Announcer: Bulletproof Radio: The State of High Performance.

Dave: You're listening to Bulletproof Radio with Dave Asprey. Today's guest is Anil Seth. He's a leading researcher, writer and public speaker on consciousness, science, neuroscience and artificial intelligence, and he's really good at communicating these new ideas at the very cutting edge research in those areas, which are some of the things as biohackers and as people interested in controlling our own biology thinks we really need to understand. He's a professor of cognitive and computational neuroscience at the University of Sussex and founding co-director of the Sackler Center for Consciousness Science, and he's working in understanding the biological basis of consciousness by bringing together neuroscience, math, AI, computer science, psychology, philosophy, and psychiatry.

Dave: Anytime you see someone bringing together a bunch of disparate fields like this around solving a problem, they always come up with new and interesting stuff, which is why biohacking, it got added to the dictionary because same idea, bringing together these fields that didn't talk to each other. That is exactly why I want to have Anil on the show today. Anil, welcome to the show.

Anil: Thanks for having me. It's a pleasure.

Dave: Your TEDtalk in 2017 about how your brain hallucinates your conscious reality went nuts and has 7.4 million views. Did you expect that when you went on stage at TED?

Anil: Definitely not. When I went on stage, I was just worried about getting through it without forgetting what I was going to say and getting this whole terrifying experience behind me. I don't think anybody really expects their video to be viewed that many times. So it was definitely a surprise, a very pleasant one.

Dave: I can tell you that the video of me with this giant beard making Bulletproof Coffee has about 2 million views and that took four years. So I got to say you kicked my butt there, and neither one of us today has a weird, bushy beard. But what did you mean when you said your brain hallucinates your conscious reality? Epic title, by the way, but what's the gist of that?

Anil: Well, the title is funny because actually one thing I didn't know in advance, but the title of the TEDtalk is about the only thing that you don't get to choose yourself. So that wasn't my title. And it can be misunderstood because one way people have misunderstood it is as something that ... we just make everything up, that there's no objective reality out there and that everything is just the product of the mind. That's not what I'm saying at all. If you go and stand in front of a bus, you'll know it. It's not just a figment of your imagination. And yeah, a few people advise me to try that because they disagreed with what I was saying. I'm not saying that.

Anil: What I mean is that ... it goes back to this old philosophical idea of the distinction between appearance and reality. So let's just assume there is a real world out there. That's really a question for physicists rather than for neuroscientists like me. We

certainly perceive that there is a world out there, and we perceive the things within that world to be real. So when I look outside of a window and I see blue sky or clouds, because I'm in England, these things seem to really exist, like the tree outside the window also seems to exist. It seems to have a particular color.

Anil: But then we know for instance, colors, colors don't exist as colors out there in the world. All that's out there in the world is electromagnetic radiation of various sorts, who knows what else. But there's certainly nothing that is actually red or green out there in the world. We've known this since Newton. The brain is inventing colors from combinations of wavelengths. So color is a sort of perceptual construction. And I think that same thing goes for everything that we perceive, not just colors, for all the attributes of the world that we experience around us and critically for how we experience ourselves through the experience of being me or being you. That's also a construction.

Anil: Now, the reason we use the word hallucination is because people typically think of hallucination as something very different from normal perception, that if you're having a hallucination, you're really perceiving something that isn't that. The point I'm trying to make ... and I'm sure we'll get onto this in more detail, is that there's really the same process going on. The same things in your brain are happening when you're having a hallucination, perceiving something that other people don't, as when you engage in normal perception. It's just some aspects of the balance has changed.

Dave: There's some pretty clear neuroscience evidence that the brain is a really good pattern matching system and pattern filtering system. So there's multiple layers of the prefrontal cortex and they filter out stuff that you expect to be there that is there so you don't have to pay any attention to it, but you don't really perceive it. The famous study with the gorilla in the middle of the basketball court that people don't see, et cetera, et cetera. So that would make sense there because we're filtering out a bunch of stuff that is in reality that we don't perceive and then therefore selectively choosing to perceive some things, not others. Is that that accurate?

Anil: I think that's half right. And it's very tempting to think of this idea of filtering out, that there's this hugely rich world of stuff out there and ... we know that we can only attend to one part of that hugely rich environment. In fact, when we think about vision, again, one of the most striking things about vision is that when we open our eyes, we seem to have this experience of a rich and detailed colored world that completely surrounds us. But we know that we only have high resolution vision and a very small part of our visual field and color vision is also quite constrained to certain parts of the visual field.

Anil: So this idea of filtering seems natural, but where I think it's not quite correct is it still assumes that perception and vision and whatever modality is a process that comes from the outside in. That there's this real world that's got all this stuff, and that we just select among that stuff some subset and that's what we perceive. What I think is wrong about that is that perception doesn't come from the outside in. It really goes the other direction. It comes from the inside out.

Anil: So again, back to this simple example of colors, colors aren't there in the real world, in the first place. The brain is projecting colors into our perception as a way of interpreting what's happening in the world. So it's not really a question of filtering out some stuff and leaving the rest. Certainly, the brain is selective about what signals it responds to in the world, but what ends up populating our conscious experiences, what ends up forming our perceptions is not simply a process of selection. It's an active process of construction.

Dave: So, something makes it through our filter, and then our brain gives it a look, a feel, a taste. And we know this to be true because of things like synesthesia, the people who can smell a color or taste a sound and things like that. So it is possible for something to be perceived differently by two people. Or the tetrachromats, people who can see more color spectrum than others. They're seeing the same thing, but one say that's a different shade of orange than the other, and the other swears it's not and they're both right from their perception.

Anil: That's absolutely right. And I think this is actually one of the most important implications of this way of thinking, because yeah, indeed. Synesthetes, tetrachromats, good examples of people who when faced with the same objective world out there will have different experiences. And there's also famous examples in the effect of language for instance, that certain cultures, Russian, I believe, will be able to distinguish perceptually more shades of blue than non-Russian speakers-

Dave: Whoa.

Anil: ... because language carves up the sensory world in some more bits, if you like. So the biggest message from all this is that we likely all see the world differently, but that somehow ... and of course, communication in society depends on, to some extent, ignoring those differences, assuming they don't exist and agreeing on some sort of consensus interpretation so that when we both point at a red mark, we both agree, well that's a red mark, even though we might be having slightly different experiences when we look at that red mark.

Dave: What's the useful implication of this? So you and I are sitting here, we may be looking at the same electromagnetic smog. I'm experiencing it as espresso with brain octane in it and you are experiencing it entirely differently. You're doing your own thing, but how does this impact what I'm going to do all day, the way I interact with you? I'm not sure that there's so what here. Is there?

Anil: There is. I have to front up and say from my point of view, I've just been interested in this because of the nature of the question, how we come to experience the world in the south is just ... there doesn't have to be a so what. It's just fascinating. Who am I, and how do I perceive the world in the way that I do? Just fundamental questions. But that are implications as well. And these implications really do arise from the fact ... or the implication that each of us can perceive the world differently from each other and that we can ourselves perceive the world differently at different times of our lives.

Anil: And we also notice through, for instance, mental illness in psychiatry, so a lot of the symptoms of mental illness. And a certain psychiatric syndromes, conditions are expressed through changes in perception. We perceive the world differently or we perceive ourselves differently. So understanding how these perceptions are constructed by the brain and the body gives us a route to understanding what's happening in these psychiatric conditions and then coming up potentially with diagnosis and treatments.

Anil: But there's also the positive side, which is that we can train ourselves maybe to perceive the world differently than we do now to optimize our perceptions, perhaps. And also in recognizing that we do perceive the world differently from each other, I think that opens a space for cultivating a greater understanding in situations where people disagree about stuff. I live in England, and for the last three years, there's been this credible debate about whether we should remain part of the EU or not.

Anil: And I think this is a good example of the most socially contextualized extension of what I'm talking about. Everybody's in the same country. We're all faced with the same data broadly though we can get back to that. But people see the same situation in radically different ways, and there that doesn't seem to be any consensus or any space for consensus. I think understanding how we can come to different perceptual conclusions based on roughly the same data is a good way to open up space for consensus.

Dave: It also opens up the way for hacking, for lack of a better word here, because both the US elections and Brexit were influenced by Cambridge Analytica, which used machine learning, artificial intelligence, big data sets and basically consciousness research or psychiatric profiling, whatever you want to call it, in order to determine the messages that would work for different people in order to influence their perception of a set of events. So I would look at that as classical hacking, very elegantly done. Not necessarily for the greatest good, but elegantly done nonetheless.

Dave: Is this stuff you're working on? Given that you're one of the few guys who has enough of a diverse thing, where you're including computer science, you're including the psychology and the AI. Do you think that we're going to get to the point in your lifetime where we can train someone to perceive a color differently or to perceive a situation very differently than they do today using tech?

Anil: Well, actually you've raised a couple of big issues, going from the mind hacking of Cambridge Analytica, down to this very concrete idea of training somebody to see colors differently. And actually, for that last point, we can already do that.

Dave: Yeah. I know.

Anil: And this example of synesthesia that you brought up earlier, we've been interested with other of my colleagues at Sussex, Jamie Ward in particular, in synesthesia, because it's so interesting with respect to consciousness. People are having different experiences. And there's been a long standing question about whether you can train non synesthetes to have synesthetic experiences.

Dave: You have to be able to. Can you? It just seems so obvious, but I could be wrong.

Anil: I'm interested why you think it's obvious. For most people, I think they would have said it's not obvious that you can, because perception is for most people, something that seems so closely tied to the way the world is. We experience the way the world is as the way the world actually is. So if I told you it'd be easy to train yourself so that you would perceive the blue sky is green, you'd probably say, "Well, that doesn't make sense because the sky is blue."

Anil: So it's, I think, counterintuitive for a lot of people that perception can be trained because they experience that perception as this direct reflection of reality. And if it's a direct reflection of reality, well, there's no space for it to be different than it is. But of course, yes, you're right, we can train it-

Dave: We can. Okay.

Anil: ... but the previous attempts to do this had not succeeded. And the reason they hadn't succeeded as simply, well, I think, because they hadn't been extensive enough. I was going to say they hadn't tried hard enough, but that sentence a bit too much with [inaudible 00:14:59]. I don't mean they didn't really try. It's just that within the constraints of what you can do in a lab, they didn't have long enough experiments, long enough training protocols. In our first experiment, we had volunteers come into the lab for half an hour a day every day for five days a week for nine weeks. And that's quite a logistical challenge for any lab, and it ate up all our resources for a long time. But turns out that's the sort of thing you need in order to get somebody who sees text, Justin, the color that it is to start seeing a black letter K as red. That's what you need. You need to really hammer that association in.

Dave: That is so incredibly cool. Look, that's installing a software upgrade or a superpower. Your ability to perceive the world differently than someone else is pretty neat. The reason that I thought it was obvious you could do that is that I've spent a good amount of time doing neurofeedback to achieve advanced states of Zen mastery. I started a company that does that for executives. Four months with electrodes glued to my head doing advanced meditation. And I just learned that my powers of self-deception are so incredibly strong that many of the things that I used to believe to be absolutely true were in fact false and based on my own biases.

Dave: And by editing out my ... we'll call them poorly constructed patterns, I was able to see the world more clearly and be a lot less reactive to it, so that I was actually happier and higher performing. And based on that experience and having more than the average amount of EEG knowledge, I know what you can do with feedback. I also did this thing called ... it was a long time ago now, like maybe eight, nine years ago, this thing called the North Pole. And for six weeks, I wore a tracking bracelet on my ankle that would vibrate in whichever direction was true north because I have no sense of direction.

Dave: And after a while, before the solder broke, because I didn't solder it very well, for a little while there, it merged with my nervous system. I stopped noticing the vibrating, I just

knew which way north was. And I know that my brain could pick that up. So those two things made me think, it seems obvious, you neuroscientists, guys with laboratories instead of soldering irons in Victoria, BC, you have to have done something cooler. But I am not a synesthete. I have not trained that. I just know that you can do a little bit of plugging into the nervous system. What's the coolest thing you've ever taught someone to do they couldn't do in this field?

Anil: I would have to say it's probably this synesthesia for example. We're not generally doing a lot of these cognitive training experiments, but we wanted to focus on Synesthesia, because it's so immediate, because it really does change your visual experience. And it also gave us something to look at in the brain. So, we know for instance, there are certain characteristics, the level of neurophysiology that distinguish natural synesthetes from non-synesthetes. One of these for instance, is that the visual cortex is more, we like to call it excitable. So basically you can ... how ready are the neurons in your visual brain likely to fire? They're just buzzing around.

Anil: And the way we assess that as we give a little electrical impulse to the visual cortex using something called transcranial magnetic stimulation, which is a way of injecting energy-

Dave: Love it.

Anil: ... and then we measure the echo, the response to that. So what you can do is if the brain is more excitable, then you see a larger response to this perturbation, to this little pulse.

Dave: Is that part of the-

Anil: No.

Dave: ... training? Is actually-

Anil: It's not part of the training. This is just a way to test pre and post training. It's one thing to establish that yes, they're self-reported experiences changed, but then being good scientists, we want to also try and correlate those changes in self-reported experience to changes in behavior, and then also ideally, to changes at the level of the brain. And in this study, when we trained synesthesia, I would say since we talked about it, what I wanted to mention, it was a study really led and run by my colleagues and post docs in the lab at the time, Nick Rothan and Dan Bore and David Schwartzman.

Anil: What we really wanted to see was, could we observe changes in the brain as a result of these training paradigms that explain the changes in experience that people reported? And we were able to do that, which was quite exciting.

Dave: I would imagine ... and I know no academic would probably want to do this because it introduces more variables, but when I'm doing heavy duty neurofeedback training, I take everything that I know will raise nerve growth factor or BDNF, brain derived

neurotropic factor. For people listening who've read my Headstrong book, you know those are compounds your brain makes that makes you more neuroplastic. But I find that during training, if you can increase those with supplements or magnetic signals or electrical signals, the training sticks faster. What if you could take your nine weeks down to four weeks in order to save money in the lab? Or would that pollute it?

Anil: I suppose it's possible. Actually, we did a follow up study because ... in fact, the nine week study we did, we did test people midway through, after four and a half weeks or five weeks and basically, most of the changes had already taken place.

Dave: Wow.

Anil: So the next study we just limited to five weeks and we got pretty much the same results. So maybe you can go even lower than maybe you could combine with other things. Lots of possibilities. Of course, the problem is that to systematically test and control for all these possible ways of enhancing and training or boosting it. [crosstalk 00:21:07]. You're right. It's very, very difficult to do.

Dave: How many hours a day were these people training?

Anil: To me, this is the surprising thing about it. Even though it sounds like a lot, it wasn't that much time. So they were training typically for half an hour a day. They would also have some homework to do each day. There was to be something like reading a piece of text where the letters were colored with the colors that we were trying to train. And then as the training progressed ... so the important thing about the training here was that it had to be adaptive. So we made the training harder and harder and harder as the time progressed, both to keep people's interest, but also just to more deeply embed these associations.

Anil: So for instance, in this reading thing, we started where people were given text with the letters just colored ink, but then over the course of the training, we gradually replaced the letters with just colored blocks.

Dave: Wow.

Anil: So by the end of it, people ... I don't remember exactly what proportion of the letters were replaced by colored blocks, but if I looked at that piece of text, I wouldn't be able to read it because it was mainly just blocks of color. But the people who had been trained by that time, they've been taken up to that level, so they now could read this text so that all the tasks are adaptive like that. But people were typically trading for half an hour a day for five days a week, and then doing something like this reading exercise at home in the evenings.

Dave: Wow.

Anil: And I'm surprised because it's actually ... if you think about it, we're managing to overcome a whole lifetime of not receiving letters in other colors. And the fact that we

can change something that quickly, which still seems quite effortful, but actually it's not that effortful, is really surprising. Now, there's a couple of caveats I really want to mention. First is I don't ... we call it synesthesia-like experiences, because of course, where we started, it's pretty impossible for me to know what your experience of the world is like, so I can't claim that the result of this training is exactly the same as somebody with synesthesia and how they would see the world.

Anil: And of course, even within synesthesia, there's a huge variety of vividness, of experience and have other characteristics. So, we're not claiming turn people literally into synesthetes this way. So that's an important caveat. And we focused on colored letters because I think there's something quite open about letters and reading, because of course, the brain did not evolve specific circuits for reading. Reading is a relatively recent cultural invention. So whatever the parts of our brain that are involved in reading, they're already expropriated from some other functions. So the suspicion there is that the part of our brain involved in processing and understanding letters is going to perhaps be more open to change than other parts of our brain.

Dave: I feel like of the quarter million people who will hear this episode in the first few weeks, at least a hundred of them right now are sketching out plans to train themselves to have some new ability in a half hour a day, and there will be open source software available to do this within nine months, and there'll be a whole community of people turning themselves to do all sorts of stuff. And I got to say, if you're someone who decides to do that, let me know because I'll probably want to play with it because it's awesome.

Dave: And if this sounds too weird, here's an example that may connect with people about this. I was just coming to realize as you talked about this. So I used to weigh 300 pounds, and I used to look at things like French fries or junk food, basically, candy bars, whatever, as food. And I would perceive them as food, and I would see them, and I'd salivate, and I'd get hungry and I'd have cravings. And after a few years of eating in a way that made me feel really good, I stopped perceiving them as actual food items. And someone said, "Oh, just turn up the street past ...," whatever the fast food restaurant was.

Dave: I had no idea where the fast food restaurant was. And they said, "What do you mean? You drive past that place every day?" I said, "Yeah, but I don't see it because it has no utility in my life." You wouldn't go there to eat, they don't have food. There's nothing of value there. And so I literally had to go to Google to figure out where the local fast food joint was, because I just didn't perceive it. It was not in my memory. And certainly, if I tried to perceive it, I could. I do know that my perception of the things that I would look for in the environment around me has shifted dramatically. Something happened in my brain there. So if that's happening in your brain, it's not that big of a stretch to think that what Anil's talking about here is possible, plus they showed it in the lab, it's possible.

Anil: That example is really helpful, actually, because it brings up something that I wanted to mention earlier when we were talking about ... when we touched on Cambridge Analytica and the way we perceive differences in society, which is as humans, we don't just passively experience a stream of sensory information. We're always actively

sampling our worlds. We're deciding where to look, we're deciding what to pay attention to within our visual field. And of course, if we're looking for news online, we choose the media sources that we find out about the world from. In perception, in neuroscience, we call this active perception or active inference, active sampling, this idea that we're not just passive recipients of a waterfall of sensory information.

Anil: And this is a major driver in how we can come to perceive things differently. Whether it's ourselves through training or whether it's how different people can perceive the same thing differently, because even if it's the same objective world, yes, they can have exactly the same sensory data and come to different perceptual conclusions about it, but also, on top of that, they're not going to be sampling the same world in the same way. They're going to be sampling different parts of it. And as they do that, you can build up these reinforcing circles, but that entrench different kinds of perceptions and different kinds of beliefs.

Anil: So in the US, it's no surprise that somebody who watches Fox News is going to have certain political viewpoints reinforced as compared to someone who watches CNN can have other kinds of political beliefs reinforced. Same thing with Brexit over here. But same thing, just as we walk around the world, your example now is beautiful, about fast food restaurants. They're not useful to you, so you don't perceive them and you don't even really look for them. So when you're doing this filtering step of perception, you're not directing your eyes or your attention to these aspects of the world that would be available were you to focus on them.

Anil: So you're sampling the world differently, and then you construct a different kind of perception of the food related ... through the food lens of your world is now different from your previous food lens of the world where these fast food restaurants were highly salient entities.

Dave: It is blowing my mind here, just thinking about what could I consciously train myself to perceive that would be most useful in order to just make me a more effective human being. If you have the ability to train your brain to see something you don't see today or to see something differently, what would you pick?

Anil: This is a very good question. I think I would probably pick perceiving my own internal state. It might sound a bit of an obtuse answer, but this is, I think-

Dave: No, that's a great answer. Tell me more.

Anil: It goes back to this idea that did I mentioned at the top of this interview, that the experience of being yourself, the experience of being me rather than you. Anybody has the experience of being somebody, that's a perception. That's not the recipient of perceptions, the self, the way I experience being Anil Seth is a perceptual construction. I perceive my body as a particular object in the world with a configuration and a color, a size, a shape, and I perceive it as mine and is different from objects that I might hold. I perceive myself as an identity over time with a particular set of memories. When I make an action, I perceive it as a voluntary action.

Anil: And of course, perhaps more fundamentally, when I experienced in motions, they're also perceptions of bodily states, changes in our physiology. This is a very old tradition in psychology that goes back to William James in the 19th century [inaudible 00:30:26]. But they come out in modern neuroscience in the same way that we begin to think about perception of the outside world. And motion is an inference, a best guess about what's going on inside the body. And the purpose of perceiving the body is not always to get an accurate picture of what it's like. I don't really care what my blood pressure is numerically. I just want to make sure that I'm going to stay alive.

Anil: So emotions, I think, reflect a perception of how well the body is doing at regulating its physiology in a way that it's adaptive and that's useful. And when that goes wrong, that's when a lot of anxiety, depression, other perhaps aversive states, but that can shade into psychiatric illness at the extremes come into play. So if I could train myself to perceive not necessarily more accurately, but if I could train my perception in a way that's useful, I think training my perception of the body would be best. And of course, that's what a lot of meditation in fact, is about.

Dave: One of the things that really blew my mind on my path and in addition to neurofeedback, which trains you to perceive some things in the brain, before I got as heavily into that as I am, I started doing heart rate variability feedback training so I could learn to perceive the state of my fight or flight arousal. And I had no idea that I had it pretty much pegged all the way into fight or flight all the time. But learning how to perceive a shift from one state to another, that was invisible to me.

Dave: It blew my mind, and it really made me more aware of what the world around me was doing to my body. And you could say that is my perception. My body was perceiving it as a threat even though it's just the world, and I was able to notice the shifts and then make changes. And so there is a straight up bodily awareness function that's relatively easy to train. Is that something you play within the lab, the heart rate variability stuff?

Anil: We look at it, certainly. We have not done too much in a way of training of heart rate variability per se. I work very closely with colleagues at the medical school here. Hugo Critchley, Sarah Garfinkel, who's done a lot of work over the years, looking at how well people can perceive heartbeat, a heartbeat to one very, very salient signature of internal physiology. And we differ in how well we can perceive our heartbeats, both between individuals and within individuals across time.

Anil: And heartbeat detection does seem to be something you can train, although we have to be very careful about whether we're training that ability specifically or just training people to be generally good at a perceptual task which involves time. There's always these worries about specificity and potential confound. One thing you said, which I think is really important, is just this emphasis on feedback. And one of the lessons that you've obviously learned in your own journey and one of the lessons that's very, very prominent in neurosciences, how powerful feedback really is.

Anil: And the brain in some sense is a machine that's for prediction, and it tunes its predictions based on feedback. We can think of sensory signals as not just telling us the

way the world is, but as providing feedback based on our current best guess about what's out there. And anytime you can give the brain a feedback signal to work with, it seems to become much more possible to train ourselves to control the source of that signal. Whether its heartbeat variability, whether it's the firing of an individual neuron, even. That can be trained through feedback.

Dave: It's actually frightening. One of the reasons that I ... when I opened The 40 Years of Zen, neuroscience thing that I do, one of the big reasons ... I wanted a neuroscientist I could work with on my own brain. But I bought clinical grade gear at to use at home many years ago. And I learned pretty quickly from just reading the papers and all, you can take a perfectly healthy brain, give it a bad neurofeedback signal, and you can turn on PTSD in someone who doesn't have PTSD. You could really mess up someone's brain with bad neurofeedback because you can train neurons to fire that have no business firing in a certain pattern, and you can scrabble things. And I realized that-

Anil: That's why we have ethics-

Dave: Exactly.

Anil: ... to prevent people from doing stuff like this.

Dave: Exactly. And so I realized pretty soon that doing brain surgery on yourself was maybe not a good idea, and you might want to work with a professional, which is the risk of being a hacker of yourself, in that if you don't have adequate safety things in your own protocols, you could hurt yourself. Then again, if you have a skateboard ramp, you could also hurt yourself. So, there are risks in everything we do, and I'm not sure the risks are particularly higher in this stuff than they are in a lot of common activities that people do on a daily basis.

Dave: The power of feedback, if you can take a healthy brain and two hours of bad feedback and make someone less than they were before or less capable or less aware, less whatever else, what you're dealing with is a tool of great power that could be used for good or bad. I love it, the way you guys are really getting into a feedback and just this kind of training. It's opening perceptives for me. You talked about something called deep dreaming. Can you talk about what that is for you?

Anil: Sure. Deep dreaming is ... actually, it's an algorithm that the folks at Google invented a few years ago that we've been using in a different context. The best way to explain it is that there are now plenty of machine learning algorithms that are very, very good at classifying images. They can take any number, have been trained on millions or tens of millions of photos that have been uploaded to the Google database in the sky. And with that huge dataset and these neural networks, so called deep convolutional neural networks, which basically are just lots of layers of artificial neurons, these can be trained to classify images. Is there a dog there are not a dog? What kind of dog? And so on.

Anil: The performance of these algorithms is now extremely good, human level or superhuman level in some instances. What was difficult to know is what's actually going

on within these networks while they're doing this. And so what the people at Google decided to do was basically run them backwards. Take a network that's working, fix it at the top level, basically tell the network there is a dog there, then run the network backwards and have it update the image bit by bit until it settles into a steady state where what the images and what you're telling the network is there all match up. And you can then look at what happens.

Anil: And this is when you start to see really strange things. A lot of these images float around the internet at the time with bowls of pasta suddenly sprouting dog heads and just weird stuff happening in what looks like, to be honest, quite a psychedelic eruption of imagery through this Google deep dream algorithm. And what we got interested in was the extent to which we could consider this as an interesting model of unusual perceptual state, because the deep networks that underlie this process are. You can think of these very simplified models of how the brain does vision. It's a bunch of neurons and information goes from one end to the other.

Anil: So we used the deep dream algorithm and instead of just taking a single photo there, what we did was we took a panoramic video and then we put each frame of the video through this process and did some continuity and whatnot, so that when you put it in virtual reality headset on, you can look around this scene and you perceive it through this deep dreaming process. So suddenly what was just as if you were the middle of our university campus looking around and seeing people grabbing their lunch. Suddenly, the scene has changed and it's as if there are dogs coming out of everywhere.

Anil: And the reason this is interesting is because I think it gives us a way of understanding this balance between sensory data coming in and our prior expectations going the other way that through their interaction form, what we perceive. And another good example of this is when we look up a cloudy sky, lots of little white fluffy clouds, we can sometimes see faces in these clouds. As you said earlier, the brain is extraordinarily good at pattern recognition. One of the patterns it's especially good at recognizing is faces. If you follow that, I think, the Twitter thread faces and things, it's brilliant.

Anil: We see faces and pretty much anything because the brain is always projecting this, if you'd like, a face template onto whatever sensory signals are coming in. And you can understand hallucination and you can understand maybe psychedelic perception and you can understand this deep dream thing as just turning the dial so that these patterns for faces or dogs or whatever just become stronger. So we start to impose these patterns on things that we wouldn't normally do. And for me, that's a really good lesson into how perception works all the time. And also how it works in unusual circumstances like hallucination, like psychedelia.

Dave: You work in the field of psychiatry as well, and I think that if I wore virtual reality goggles for a week nonstop, that were running the deep dreaming algorithms, you'd be flirting with madness. You'd see all this stuff around you that isn't there. You'd be able to function. And I look at some of the most impressive and interesting art out there, where there's all sorts of images in bedded in things, and you look at it and you're like, "What was going on?" And then you find out that the artist was pretty much deranged on some

level or another. What happens when people put on these VR goggles, seeing the world through one of these AI filters?

Anil: The honest answer is we don't know. There's always a worry about the long term. We know over 10 minutes is not a lot. We don't tend to do these things for very long-

Dave: Not much, yeah.

Anil: ... mostly because we don't need to do it for more than 10 minutes to get some idea of how they're perceiving things. Also, just in VR, people tend to feel a little bit nauseous if they're goggles for far too long, just technical things like that. But the bigger question is indeed if people are manipulating the way they perceive things systematically and for extended periods of time, what happens? And we were talking earlier about this cognitive training paradigm, but even there, that's just isolated at the size of half an hour a day when people are doing particular tasks. We're not changing the way they perceive everything throughout their whole waking life. And that's something that that isn't done very often.

Anil: You mentioned you were wearing this magnet or something like a magnet that was giving you a sense of north.

Dave: It was a vibrating cell phone motor. It would just vibrate whichever way was north.

Anil: That's fantastic. I heard that Oliver Sacks used to do something similar. I don't know if you heard this, that apparently he used to walk around with a bunch of magnets in his pockets that was so arranged-

Dave: Oh wow.

Anil: ... that it would line up and always give them a sense of where north was.

Dave: Interesting.

Anil: He used to walk around New York with these magnets in his pockets. I quite like that idea. There is a wonderful tradition actually, of individual people just doing stuff like this, some of these early 20th century psychologists. There's a guy whose name I can't remember off top of my head, but he was very interested in perceptual adaptation, so he'd would wear these goggles, these inverting goggles, basically like a 45 degree mirror. And you put those on, and then the world flips upside down, and you can no longer do anything. You try and pick up a cup of tea and you pour it all over yourself because you automatically adjust to your perception. And of course, your perception is now inverted.

Anil: The idea is if you wear them long enough, your perception will invert and become the right way up, and you'll be able to behave normally. And there are these wonderful videos from the 1940s, I think, of people doing ridiculous things like skiing and fencing, wearing these inverting goggles-

Dave: Wow.

Anil: ... and managing to do it. But they have the before and after videos. The before videos is some of the funniest things I've ever seen, I think. It's like somebody tries to stab somebody in a fencing thing, and the other guy just lifts his arm completely out of the way because that's what you would do if you see things upside down. So, there's a lot of questions to be asked actually, about what the long-term implications are of changing the way you might perceive the world. I think one of the lessons these earlier studies was that if, for instance, you wore these inverting goggles for a while, after a few days or after a couple of weeks, I don't know how long it took, people would be able to function and would perceive the world the right way up again. But then you take the goggles off and suddenly now they couldn't function.

Dave: I think it was a couple of weeks if I remember right, because this is one of those things, if you don't think your brain is neuroplastic and you read about these studies, it has to be.

Anil: Yeah. It is. It is. It is. But what was interesting though was the recovery period was much shorter than the initial training period. So it might have taken a couple of weeks to train people to perceive things the right way when they're wearing the goggles, but when they took the goggles off, it didn't take two weeks for them to recover, to restore to that normal pre goggle situation. So there is a lot of plasticity, but there's this ... I think there's a tendency to for the brain to return to old entrenched patterns once you take the training away.

Dave: I want to get your neuroscience take on a couple of different perception exercises that just stand out in my own self experiments. One time a while ago, I was at a yoga retreat at Yosemite National Park, and I'm standing on a stone at near the edge of a cliff and doing a one legged standing pose. Now, normally when you're going to stand, you lose your balance, so you pick a fixed point in front of you on the floor about five feet away. But for me, the nearest fixed point was a half a mile away, and it was half dome. And I felt this really weird experience where all of a sudden my perception of reality around me got really big because my fixed point was no longer in my local area.

Dave: In fact, it inspired me so much. I have a 28 foot tall tree that we topped in my backyard with a ladder going up. And so I can stand on the top of the tree on one leg wearing a climbing harness so I won't die in case I fall, and look out at the island across the way. And I can stand on one leg and my perception of the world is so different than it normally would be if I didn't do this every now and then. What is going on with that?

Anil: Wow. That is a good question. That's very interesting because it speaks to a couple of things, I think, of the neuroscience perception. One is this idea of perception, not as a way of discovering what's out there, but as a means of control. So when you're using a fixed point to retain balance, you're not perceiving half dome in a distance or whatever fixed point you're looking at to try to understand what it is or see what it is. You're using it as way to control your posture. Your sexual system is now working as a thermostats for balance, a homeostasis. There's a fixed point and you want to prevent deviations

from that fixed point, and if you prevent deviations from that fixed point, that means you'll still be standing up, and that's what you want to do.

Anil: There's a beautiful and actually quite a neglected theory in perception called perceptual control theory. And this is exactly the idea that behavior is in the service of perception rather than the other way round. Because again, we're so conditioned to think of perception as, there's a world out there and we perceive it as it is, or maybe we systematically misperceive it in some way because we know about visual illusions and all that. But it would be great if we could perceive the world more accurately as it is. And once we've got that perception, then we can decide what to do and we execute actions and we move our bodies.

Anil: I think this is almost entirely wrong. The purpose of perception is not to figure out objectively what's out there in the world. The purpose of perception is to enable our adaptive behavior.

Dave: So we don't die.

Anil: So don't die. In the most extreme version of that, the cause perception is to keep the body alive and to keep my heart going, to keep my blood pressure within bounds. This is a theory I've written about in my work called ... I like to call it The Beast Machine Theory. The way of saying the way we perceive everything, whether it's out there in the world or in here in the body can only be properly understood then because of it's a utility in keeping us alive. We perceive the world with, through and because of our physiological bodies.

Anil: The bodies aren't just vehicles for moving our brain from meeting to meeting. We can only understand perception through this imperative to staying alive. But just in your example, it really highlights that perception in that case is about regulating a variable. And that when you perceive the same situation from the perspective of regulating something rather than discovering what it is, your experience is going to be very different. And we know perception works like this in many cases.

Anil: One of the classic experiment is how people catch a ball, whether it's baseball in the states or cricket in England, the UK. If you ask a cricketer what they're doing when they run to make it catch, you ask anyone what they do when they run to make a catch, and let's say the ball was sailing overhead, then most people would probably say something like, "Oh yeah, I look up and I figure out where the ball is and where it's going to land, and I run to where it's going to land so that I can catch the ball."

Anil: But that's not what people are doing. What people are doing is they're running so as to minimize how the angle of the ball to the horizon changes. There's a very specific equation you can write down. They're minimizing, I think, it's the acceleration of the tangent of the ball. It doesn't really matter, but there's a very simple perceptual variable that they're trying to regulate, to maintain constant. And you can just prove it mathematically quite easily, that if people move so as to control that perceptual variable, the ball will just end up hitting them squarely between the eyes.

Anil: So if people do that, they will intercept the ball. Obviously, the ball doesn't ... they have to at some point switch to catching the damn thing. But you can make predictions about how people will move if they're following the strategy compared to figuring out where the ball is going to land and running there as fast as they can.

Dave: Wow.

Anil: And so it turns out that people are following this control strategy, but they don't know that that's what they're doing.

Dave: So there's a lot of layers of perception that are in the story we tell ourselves. Here's another question for you. So, I put on a conference on biohacking every year. We just finished the sixth annual one, and at least four of those years, I put on an experiment. I didn't do it this year. I just didn't have time for it. Where we allow people to strap on a pair of virtual reality goggles, and then we have a camera mounted up behind them. So they're able to play themselves like a video game. So they can see their body from up from above and behind them.

Dave: And then their job is just to walk through a simple obstacle course on the ground. Touch the red thing, touch the orange thing. And it blows people's minds, like, all of a sudden, your consciousness is outside of your body, and it's actually kind of an emotional experience, for lack of better word. And I set this up and I've had my kids do it in the driveway, and I've certainly done it and it's just kind of a liberating thing where you just realize, maybe I'm not that meat. What is your neuroscience perception expert take on what that's doing to our brains?

Anil: That's a great exercise. Great experience, actually. We've done very similar things in the lab here. And we do public science events quite frequently and we set up virtual reality things much like that.

Dave: Oh, neat.

Anil: I love it for a number of reasons. The first is that I think the most fundamental thing I take from these kinds of setups is can it going to deconstruct our assumption about what the self is? And we tend to assume that part of what it is to be me is the first person perspective. That my first person perspective is located somewhere inside my head, probably maybe in my forehead, a little bit behind my forehead, but somewhere in there. That's just taken for granted. That's where my first person perspective is. And then when you hear of people reporting things like out of body experiences, it's tempting to dismiss it a little bit and say no, The soul ... being a good material list and thinking that souls aren't these things that float around in a Cartesian immaterial heaven. That your soul doesn't leave your body and go flying around.

Anil: And what a demonstration like this does is it shows that actually, you can very well have the experience of a first person perspective that is not located where your body is. And that doesn't mean that your soul has left your body. It just means that a first person perspective is another kind of perception. It's another perceptual inference. In your

case, you generate these out of body like experiences because you're giving people literally a different perspective. They see themselves from an external perspective. So from the brain's point of view, the best explanation for that video input is that the first person perspective has shifted to somewhere else. It's what makes best sense of the data.

Anil: And so it selectively modulator one part of what it is to be yourself. And we realized through doing this, that aspect of the way we experience ourselves in the world that we previously took for granted, we shouldn't take for granted. And it also helps us understands phenomena in neurology because there are ... it's not just these very vivid and occasional out of body experiences that we've heard about and in spiritual and religious contexts or in operating theaters and so on. There's a whole variety of these, what we call full body illusions.

Anil: The closest, I think, that these virtual reality manipulations get us to is something that we call otoscopic phenomena. So, an otoscopic phenomena is something where you see yourself from a different perspective, but you still feel yourself to be where your body really is, to some extent. There's a dissociation from ... it's not a full blown out of body experience where everything about you has shifted somewhere else. Then there's [inaudible 00:56:05] experiences, which is where people ... these are also called doppelganger experiences where people can perceive another version of themselves and their self-location may oscillate from one body to the other.

Anil: And apparently, I think Dostoyevsky used to suffer from this condition, or some famous author did. So we can start to get a handle on some of these water on the face of it, very peculiar conditions where people report pretty weird disturbances of how they experienced their selfhood, and we can come up with quite natural explanations for them.

Dave: That is amazing. I'm blown away at just all the stuff that's going to be coming our way over the next 10 years because of the work you're doing and the work many others are doing around our perception of reality. I think we're going to become better at understanding when we're seeing an accurate representation and when we're seeing one that is highly colored by our own experiences in the past. It feels like the better we do that, the better off we'll be as people.

Anil: I think the key is that ... my hope is that we might actually move away from this idea, this ideal of accuracy because it really, because it really relies on this assumption that there is a single way the world is and that we need to calibrate our perception to fully, objectively, accurately reflect that. But just to go back to where we started with the simple example of color, color is not out there in the world. Color is already a construction of the brain. So I think we need to develop ways of training our perception. Not necessarily say that it's the most accurate, but so that it's the most useful for us as individuals and for us as collections of individuals within a society of diverse people who will see the world in different ways.

Dave: Very well said. Anil, I have another question for you that is going to touch on consciousness for sure. And I've been asking people, and Game Changers, my last book was based on this, almost 500 people advice for performing better as a human being. One of those big pieces of advice was getting outside yourself. People who perform well found some way, whether it was meditation or hallucinogens or some practice to get a better perception themselves. So, I changed my question because my next book is around anti-aging and my quest to live to at least 180. And you may look at that and go, "What the hell are you talking about?" Different thing, but I believe that that is probably achievable. So someone's got to do it. I'll sign up. It's okay if I die trying. Now, my question for you is, how long do you want to live?

Anil: That's a very good question. It varies, in all honesty. My answer might not be the same every day. I'll answer it indirectly with a short story of a personal experience or the personal lack of experience. Now of course, there's fear of mortality or just the conception of mortality that is so difficult to face or grasp. The idea of not existing is so counter to everything that our brain does. All our perceptions are geared towards the continuity of both our physiological and our psychological identity. And I think that's why it's so difficult to face up to the realization that ultimately, whether it's after 80 years or 180 years or 180,000 years, that's going to come to an end.

Anil: So I've nothing against life extension, apart from its possible inequitable distribution among society. That's definitely an issue. But these anti-aging technologies, that's a different conversation. But in thinking and reflecting on this, personally, I'm drawn to a couple of things. One is that I think we overestimate our continuity and identity as an individual anyway. So I've used this term in some of my work called Self Change Blindness. So we know from many experiments in psychology that if things change slowly, we tend not to perceive them as changing at all. We're kind of blind, perceptually and cognitively be blind to things that change very slowly, explains why we're not perceiving the effects of climate change. Things are changing more slowly, so we perceive them as not changing at all.

Anil: And I think this applies to the self as well, and actually more than it applies to the world, and that's because perception of self is really geared towards keeping it the same. In the same way that we wanted to keep the angle of the cricket ball the same to catch it, I want to keep my blood pressure the same, I want to keep my heart rate variability the same because that's consistent with me staying alive. So I'm going to perceptually overestimate how continuous I am. I know that I'm not the same person I was when I was 10 years old. I'm unlikely to be the same person when I'm 76 as I am in my mid 40s now.

Anil: In a sense, there's less to hang on to. What does it mean to extend my life to whatever arbitrary horizon? Because I won't be the same person then anyway. So that's one thing. And I think you can come to this recognition through meditation, through other kinds of, as you say, various ways getting outside yourself. You can start to realize this. And the other reflection was my experiences of general anesthesia. I've had a few operations over my life. They've all gone well, thankfully. And each time, I've got more interested in

just the experience of losing consciousness under anesthesia and regaining it on the other side.

Anil: And there's something about anesthesia, which for me I find extremely reassuring about the prospects of nonexistence, because it's really oblivion. It's not like going to sleep at all. Dave, have you had general anesthesia?

Dave: I have had general anesthesia as well ... I just did ketamine on video recently.

Anil: I think there's probably a big difference there because-

Dave: There is.

Anil: ... whether you are asleep ... ketamine is used as an anesthetic, but it's-

Dave: Kind of general.

Anil: ... an extreme dissociation.

Dave: Correct.

Anil: It's not the complete oblivion of something like Propofol and midazolam or some of the classic general anesthetics that you would get in operating theaters in the west, or everywhere, really. And when you go under general anesthesia, there is nothing. You could have been under for five minutes, five hours or 500 years. It doesn't matter. You were not there. And I find this sort of existentially reassuring because when you're gone, you're gone, and there is nothing. There's a book title by one of my favorite authors, Julian Barnes, and the book title is called Nothing to Be Frightened Of. And I think the double meaning of that title when it comes to mortality is exactly right. There really is nothing to be frightened of. Of course, it doesn't always feel that way at the time.

Dave: That is very eloquently put. And yeah, if there's nothing to be frightened of, then you've got nothing to be frightened of. And if there's something else that you have no provable ability to do, you have no control over it anyway. So there's still nothing to be frightened of either way. You got nothing to lose, whatever your belief system is.

Anil: Also, just let me be clear. I'm not saying this is a desirable condition to be in. I think life is better.

Dave: Me too.

Anil: I'm keen to be alive, but I'm also aware that the value of life is the emotional states that you experienced while alive.

Dave: Driven by perception. Right?

Anil: And those can be a [inaudible 01:04:59] positive. And then of course, there's the value of life and the meaning of your life, others and so on. But the fear of mortality, I think, is something that can be addressed and that neuroscience does have something specific to say about.

Dave: Wonderful answer. I really appreciate your of work, Anil. I think you're doing some stuff that is fundamental to cracking the code for what really makes us tick and what really it makes us a human are at our core and how we interact with each other and the world around us. And thanks to you and your colleagues for doing that work. Your body of work is probably best accessed via your Twitter feed, I would say. Anil K. Seth, A N I L K S E T H on Twitter. And I think you have a website as well, but I'm not remembering the URL. What's your website?

Anil: It's simply AnilSeth.com.

Dave: AnilSeth.com. Well, keep on hacking human brains. When you have a really cool perception experiment that I can do at home, give me a call. I'm totally game.

Anil: And I'll be happy to. Thanks a lot. It's been great chatting to you.

Dave: If you liked today's episode, you know what to do. Change someone else's perception of reality by heading over to Amazon and leaving a review for one of my books, like Game Changers. Because believe it or not, you can change someone's perception of reality by saying, "Hey, I like this." Or conversely, "I don't like this." Whichever one you choose, people do look at what the crowd does and it changes their behavior, it changes their perception. So if you think the show was worth your time, leave a review for the show. If you think reading a book based on the show is worth your time, do that. And as always, enjoy your Bulletproof Coffee. Have an awesome day. I'll see you in a couple of days.