talking about this study because the specific brain areas that maintained or in some cases increased in volume as a consequence of doing these three hours per week of moderate intensity cardiovascular training included, of course, the anterior mid-singulate cortex, that was actually the primary location in which the maintenance of brain volume was observed. And in some cases increases in brain volume were observed, right? This is a group of people who normally would be losing volume size of their anterior mid-singulate cortex, but for which three hours a week of moderate intensity cardiovascular training maintained the volume, the size of that anterior mid-singulate cortex. And in some cases increased the volume, the size of anterior mid-singulate cortex. And they also observed a maintenance or increase in the size of the anterior white matter tracts. Remember, T-R-A-C-T-S, I didn't spell that out before just to spell it out for fun, although that is the sort of thing that I would probably do. Those white matter tracts are the communication routes by which different brain areas communicate. And this anterior white matter tract that maintained size in the people that did cardiovascular training, as compared to those that simply did the calisthenics training and stretching, is the very white matter tracts that connects the two sides of the brain, the frontal lobes, that allows the anterior mid-singulate cortex on one side of the brain and the anterior mid-singulate cortex on the other side of the brain, as well as other brain structures to communicate with one another. So this is really spectacular. I mean, the authors of the study didn't embark on the study to find or even look for increases or maintenance in the volume of the anterior mid-singulate cortex and the communication routes in and out of the anterior mid-singulate cortex. It just so happened that cardiovascular training done three times per week for an hour at a time at moderate intensity increased the size of the anterior mid-singulate cortex. And as I mentioned, the white matter tracts, which allow information to go in and out of the anterior mid-singulate cortex. Now, we should all be asking ourselves, why would that be the case? I mean, somebody gets on a stationary bike in pedals or goes out on a road bike or runs. Is there something inherent to running or cycling or rowing or swimming or an aerobics class dancing, et cetera, that gets the heart rate up that directly feeds into the anterior mid-singulate cortex? After all, is the anterior mid-singulate cortex responsible for generating the activity of running or cycling or swimming? No. Rather, the interpretation is that

in order to engage in this one hour, three times per week set of sessions of cardiovascular training, they had to allocate resources. They had to get up out of a chair. They had to get off the couch. They had to say no to other potential obligations, social engagements, meals, et cetera, and get to these exercise classes or sessions that they did with others or alone. Now, an interesting and, in fact, important aspect of the study is that the compliance with this three hours per week of cardiovascular training was very high. 85% of individuals engaged in these sessions.
Across the six month period of the study, I should have mentioned that earlier, the study was carried out over the course of six months. They did not have the opportunity to do neuroimaging after, say, a week or two weeks. So they imaged these people's brains before and they imaged these people's brains after the six month period. It's anybody's guess as to whether or not they would have observed the same or maybe even greater increases at the one month interval, et cetera. We simply don't know. It was a great cost, both energetic and financial, to doing these kinds of studies. So they looked at a six month period. But setting all of that aside, this is a very important study in the context of today's discussion because what it means is that if we acknowledge that the anterior mid-singulate cortex and the volume of anterior mid-singulate cortex is related to one's ability to generate tenacity and willpower for any number of different endeavors, well, then having access to a tool or a protocol that can increase the size of one's anterior mid-singulate cortex is going to be extremely valuable. So what's the takeaway from this study? The takeaway from the study is not necessarily that you should be doing three one hour bouts of cardiovascular training per week for six months to maintain or increase the size of your anterior mid-singulate cortex. I do think that's the case if you're not already doing sufficient amounts of cardiovascular training and what constitutes sufficient amounts. Well, I think there's general agreement now, both between the material that I've covered in our foundational fitness protocol and in the series on exercise physiology with Dr. Andy Galpin and in various discussions with Dr. Peter Atia. The general agreement is that everyone should be getting somewhere between 150 to 200 minutes of so-called zone two low intensity cardiovascular exercise per week. But the results of this study really point to the idea that we should all be doing perhaps three hours, but certainly we should all be doing some form of physical exercise. But for any of us that are interested in increasing tenacity and willpower across domains, both for cognitive and physical endeavors, emotional endeavors too, for that matter, that we should be engaging in some exercise. And again, we're going to talk about cognitive exercise in a moment, but that we should be engaging in some exercise that we are not already doing. Now that, of course, will lead many people to think, wait, I'm already doing 200 minutes per week of zone two cardio. How can I add three hours more of cardio? That's not what I'm saying. What's important to understand about this whole discussion about tenacity and willpower is that the ability to engage the enter mid-singulate cortex and to build up its volume literally and increase its activity relies on one critical feature, which is that you have to be in some degree of resistance, some lack of desire, or I should say lack of reflexive desire or ability to engage in that behavior. This is super important if you're thinking about tools and protocols to increase your level of tenacity and willpower. If, for instance, you love cold showers and ice baths, well, then it's very unlikely that taking cold showers or getting into an ice bath is going to increase your level of tenacity and willpower further. It might reinforce the tenacity and willpower that you've already built, but it's not going to increase it further. You need to add something or subtract something that makes it harder, not easier to engage in or resist a behavior. I want to be

really clear about this in the study that I just described from Coleman colleagues. They took individuals that were not exercising prior to the study, and those people had to therefore generate significant amounts of motivation in order to regularly engage in these three one hour per week episodes of cardiovascular training. Now, the fact that there was no comparable increase in the volume of the enter mid-singulate cortex or enter white matter tracts in the group that did the calisthenics and stretching is also important because it implies that activities that are easier to carry out that don't get the heart rate elevated as much are not going to create changes in this brain structure that is associated with tenacity and willpower.
There's a nice confirmation of that in the study, in fact, because they observed, as one would expect, a significant increase in VO2 max in the individuals that were assigned to the group that did cardiovascular training, but they did not observe a significant increase in VO2 max in the individuals that did three one hour per week sessions of calisthenics and stretching across the six month period. The important point here is if you're already doing, let's say, an hour a week of moderate to high intensity cardiovascular training or resistance training, for that matter, you're going to need to add something in order to get further activation of this brain hub for tenacity and willpower. Of course, the idea here, or else we wouldn't be talking about it, is that that activation and that increase in volume in the anterior midsingulate cortex would then be applicable to other endeavors, for instance, academics or some aspect of your professional life or relationship life, that you can build up tenacity and willpower as a capacity within you, or we should say within your anterior midsingulate cortices, but that the route to activating and increasing the robustness of your anterior midsingulate cortex requires that you engage in something that you don't really want to do and certainly not something that you're regularly engaging in already. Remember way back at the beginning of today's episode, we compared willpower and tenacity to habit execution. Well, this is a simple case where if you're already doing something, simply continuing to do it might maintain what you've already got, but it's not going to further build up your tenacity and willpower. So along those lines, I don't want you to simply take the three one hour cardiovascular sessions per week protocol that they use within the study and expect it to increase your levels of tenacity and willpower, unless of course you're currently only doing one hour of cardiovascular training at moderate to high intensity per week, in which case increasing to two hours may very well increase your anterior midsingulate cortex and overall level tenacity and willpower. And certainly doing three hours per week would be expected to do it even further. And I should mention that we can extrapolate from this
study in a meaningful way, I think in a grounded way that's related to mechanism and say, well, if you for instance, like me can't play a musical instrument or are not bilingual in language that taking on the challenge, if indeed it's a challenge and for me it would be a challenge perhaps for you as well to learn an instrument as an adult or to learn a second or maybe a third language.
If that's challenging and in fact that's something that you're resisting doing, well, then great. It's going to provide an even greater opportunity to engage the activity of the anterior midsingulate cortex. Remember that study that showed that hard tasks, hard challenges are what activate the anterior midsingulate cortex. Easy challenges don't, okay? Habits that are reflexive simply do not. So you have to pick something hard. You have to pick something that's either physically and or psychologically hard. And of course we want to highlight the fact that you never want to engage in anything physical or cognitive, emotional or otherwise that is

psychologically or physically damaging to you, right? Because this is something that you're going to want to maintain or carry out for some period of time. Now along those lines, we could imagine a huge number of different protocols that one could engage in. But I think there are a couple of key things that extend across all of those opportunities. First of all, it's clear now based on our understanding of the anatomical inputs to the anterior midsingulate cortex that while exercise is great and certainly movement to the body when we don't want to move our body,
aka running, aka weightlifting, aka learning a new skill like dancing or gymnastics or something of that sort is going to engage this hub for tenacity and willpower the anterior midsingulate cortex. But there are a number of other opportunities to do that. And we can think of those in a kind of playful context, but one is both playful and highly functional and applicable. So for instance, if you already resistance train and you're doing what we now generally agree as a field is the minimum of six hard working sets per muscle group per week in order to maintain or build muscle size and strength. Some of you don't want to build muscle size, but everyone should be trying to maintain muscle strength. There's a very high correlation. We now know between muscle strength and cognitive function, especially as one gets past 40 years of age,
but even younger. So maintaining neuromuscular function and strength is very, very important. Even if you don't want to increase muscle size, you can learn how to do that, by the way. We have zero cost protocols. They're all listed out by going to hubermanlab.com. Check out the series I did with Dr. Andy Galpin. Check out the key toolkit takeaways from that series also available at hubermanlab.com. Just put exercise protocols into the search function. But let's say you're already resistance training, you're already doing cardiovascular training. What can you do to build up your tenacity and willpower for application in not just that endeavor, but other endeavors? Well, pick something that you don't want to do. These are what I call in a very non-scientific way micro sucks. These things suck, but they suck a little bit and they're safe, right? You have to pick things that are safe for you. But they suck enough that they require some effort. They require getting over some friction, engaging in something that you don't reflexively want to do. So for instance, that might be one extra set at the end of a round of three to five sets of a given exercise. Or it could be, for instance, 100 jumping jacks at the end of what you consider a hard run. It could be, for instance, finishing out that language lesson and then deciding to do five minutes of sitting still thinking about the material that you learned when you so desperately want to just jump on your phone, right? Pick circumstances where the degree of resistance is very high, where the degree of impulse to do something else than the thing that you know you need to do is very high and then start applying those on a regular basis. It could be after every workout. It could be in the middle of the workout. For instance, some people have a really hard time not looking at their phone during a workout. I like to listen to podcasts or music during a workout, but I really try and resist text messaging and reading email and things of that sort while working out. So the harder that becomes, the more I think about it and the more I resist it, the more presumably activation of the enter mid-singulate cortex I'm getting and that you would get as well. So these little micro sucks, like, ah, it sucks not to look at the phone right now. It sucks to do 100 jumping jacks at the end of a run. Of course, if you're excited to do the 100 jumping jacks at the end of the run, that's not going to be a good avenue into activating and increasing the volume of your enter mid-singulate cortex. Everything we've talked about up until now supports the statement I just made. Easy tasks, desirable tasks, don't do it. It's the thing you

don't want to do. So imparting these little micro sucks can be very useful. You'll have to think about what particular micro sucks you incorporate into your exercise routines, your cognitive routines,
and your daily routines and how often. I don't think you need to go completely berserk on this, doing them all day long, but keep in mind that these are the sorts of behaviors and resistance of behaviors because again, certain micro sucks might be, you know,
if you're somebody who practices intermittent fasting, you know, we don't want to send you into the realm of eating disorder, but you know, maybe you really do wait an extra 15 minutes before your usual first meal time, which for me would really suck. That might even move from micro suck into macro suck because I like to eat when I'm hungry, but waiting a few extra minutes for no other reason than allowing oneself to activate that enter mid-singulate cortex circuitry would be one way to try and build up one's tenacity and willpower. So at some level,
this should all seem pretty logical. It actually doesn't even require a firm understanding of the underlying neuroscience for it to make sense, right? You want to do something, you resist doing it, that's building up tenacity and willpower. You don't really want to do something, you do it,
that's building up tenacity and willpower. Well, I do believe in fact, there's a lot of data to support the fact that our understanding of the mechanisms underneath things like tenacity and willpower can be very advantageous when trying to carry out these different types of behaviors to increase tenacity and willpower. Why? Well, today we learned that there's a huge variety of contexts in which one can activate the enter mid-singulate cortex, which means that it's not cardiovascular exercise per se. It's not resisting the cookie per se, right? It's not waiting 15 more minutes to eat or making sure that you sit still and don't look at your phone at the end of a learning bout and really think about what you learned a little bit more. You know, it really, really sucks to do that. It's really hard. It creates a lot of agitation. It's not about any one of those protocols, if you will, per se. Rather, it's about deliberate engagement in the behaviors that we least want to do in a given moment. Or if you're trying to build up willpower and tenacity to not engage into certain types of behaviors, it's about our ability to suppress behavioral action. Now, I do want to highlight the potential hazards of this type of approach to building up tenacity and willpower and indeed to life. And we can call on the earlier example of eating disorders as a very salient one, right? There is a way in which all of this can run amuck
and we can get so heavily into stoicism, we can get so heavily into the idea of building up tenacity and willpower that it takes us into realms that are unhealthy for us psychologically,
emotionally, and or physically. And that's certainly not the goal here. And I certainly don't want to motivate that type of behavior or resistance of behavior. We should all be seeking a relationship with life and with goals, etc. That involves, yes, I believe some degree of activating tenacity and willpower, really finding that fight within us that Parvizian colleagues found when they stimulated the anterior midsingulate cortex of people, right? All of a sudden they're like, yep, I'm driving into a storm or there's something about to happen and I'm going to have to resist. I'm either going to have to do something or resist doing something, but there's something activated inside of me. I think it's very important that we are all able to garner those resources and to activate those states within us voluntarily. But I also know from experience and from observing
others and indeed from the literature on the anterior midsingulate cortex as it relates to eating disorders and other aspects of neurologic and psychiatric challenges,

is that we also need to learn how to turn that off. With that said, the little micro sucks that we discussed, you know, the addition of 100 jumping jacks at the end of a cardiovascular training session when you would much rather just shower up and go home, getting into the cold shower
or cold plunge when you absolutely don't want to do it. Well, provided you can do it safely, that's going to be the best time to do it. If your goal is to build up tenacity and willpower to say nothing else of the known benefits of things like deliberate cold exposure and exercise like jumping jacks, etc. There are also entire landscapes of life and academics and sport
that afford us the opportunity to build up tenacity and willpower. I, for instance, can recall taking my so called qualifying exams in graduate school where they ask you questions until you say I don't know until you don't know the answer. It's just like that puzzle in the Balmeister study. They're taking you to the point where you basically can't win. And that turns out to be a very important lesson that extends beyond the information that they're asking you about. And of course, every student at the end of their qualifying exam runs off and figures out the answer to the question that they couldn't get the right answer to. Sometimes there is a right answer. Sometimes they're not. If the committee is pretty diabolical, they'll give you an impossible to answer question because there's no answer. But the point being that whether or not it's in martial arts, whether or not it's in sports, whether or not it's in music, whether or not it's in academics, whether or not it's in relating to others, there is some value to getting to that point
where you can't solve the puzzle. And I think that's an important message for us to understand and maybe to incorporate into our tools and protocols that there are some endeavors that have no end point, right? There's no winning. There's no finish line. And those type of endeavors are extremely important, extremely important for continually building up our tenacity and willpower. So much so that we can even take a somewhat 3000 mile view from the top down onto everything we've
talked about today and think about those superagers, those superagers that somehow are able to maintain
the cognitive function of a much younger person. And if you look at the date on superagers and people similar to them, you'll find are always engaged in some activity that's hard for them. They're always trying to learn something and they have a sort of playfulness about it.
But they seek out those friction points, both resistance of certain behaviors, right? Trying to not do certain things, but perhaps more often doing certain things, learning a new skill, learning pottery, learning music, placing themselves into novel environments that are a little uncomfortable or a lot uncomfortable, provided that it's safe. So from that standpoint, one could even entertain the idea that because these people are living much longer than everybody else, in addition to maintaining the cognitive function of much younger individuals, that perhaps the inter mid-singulate cortex in its ability to allocate resources to different parts of our brain and body to meet certain motivational goals is actually associated with this thing that we call the will to live. Now the concept of the will to live is certainly getting a little bit squishy for scientists like me who, yes, I'm happy to entertain discussions that relate to psychological constructs such as tenacity and willpower. But as you've probably noticed, I'm very comfortable with and very excited about the idea that, okay, maybe it's related somehow to brain energetics and glucose, maybe not. Certainly I'm on board the idea that beliefs impact our physiology and physiology impacts our beliefs. I'll Dr. Ali Krum, who was a guest on this podcast previously,

talked about belief and mindset effects, which are very powerful. They change our physiology literally and the Dweck data that we talked about today. But of course, also that there are brain areas and circuits that underlie these things that we call tenacity and willpower. So when we get into a discussion about tenacity and willpower and then find ourselves as we are now talking about the will to live, I don't think it's going too far to say that when one looks at the data on longevity, both physical and psychological longevity, it's very clear that they're underlying physiological explanations, not the least of which is likely to be the maintenance if not growth over the lifespan of this anterior midsingulate cortex. But also that the people that are achieving that are continually forging in their environment. They're continually looking for new environments. They're continually exploring. They are not becoming complacent. They are not becoming sedentary. They're not existing down at that end of the continuum that we call apathy and depression, but that they're not existing down there. And they are existing up toward the end of the continuum that we call tenacity and willpower and engaging motivation to get there. Okay, motivation again as a verb. But in doing that, that they're reinforcing the very circuits that give rise to tenacity and willpower. This is what in engineering terms is referred to as a closed loop. It's like you do a, which leads to B, which leads to C, which feeds back on to a and makes a that much more likely to occur. It's like turning the little a into a capital A and then turning into a bold face capital underline a the buildup of neural circuits. So while today we focused a lot on an individual brain area anterior midsingulate cortex and in many ways I presented it as if it's the be all end all of tenacity and willpower. It is not the be all end all of tenacity and willpower. It's our ability to engage the anterior midsingulate cortex that allows us to express tenacity and willpower. But in this closed loop fashion, it's our ability to express tenacity and willpower that then feeds back onto that circuit and makes it more robust and more likely to be accessible in the future when we encounter something that we don't want to do or that we have to resist very strongly in order to not engage in some sort of behavior or thought pattern. So the big takeaway is that if you want to increase your tenacity and willpower, you absolutely can. You can do that by triggering activation of this incredible hub within the brain, the anterior midsingulate cortex for which there is now a very large amount of evidence is at least central to the whole process of generating tenacity and willpower. The I absolutely will do that and the no, I absolutely won't do that. It's the resistance hub. It's the thing that's allocating resources to do the thing that we don't want to do or that someone's trying to prevent us from doing. It's also the brain area that's allowing us to resist doing the thing that we want to do or that someone else wants to do when we decide that's not good for us. We can really be certain based on the psychology literature, based on the neuroscience literature, and really based on this beautiful literature that's now emerging that includes the column study, but some other studies as well that perhaps we'll
talk about in a future episode, that we really can build up our capacity for tenacity and willpower. It's a real thing. And as a final point to this, and indeed as a final protocol, I was very excited to look into the early release of peer reviewed papers out from Neuron just this last week and to see that there was a study, albeit in a preclinical model, in an animal model, that explored what is called stress relief as a natural resilience mechanism. And I won't go into this study in full detail, especially not now, laid into a slightly long episode, such as this one, but what the study showed is that when an animal is in a state of despair or a hedonia, a lack of pleasure, when it's under stress, and then that stress is removed, there's a sense of reward,

there's a sense of well-being that accompanies that release of stress. And that's pretty obvious. That's something that we've known about for a very long time. But what's interesting about this study, and they actually talk about this in terms of its applicability, potentially to humans, is that when we are able to withstand a stress, maybe that stress is school, maybe that stress is a particular relationship. Again, you never want to do these things in a way that's unhealthy or dangerous. But when we are able to do that, the relief that we feel afterwards is its own form of reward that serves to reinforce that whole process of tenacity and willpower that got us through the stressor. And an interesting thing about this study is that they went on to compound that reward. They showed that rewarding oneself or having gotten through a stressful episode actually serves to increase the capacity to get through stressful episodes in the future. In other words, if you decide to develop certain tools and protocols to increase your levels of tenacity and willpower, which frankly, I hope that you will at least consider, again, providing you do it safely, this seems like a very good thing to do for all of us, especially as we age. And guess what? We're all aging from the time we're born. If you decide to do that, pick something that's challenging, overcome that challenge. Again, this could be the requirement to engage in a particular behavior when you don't want to or to resist a particular behavior that you would otherwise want to engage in. But also, when you've successfully completed that resistance, when you've engaged that tenacity and willpower and you've activated that anterior mid-singulate cortex, well, then occasionally, not always, but occasionally providing yourself with a reward of something that you like. And here it's highly subjective. You'll just have to pick something that you like, again, something that's hopefully health promoting, not health diminishing, can serve to further reinforce the behavior that you just engaged in, which was to increase your tenacity and willpower. And if you listen to the episodes that I've done on dopamine motivation and drive or on dopamine more generally, you will know that I am not a fan of rewarding oneself for wins or for engaging to nasty or willpower for that matter on a regular basis or certainly every time. This is the sort of thing that just randomly every once in a while, when you've done the hard thing or if you've resisted the thing that was pulling on you, that you should reward yourself, but of course, reward yourself in healthy and safe ways.

For those of you that are interested in learning more about how to reward the actions of tenacity and willpower, I'll provide a link to the recently published paper in Neuron in the show note captions. I will also be doing a toolkit episode that relates to what we covered today as well as some additional tools gleaned from other papers and resources in the not too distant future. Thank you for joining me for today's discussion all about tenacity and willpower.

We talked about the idea gleaned from research in the field of psychology that tenacity and willpower are limited resources and that perhaps again, perhaps they relate to this concept of ego depletion that relates to this idea that what is depleted or what's limited in our ability to engage tenacity and willpower somehow relates to brain energetics and fuel consumption, namely glucose. I also talked about the conflicting data that argues that if we believe tenacity and willpower are limited and that glucose is the thing that limits them, well, then that's exactly what happens. So I talked about that controversy and some of the data that actually reconcile a bit of the differences there.

So in the absence of new data, you'll have to decide for yourself what you believe about tenacity and willpower. However, it's very important to acknowledge the universal truth, which is that our tenacity and willpower rides on the tide of autonomic function. That is when

we are sleep deprived, when we are in pain, when we are in emotional pain or when we are distracted,
our tenacity and willpower is diminished, which calls upon all of us to make sure that we're taking care of our autonomic functions through viewing morning sunlight, getting sufficient sleep, adequate nutrition, social connections, things that I've covered extensively on previous episodes. Then we talked about the neural underpinnings of tenacity and willpower and this absolutely incredible brain structure that we'll call a hub because it's not operating in isolation, but rather it's getting inputs from lots of different brain areas relate to reward, executive function, autonomic function, motor planning, goal seeking, et cetera, that we call the anterior mid-singulate cortex. This phenomenally interesting brain area that seems to be able to generate this thing that we call tenacity and willpower and that when we engage or express tenacity and willpower by doing the thing that we least want to do, by not doing the thing that we most want to do in a given moment, that we actually can build up our anterior mid-singulate cortex and thereby build up our future capacity to engage the anterior mid-singulate cortex when we need to call on tenacity and willpower. Then we talked about some of the peer-reviewed data that shows how that actually can be done where these individuals who were not previously exercising
did a challenging three one-hour sessions per week of cardiovascular training and indeed their anterior mid-singulate cortex and the connections to and away from it increased in a way that set them apart from their age-related cohorts. That is, their brains stayed younger, maybe even got younger, whereas those that did not do the hard thing that didn't engage tenacity and willpower did not experience the same effect. Then we talked about how those data could be extended into a number of different realms, such as cognitive learning, learning languages, learning math, learning art, learning any number of different things or in the physical realm, engaging in certain types of exercise that one is not already engaging in, adding in a little bit of additional exercise specifically at a time in which you least want to do that or extending your fasting period if that's something that you're doing and that you can do healthfully, simply because it allows you to exercise your anterior mid-singulate cortex,
aka tenacity and willpower. Of course, we highlighted that all of that needs to be done in the context of psychological and physical safety. We don't want anyone to do things that are going to be physically damaging to themselves, but if one simply takes the stance of, okay, what's something that I can do in a moment that will allow me to build up tenacity and willpower? Well, it's going to be the thing that I least want to do in that moment or the thing that I least want to resist doing in that moment. To periodically add in those little, what I referred to as micro-sucks, a very non-scientific, frankly, non-psychological term, but I think we all understand
what it means, little things that we don't want to do, but that if we do them, you can be sure that you are activating the anterior mid-singulate cortex and thereby increasing the probability, the likelihood that you can access tenacity and willpower more readily in the future.
So what I've done today is explain the scientific studies in the realm of psychology and neuroscience that explain what tenacity and willpower are and what allows us to build up our tenacity and willpower
over time. And then it's really up to all of us, to you and to me and everybody else, to figure out in which particular domains and with which frequency we're going to

decide to build up our tenacity and willpower. So it's clear that tenacity and willpower are not just resources that we need to call upon from time to time in order to overcome things, but that indeed calling on our ability and building up our ability for tenacity and willpower can allow us a much richer enjoyment of life and perhaps can even extend our life by engaging the will to live. Thank you for joining me for today's discussion about the science of tenacity and willpower and tools and protocols to increase one's ability to access tenacity and willpower. If you're learning from and or enjoying this podcast, please subscribe to our YouTube channel. That's a terrific zero cost way to support us. In addition, please subscribe to the podcast on both Spotify and Apple. And on both Spotify and Apple, you can leave us up to a five star review. If you have questions for me or comments about the podcast or topics or guests that you'd like me to cover on the Huberman Lab podcast, please put those in the comments section on YouTube. I do read all the comments. In addition, please check out the sponsors mentioned at the beginning and throughout today's episode. That's the best way to support this podcast. Not on today's episode, but on many previous episodes of the Huberman Lab podcast, we discuss supplements. While supplements aren't necessary for everybody, many people derive tremendous benefit from them for things like improving sleep, for hormone support, and for focus. To see the supplements discussed on the Huberman Lab podcast, go to livemomentus spelled O-U-S. So it's livemomentus.com slash Huberman. If you're not already following me on social media, you can do so by going to Huberman Lab on all social media platforms. So that's Instagram, Twitter, now called X, LinkedIn, Facebook, and Threads. On all of those platforms, I cover science and science related tools, some of which overlaps with the content of the Huberman Lab podcast, but much of which is distinct from the content covered on the Huberman Lab podcast. Again, that's Huberman Lab on all social media platforms. If you haven't already subscribed to our neural network newsletter, the neural network newsletter is a zero cost monthly newsletter that includes podcast summaries as well as tool kits. So tool kits for sleep, tool kits for learning and plasticity, tool kits related to dopamine regulation, and much more. Again, it's all zero cost. You simply go to hubermanlab.com, go to the menu tab, scroll down to newsletter, and simply enter your email, and we do not share your email with anybody. Thank you once again for joining me for today's discussion about tenacity and willpower. And last but certainly not least, thank you for your interest in science.