3 Takeaways Podcast Transcript
Lynn Thoman
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Ep. 154: Livewired: Creating New Senses For Humans

INTRO male voice: Welcome to the 3 Takeaways podcast, which features short, memorable conversations with the world's best thinkers, business leaders, writers, politicians, scientists, and other newsmakers. Each episode ends with the three key takeaways that person has learned over their lives and their careers. And now your host and board member of schools at Harvard, Princeton and Columbia, Lynn Thoman.

Lynn Thoman: Hi everyone, it's Lynn Thoman. Welcome to another 3 Takeaways episode. Today, I'm excited to be with David Eagleman. He's a neuroscientist, a Stanford professor and the author of the wonderful book, *Livewired*. I'm excited to learn about the latest findings on our brains and what new senses we can potentially create for ourselves. Welcome David, and thanks so much for joining 3 Takeaways today.

David Eagleman: Pleasure to be here.

LT: People are shocked to discover how little of the reality of the world that we can see. Can you tell us about the umwelt, starting with what it is, and then give us just a few examples of what different kinds of animals are able to sense that we do not?

DE: Generally, the issue is that we pick up on just a little bit of the world out there. So, you've got your eyes and your ears and your fingertips and your nose and so on. And we think we are experiencing everything that's out there, but in fact, we're just sampling a small bit. So, an example is the electromagnetic spectrum, which is light out there. We're just picking up less than a tenth trillion of the light that's available out there, and we call that visible light, but there's much more radio waves and microwaves and gamma rays and X-rays and so on. And as far as smell goes, we're just picking up on a few of the molecules out there. If you look at a dog, for example, with its big snout, it's picking up on so much more than you are in the auditory world. Lots of animals are picking up on sounds in the range of things that are very high or very low. The word umwelt, describes the signals from our environment that we're able to pick up. And we have a very small umwelt, and each animal actually has its own small umwelt. As far as examples go, the tick just picks up on temperature and body odor. That's all that it can sense in the world, or the echo-locating bat just picks up on air compression waves that are coming back to it, things like that.

LT: Do we have to be stuck in our own sliver of the world? What are the possibilities?

DE: As a neuroscientist, I've been very interested in this question about whether we can expand our umwelt by using technology. So, one of the things I've done is, spin a company off from my laboratory called Neosensory, and we build, for example, a wristband with vibratory motors on the wristband. And this allows us to pass any kind of information into the brain via patterns of vibration on the skin. So as an example, our first product was for people who are deaf, we capture sound through the microphone on the wristband and then turn that sound into patterns of vibration, which is exactly what your inner ear is doing. Your ear is picking up on vibrations caused by air compression waves and your inner ear is just translating those into spikes which go into your brain,

and you learn how to hear that way. So, we transferred hearing to the skin. We've now done this to replace hearing aids. We are just using the wristband with machine learning to listen for high frequency parts of speech, and we just alert the user, "Hey, I just heard an S, a T-H, a V, a P." And so on. And this way people with high frequency hearing loss can understand what's going on in the world.

LT: Fascinating. Can we extend our eyes or our nose further and our other senses further than they already are?

DE: So, we actually have 70 projects going on in the company where we're doing various things of extending our sensory experience. So infrared for example, something I'm very interested in, being able to pick up on information in the infrared range and have a direct perceptual experience of that. Or we've done things where we're picking up on the states of your body that are normally invisible to you, like blood pressure and galvanic skin response and heart rate variability and things like that. But we can also do it where you're picking up on someone else's. So, let's say your spouse, you're feeling your spouse's physiology at any given moment, which is very interesting. And we can pick up on the stock market or social media, any kind of trend that's going on. You can feel that directly on your skin and develop a direct perceptual experience.

LT: Our brains are extraordinarily flexible and adaptive. Can you tell us about that? What happens for example to a blind person's other senses?

DE: The general story is if you go blind, your visual system, which is at the back of your head, that gets taken over by other domains like hearing and touch and so on. And so, this is because the brain is not hardwired the way we typically think about it. If you look at a brain in a textbook, it says, "Okay, in the back of the brain, this is your visual system and over here is your auditory system, and over here is your system for touch and so on." But in fact, the whole system is very fluid and if you're not getting new visual information coming in, the system will readjust itself. And so, a blind person has a takeover of the senses by the other domains.

LT: What are some ways that a blind person could see?

DE: So, people have worked on sensory substitution for the blind for a number of decades, which is to say, feeding information into the brain of a blind person, feeding visual information in through an unusual channel. So, one example is, in 1969 a scientist named Paul Bach-y-Rita, put blind people in a modified dental chair, and he had a solenoid grid in the back of the chair. So, you have all these things that poke you in the back. And he set up a video camera, and whatever the camera was seeing, you would feel that in your back. So, if the camera is seeing a coffee cup, then you feel a coffee cup poked into your back or if it's seeing a face, then you feel the face poked into your back, that kind of thing. And so, he was able to demonstrate that blind people could get pretty good at understanding what was in front of the camera just based on what they were feeling through the small of their back.

LT: Could we have new senses and can you give some examples of some completely new senses that we could potentially have?

DE: There's actually two things there. One is sensory expansion. So, for example, hearing at higher or lower frequencies than a human normally does or seeing in light ranges that a human normally

doesn't see in like infrared or ultraviolet, things like that. And then there's sensory addition, which is actually adding brand new senses. So, this is the stuff I mentioned about stock market or feeling a drone and understanding what you're feeling, the pitch, yaw, roll, heading orientation of the drone on your skin and you come to be one with it that way. There's essentially no end to the possibilities on the horizon that we can imagine as far as adding and expanding new senses.

LT: That is so cool. Can you talk about what's happening under the hood, so to speak, of what the brain actually sees? Is the brain directly seeing or hearing or touching anything?

DE: It's not. It's locked in silence and darkness and all it ever experiences are these little electrical spikes and then the chemical releases that are caused by these spikes from the cells. But that's all it is, these trillions of spikes running around in darkness. That's your whole brain's experience. But what the brain's really good at doing is extracting patterns from this and assigning meaning to this such that you have your whole colorful world of sounds and sights and experiences, but it's all constructed from spikes in the dark.

LT: So interesting. We've talked so far about input from the body's senses. What about the brain's other job of output to the limbs of the body? Is that flexible and could we embellish our bodies?

DE: The brain is this three-pound mission control center, again, locked in darkness, but it has to control this giant body of yours. And so, it figures out, "Okay, here's how I move my limbs around and here's the sensory consequences when I do this and I move that and here's what happens." And so, it does this, but it is extraordinarily flexible. Why? Because you change height during your life, you get on bicycles, you get on skateboards, you get on hang gliders, you get on pogo sticks, stuff like this. So, the brain is used to saying, "Oh, okay. Now I got it. I'm in this different mode now, where I'm doing this other... Now I'm on a surfboard. Okay, cool. Here's how I move now to accomplish what I need." So, it's extraordinarily flexible. And what experiments in the last decade and a half have been showing is that, you can actually have the brain control other things like a third arm for example.

DE: With a brain machine interface, you can control new body parts that you didn't normally have before and the brain has no trouble figuring this stuff out. And one of the easy ways to experiment with this is in virtual reality, where you can add all kinds of new senses... Sorry, new body parts. So, for example, you can become an eight-legged lobster or you can have a third arm coming out from the middle of your chest in virtual reality, and you just learn how to control that. One experiment at Stanford, you move your two arms around with these controllers, and the turn of your wrist is what controls the third arm. And people get pretty good at this after a couple of minutes.

LT: Can you give some other examples? What are some of the more far out or interesting examples of what we could potentially have?

DE: Well, I think at some point we're going to be controlling totally separate bodies, and again, the brain has no trouble with this. And in fact, this is actually how the brain determines its sense of the self by determining what it can control. So, for example, you look at your mirror image and you move your arm, and you move your neck around and stuff like that, and your brain says, "Oh, that's me. That's part of this self. Why? Because I'm able to control it." Or you get in a car and you're the one controlling it. And so, if you ever hit the right front wheel on something, you feel like, "Oh, that was me." You feel like you hit it because the car has become an extension of your body. And so, I

think eventually, we will... With brain machine interfaces control, let's say a robot that's separate from you, but your brain will have no trouble saying, "Oh yeah, this is part of me." Instead of using muscle and sinew, it's using bluetooth.

LT: And we're already doing that. People can already do that. Paralyzed people can use their thoughts to move prosthetic limbs or to type their thoughts on a computer.

DE: Yeah, that's exactly right. And so all that it's doing is the same thing that we normally do. We just take it for granted, which is to say, our brain is controlling something on the outside world, and you get to see the consequences of it. So yeah, exactly as you said, there's all kinds of control you can do directly with the brain machine interface. [With] electrodes implanted in your brain, you can control a cursor on a screen or you can type, or you can control a robotic arm across the room.

LT: Do you think that our progeny will be limited to the boundaries of their bodies or do you think they will be able to extend their senses across the universe?

DE: Well, the only thing about... So yes, they'll be able to extend their senses across the universe in their motor actions. The only thing we have to deal with is the time delay, which makes it a little weird. So, if I'm controlling something on Mars, there's a couple of minutes delay there. So, it is my body and myself, but with a delay, and that one we'd have to just get used to that.

LT: And you believe that we can enhance ourselves with not just enhanced senses, like being able to see ultraviolet light or hear infrared sound that we can have completely new senses?

DE: Yeah, exactly. So, picking up on your spouse's physiology or being tapped into an airplane or whatever, that's a new kind of sense that humans have never had, but it's trivial actually to learn how to have such a sense.

LT: Do you think that changing our bodies and our senses might change us?

DE: I do. I think we are a product of all our sensory input and our ability to control bodies. And as that changes, we will change. And probably there's a very real sense of which we already have. I mean, just the fact that we have, let's say the internet and we're able to access information from all over the world and access the entirety of humankind's knowledge, in a rectangle in my pocket, probably already changes me from my great-great-grandfather.

LT: And you compare what you call live wiring with hard wiring, and explain why live wiring is so critical for us as humans?

DE: Something that's hardwired is like your computer or your cell phone, which comes with its circuitry and it doesn't change. But brains are extraordinarily flexible. For example, children with epilepsy of a certain type that affects a whole half of their brain, they'll get that hemisphere of their brain removed. So, they've got half of a brain in their skull, and they do perfectly fine. They're completely fine because the remaining half just wires up all the functions that would have been there otherwise. So, it's an extraordinarily flexible system, and this is what I call live wiring. Technically in the field, we call this brain plasticity, that is a term that comes from the way you can mold plastic into a certain shape and it'll hold onto that shape. And the great American psychologist, William James, was very impressed with that. But I think the days of being impressed

with plastic manufacturing are past us. That's why I call this live wiring because it's this completely amazing thing that brains do. And we have made a lot of progress on this in the past 20 years really.

LT: I was fascinated by your extension of live wiring to design. Nature uses live wiring, but we tend to design with hard wiring. Can you talk about using live wiring for designing physical things like for example, the Mars rover or buildings.

DE: The Mars Rover Spirit cost a lot of money and it was a giant project and it finally got to Mars and was very successful there. It was a great project. But it eventually got its right front wheel stuck in the Martian soil and it couldn't get out and it died. And when you look at something like a wolf that gets its leg caught in a trap, it chews its leg off and then figures out how to walk on three legs, because it's live wired and its brain says, "Oh, okay, I'll figure this out." And we don't build our machines that way, so they break in ways that are frustrating. And so, what I'd really like to do, and this will probably be my next company, is building devices that are live wired so that the Mars rover gets stuck and says, "Well, I'm many hundreds of thousands of miles from home. I will just saw my leg off and figure out how to walk in a way that I wasn't pre-programmed for."

LT: And how about buildings? What would a live wired building be like?

DE: So, I was just speculating on this thing about, instead of putting into place the way we hard wire everything, what if you had a building that could say, "Hey, there's wind coming from this direction. I'm just going to adjust myself. I'm going to adjust the way the building is shaped." Or maybe a building that says, "Hey, I'm just going to get up and walk somewhere else as the sea level moves in." Or even a building internally that can just change its wiring and it's piping the way that we do with our vasculature all the time. So, it says, "There's a dinner party going on here, and I noticed that there's a lot of people who need the restroom, so I'm just going to grow some more piping and have more toilets here for the moment." This is what happens, when you get a tumor for example, and cancer, you're growing your vascular system, you're changing the blood supply, you're changing all kinds of stuff. And so, this is a much more distant future issue. But the question is, could we build buildings that actually adjust that way?

LT: What are the three takeaways you'd like to leave the audience with today?

DE: The main thing I'd say, is the importance about challenging your brain and this is very easy to do. So, switching up your office furniture or driving a different route home or brushing your teeth with your other hand, any of these are really important ways to keep your brain healthy. The second takeaway has to do with the fact that the brain will take in any new sensory information. So, this gives us the ability to create new senses. So, one of the things for everybody to think about is what kind of universe do you want to experience? And the third thing is that your brain will wrap around any new kind of motor capabilities. And this is what allows us to be able to learn how to use a pogo stick or a hang-glider or a bicycle or a surfboard or whatever. So, it's really interesting for us to think about, especially as we move into the era of brain computer interfaces, what is the way that we are going to add new capabilities to our bodies and what kind of body do you want to have?

LT: David, this has been great. I really enjoyed your book, *Livewired*.

DE: Thank you so much, Lynn.

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